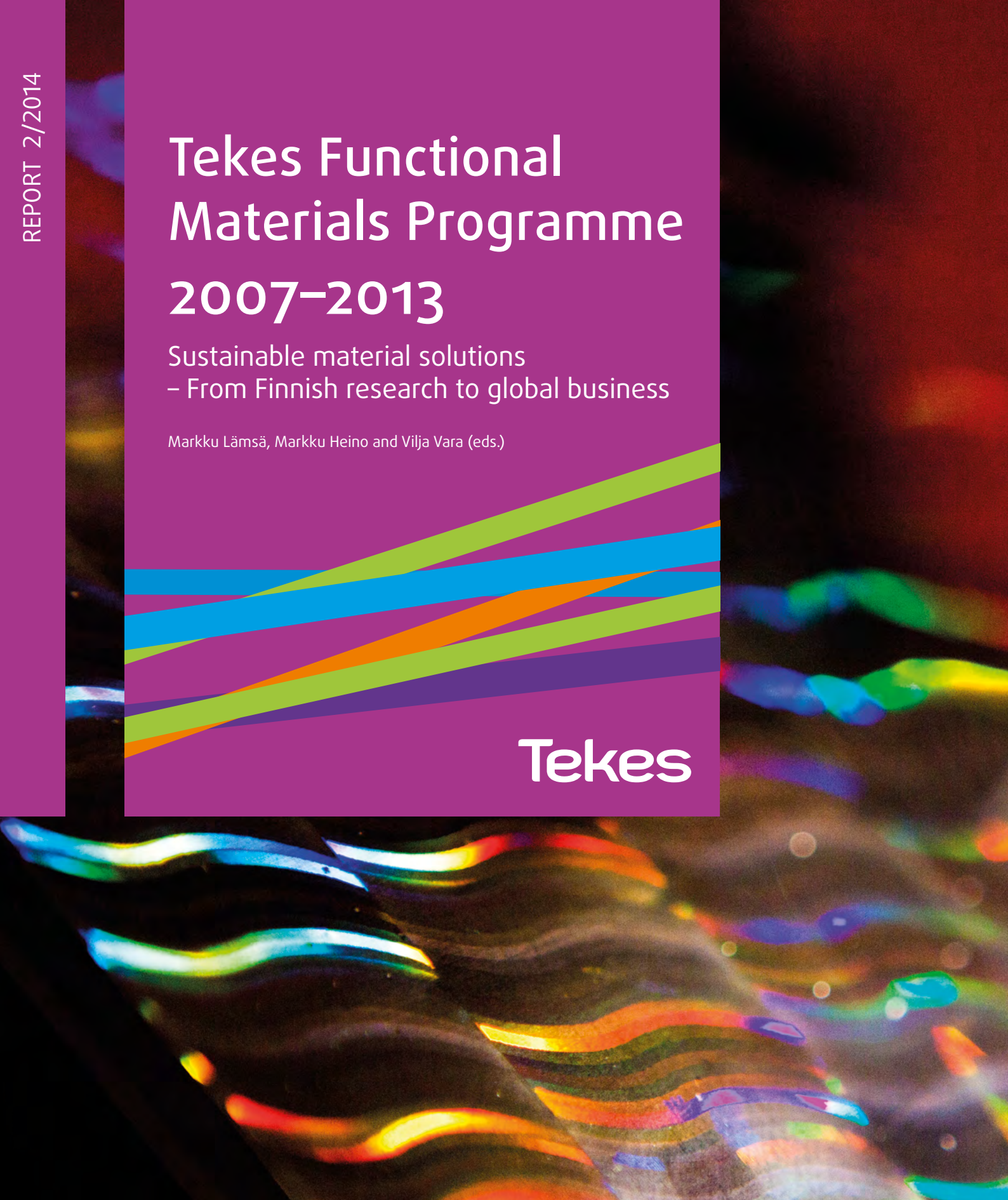
REPORT 2/2014

Tekes Functional Materials Programme 2007–2013

Sustainable material solutions – From Finnish research to global business

Markku Lämsä, Markku Heino and Vilja Vara (eds.)



Tekes

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Tekes Functional Materials Programme 2007-2013

Sustainable material solutions — From Finnish research to global business

Final Report

Tekes Report 2/2014
Helsinki 2014

Tekes – the Finnish Funding Agency for Innovation

Tekes is the main public funding organisation for research, development and innovation in Finland. Tekes funds wide-ranging innovation activities in research communities, industry and service sectors and especially promotes cooperative and risk-intensive projects. Tekes' current strategy puts strong emphasis on growth seeking SMEs.

Tekes programmes – Tekes´ choices for the greatest impact of R&D funding

Tekes uses programmes to allocate its financing, networking and expert services to areas that are important for business and society. Tekes programmes have been contributing to changes in the Finnish innovation environment over twenty years.

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Preface

The Functional Materials programme (2007–2013) funded by Tekes has driven application-oriented R&D on advanced materials and related processing methods through intensive multidisciplinary cooperation between top players in academia and industry to create a competitive advantage for Finnish industry.

The programme scope covered the whole range from understanding of materials and their features, tailoring specific functionalities, to production, application and disposal of the materials. Sustainable development including material and energy efficiency and life-cycle thinking, international cooperation both in research and business creation and active transfer of research results towards commercialization recognizing global value chains were key aspects throughout the programme. In the turbulent economic and innovation policy environment, the programme was adjusted during the programme period to offer suitable services to fulfil customer needs.

Combining advanced materials and manufacturing skills with an understanding of real application needs, the Functional Materials programme was designed to provide the critical solutions to shape our future – in particular, to tackle the challenges of dwindling natural resources, increasing global energy consumption, and climate change. Although our portfolio, consisting of 61 research consortia projects and about 90 company projects, covers a wide range of material and application fields, special focus has been placed on new material solutions for energy technologies, advanced manufacturing (especially coatings), printed intelligence, and biomaterials. Already today, our intensive, target-oriented industry and academia R&D cooperation has resulted in a variety of important scientific novelties, emerging technologies, and new business bases in these fields. And this progress is not only for Finland – the results will have a global impact.

This publication will highlight some key aspects and achievements of the programme. We have been gathering the Finnish materials R&D community actively together, boosting the building of ambitious research activities to provide critical solutions and grow new multi-disciplinary competences needed for research and industry. The major part of the publication will present selected results highlights of a bunch of projects representing the main research themes. Check the example cases, learn about the new competences, technologies, opportunities available – contact us or the key players, and let's build the next big things together!

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Read more: www.tekes.fi/materiaalit

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Chairman's view

The Functional Materials program is probably the largest publicly funded R&D investment ever in Finland for materials technology. For several decades, materials science has been receiving significant recognition including private and public funding also in other major economies investing in technology. In the EU, USA, China, Russia, Japan and South Korea, materials is considered as a core generic technology having a key role in the development of new technical solutions for energy, life science, process technology, aerospace, transportation, tooling, machine building, electronics and telecommunication industries.

During the last 20 to 30 years, material suppliers, OEMs (original equipment manufacturer) and end users have created revolutionary solutions, where the role of material science has been critical. Silicon technology, new coating and joining technologies, powder metallurgy, advanced ceramics materials, composites, hybrid materials, new type of polymers and active materials have truly created breakthrough solutions and enabled entirely new industries to be built. Most of us know the impact of silicon technology in electronics engineering and manufacturing. In wear-resistant solutions, powder metallurgy tool steel with over five times the life of conventional or new cutting tool solutions with novel structures and coating technology have radically reduced life-cycle costs of manufacturing and process operations. In automobiles, extra-high strength steel, light metals and composites have led to a radical reduction in weight and fuel consumption. Additionally, in the latest generation of passenger airplanes, composite materials have allowed a totally new level of fuel economy and reduced environmental impact. In future energy technology, an ITER fusion plant (ITER = International Thermonuclear Experimental Reactor) is a masterpiece as a diverse combination of totally new materials manufacturing technologies. New building blocks like nanotechnology and biomimetic materials are on their way to become everyday technical solutions. In new emerging technologies like solutions for life science and medical technology, renewable energy, printed electronics, sensors, MEMS and optics materials science will be in a key mission-critical role. As an example of the latest extension in a technology portfolio, graphene technology is hopefully coming to the engineer´s toolkit as a disruptive technology in coming decades.

From a solutions point of view, materials technology is typically support technology for the hosting technology like energy production, mining process, electronics, telecommunication, optical or sensor devices and systems or medical implants. Because the development timeframe for a new materials solution is typically long, it is crucial to have good strategic insight for optimum choices of technology and applications. This was one of the key discussion topics in the program steering group´s strategy workshops.

As compared to R&D investments globally, our national level investments are limited. In other words, the bulk of the researcher man-years and investments are done outside of Finland. This pushes us not just for right choices but also for identifying the right international partners for collaboration. This was done based both on program management initiatives and on the actions of participating large and SME companies. New networks created among scientists, companies, customers and suppliers are going to promote our technology and business development long after these programme projects are over.

The mission of the Functional Materials programme was the creation of new initiatives for existing businesses and to support the creation of new materials technology platforms for new, partially emerging industries and applications. We were looking for focus applications where Finland-based businesses and start-ups could develop globally competitive business platforms and products and to create both R&D, engineering and manufacturing job possibilities in Finland.

Fundamentally, these choices should be supported by publicly accepted and agreed megatrends. Development of new business platforms and start-ups could diversify materials technology industry in Finland and create more technology-intensive job opportunities, both in R&D and manufacturing, in Finland.

One target in planning of the program was to avoid overlapping with the SHOKs (Strategic Centres for Science, Technology and Innovation). Overall, our R&D investments, in parallel with the Breakthrough Materials programmes of the Metals and Engineering SHOK, FIMECC Ltd, for example with leading technical universities in Finland, have clearly boosted national cooperation and a joint realignment of research agendas for both industrially and scientifically feasible areas. A visible ramp-up in competence of scientists and facilities is visible at Aalto University, Tampere University of Technology and University of Oulu.

Several projects of the Functional Materials programme are still active and ongoing. To be honest and fair, it may be too early to make any final judgements for the strategic choices and the concepts used to plan and manage this programme. However, I assume all agree that the creation of new healthy business initiatives and technology that can be integrated into existing businesses to boost them or as a foundation for new businesses, are key performance indicators. When we succeed in this, we can create new export industry job opportunities in Finland and maintain existing ones by technology and competence injections, in this case by materials science and technology. One interesting observation – in many areas, developed products require new, advanced manufacturing methods with tight integration with tailored customer solutions, and this will certainly enable the creation of manufacturing jobs in Finland. International networking and building a new generation of materials technology scientists for companies and universities as well as improvement of national cooperation are very important "soft" achievements.

The results of projects managed by SMEs, large companies and universities, nanotechnology and nanomaterials, hybrid materials and several new material manufacturing methods are now on the verge of commercial breakthroughs, some of them already in full industrial use. Several start-ups and SMEs have also been recognized by international investors who have been supporting the development of several SMEs by direct investments. This is not a bad measuring stick for the results of the program and could be a suitable one for university research as well. It is also clear that after the programme, many companies and universities are now more attractive research and business partners globally, and this has been confirmed by persons active in the program.

In the final stages of the program, the steering group was assigned to create a vision for materials technology with a +10-year perspective. The results of this work show that there is the possibility and trust to support diversification, a face-lift and even a renewal of the industrial base in Finland with good choices, investments and both national and international cooperation.

Finally, I would like to thank the entire Functional Materials programme steering group, Spinverse and Tekes, for their cooperation and for the exciting possibility to be involved in diversifying and creating a new industrial base in Finland.

Dr. Jari Liimatainen
Chairman of the Steering group
CEO, Picodeon Ltd Oy

Executive summary

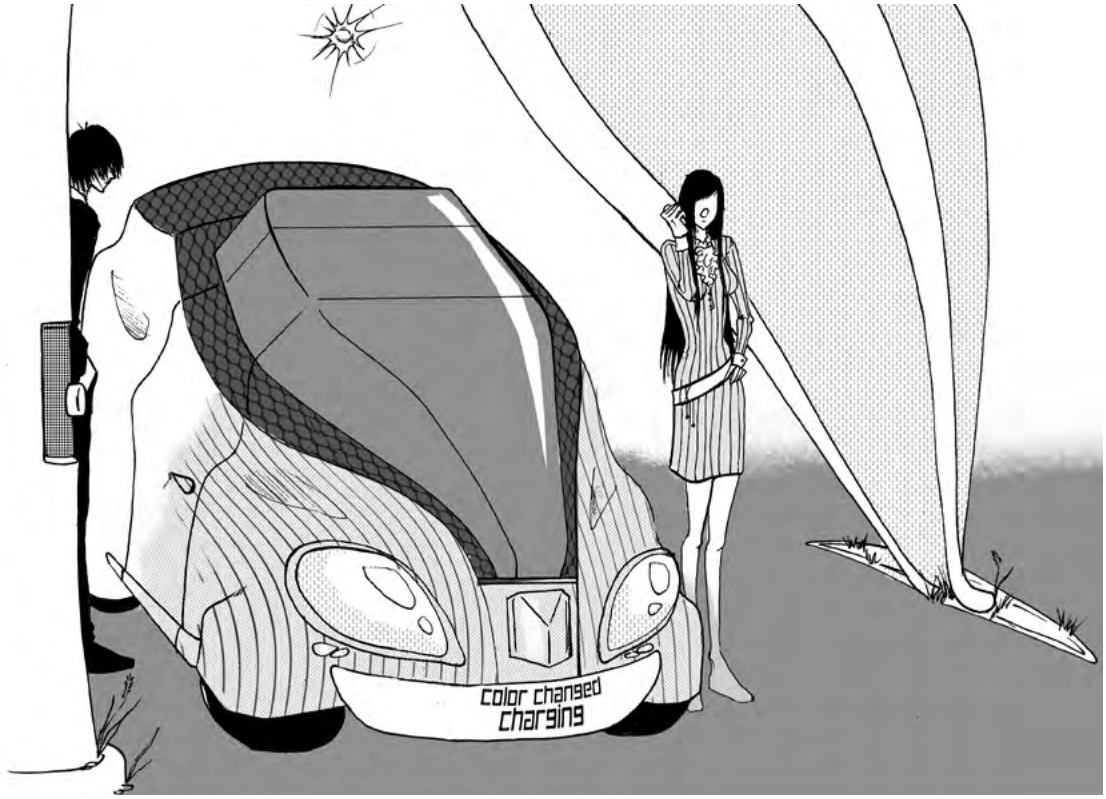
The Tekes Functional Materials programme has driven a set of systematic activities to build new solutions and competences for the Finnish industry and research community. Combining deep science to real industrial needs, bringing together key players in academia and companies in different fields, and building bridges with top-notch foreign players have formed a solid base for our success – world-class results achieved renewing industries and providing concrete solutions to the great societal challenges regarding energy, health and the environment.

Programme key activities

- Driving strategic application-oriented R&D on advanced materials and manufacturing
- Gathering and coaching key players to act together
- Creating visions and strategies: four focus areas defined, co-creation with more than 300 experts, and turning strategies to actions
- Activation and building target-oriented R&D cooperation projects: need- and application-driven, multi-disciplinary approach, international partners
- Sustainability: bringing life-cycle aspects, material and energy efficiency as a concrete part of R&D work
- Recognizing and building value chains, both for research and business
- Commercialization: bringing results from research to business
- Generating and disseminating results with concrete actions: tailored events, workshops, mission trips and versatile communication in different fora and media
- Preparing the next steps – Vision towards 2025

Result highlights and key figures

- World's strongest fully bioresorbable composite for orthopaedic implants (Vivoxid Oy)
- Holographic-like printed films without inks and metals (Iscent Oy)
- Unique Roll-to-Roll Atomic Layer Deposition technology industrialized (Beneq Oy)
- Transparent, highly conductive nanotube films revolutionalizing touch devices (Canatu Oy)
- Bringing nanocellulose manufacturing towards industrial scale (UPM Kymmene Oyj)
- Nanocellulose as unique media for cultivating stem cells (Helsinki University, UPM Kymmene Oyj)
- High-performance solar-thermal collectors integrated in buildings (Savosolar Oy, PolarSol Oy, Aurubis Finland Oy)
- Industrial aerosol technology for transparent conductive oxide coatings for solar cells (Beneq Oy)
- Safe and sustainable lithium-ion battery materials and manufacturing processes (Aalto University)
- Critical semiconductor materials for high-performance multi-junction solar cells (Tampere University of Technology)
- New thermo-formable wood material renewing furniture (UPM Kymmene Oyj - Grada™)
- A variety of proof-of-concept demos on printed intelligence (VTT's PrintoCent, Aalto University, University of Oulu, Tampere University of Technology, and Åbo Akademi University).



Vision – Functional: adaptive and context-aware materials.

Table 1. Key results of the Functional Materials programme 2007–2013 from completed projects.

	-2010	2011	2012	2013	Total amount
New start-ups	11	0	1	2	14
Patents and patents applications from companies *)	4	19	33	13	69
Patents and patents applications from research organizations *)	2	7	13	0	22
Diplomas and thesis form research organizations *)	9	22	37	15	83
Scientific publications form research organizations *)	11	72	76	34	193

*) Ongoing 29 company and 30 research projects not included.

1

Policy and strategy

1.1 Background

The impact of material science and technology on Finland's economy cannot be underestimated. Developments in materials enable modern technologies and provide the cornerstone for industrial activities. Investment in materials research leads to new technologies and the economic growth they engender. It also develops the human capital that fuels the economy.

In 2006 Tekes ordered a study of materials technology research in Finland from Spinverse Consulting Oy to find answers to the question, "How should Tekes strategy be implemented and funding be directed for maximum impact in the field of materials technology?" The study mapped Finnish materials research know-how and identified drivers and key focus areas for development in the future. Information was collected from 160 research groups and companies from different industrial sectors.

The Finnish economy was performing well during the planning phase of the programme. Finland's GDP growth was 5.3% in 2007 and Nokia was by far the largest mobile phone maker, with almost 50% market share. Tekes' new strategy introduced in 2007 emphasized materials technology as one of its strategic technology focus areas. It was seen that Finnish competitiveness can only be based on expertise and efficiency in narrow sectors, in which Finland and Finnish companies can be global leaders.

Continuous global competition and future challenges necessitated focusing on specific areas in the programme. Combining advanced materials and manufacturing skills with an understanding of real application needs, the Functional Materials programme was designed to provide critical solutions to shape our future – in particular, to tackle the challenges of dwindling natural resources, increasing global energy consumption, and climate change. The objectives of the programme were crystallized in the vision and mission statements.

Vision:

Finnish industry utilizes advanced material technology more efficiently than competitors and therefore gets competitive advantages in the global market. Industry has access to the best expertise on production and application of materials through national research organizations and their international networks.

Mission:

As a result of the program, business opportunities in Finnish industry have been significantly improved through effective exploitation of the latest results of materials R&D.

Vision – Sustainable: 3D manufacturing and recycling.

1.2 Materials technology

Materials technology itself is a relatively comprehensive discipline that begins with the production of goods from raw materials to processing of materials into the shapes and forms needed for specific applications. The more traditional materials are now supplemented by new concepts that require interdisciplinary approaches.

Functional materials are materials that generally exhibit some non-structural properties (for example, electronic, magnetic or optical) and are incorporated into associated functional devices and systems (for example, microelectronics, photonics and electrical machines). Functional materials, defined here as 'materials' and their associated process technologies with the potential to be exploited in high value-added products, is both a multidisciplinary area within itself (including physics, chemistry, biology, etc.) and one cutting across technology areas (e.g., electronics and photonics, and biosciences) and market sectors (e.g., energy, transport, healthcare, and construction).

Functional materials generally require a precise structure that is achieved only through highly advanced synthesis and processing in addition to an atomic-level understanding of the material properties. Nanotechnology, in particular, enables the fabrication of materials that can react to external stimuli. Future intelligent materials are designed using bio-inspired processes. These are precisely controlled, self-organized, responsive and interactive materials.

1.3 The Functional Materials programme NABC

NABC has been developed in order to acquire a more systematic approach to the understanding of value propositions; in other words, the value of original thinking. The NABC method was developed in the USA by the Stanford Research Institute.

- **N for Need** is the most important factor in the method. An idea without a practical need for it remains just what it is: a good idea and nothing more.
- **A for Approach** is usually a point of departure for most activities, but with the NABC method, A always comes after N.
- **B for Benefit** stands for the innovative elements of an idea; in other words, that which constitutes its uniqueness.
- **C for Competition** stands for a study of the competition existing in the area concerned. C focuses on the reality within which a concept has to function.

The programme was planned to focus on creating an understanding of materials and their features, tailoring specific functionalities, as well as the production, application and disposal of materials. The key aspects throughout the programme were:

- sustainable development including material and energy efficiency and life-cycle thinking,
- international cooperation both in research and business creation, and
- active transfer of research results towards commercialization recognizing global value chains.

In the starting phase of the programme (during 2007-2008), the interest groups were gathered together around five themes:

1. high-durability materials,
2. new materials for energy technology (solar energy),
3. materials for light structures,
4. materials for bio- and medical technology, and
5. materials for consumer products.

Several workshops were arranged to map these areas and prepare the basis for the first research calls.

Vision – Smart spaces: energy-efficient and user-driven.

The Functional Materials programme value proposal can be formulated based on the NABC method in the following way:

Need:

- Finnish industry needs new solutions
- Materials technology is seen as a key issue
- Starting point: good materials research exists in academia, several companies are applying new materials, but only a few producing them
- Currently, the application-based needs and offering do not match well enough

Approach:

- Foster application-driven materials R&D
- Recognizing industry needs, global value chains, and research competence
- Active partnering – bringing relevant players together to multi-disciplinary innovation groups. Finnish key competence combined with relevant foreign players
- Effective implementation of research results to industrial applications in global value chains
- Environmental aspects and life-cycle thinking taken as a natural part of R&D

Benefit:

- Provide new applications and competitive advantage globally for Finnish industry through advanced material technologies
- Functional materials enable new solutions for several industry sectors to renew existing industry and create completely new application areas and businesses
- Create new multi-disciplinary competence and cooperation networks to pave the way to the future

Competition:

- Increasing global competition in raw materials, energy, markets and skilled people
- Mass volume production moved to Asia and cheap-labour countries; cost-efficiency
- Tough competition in traditional businesses in global markets and small or nonexistent domestic markets – Finnish companies need to be forerunners to survive

1.4 The Functional Materials programme on a waterhole in 2010

A waterhole is one of the techniques in the NABC method that can be used in the development process. Stopping at a waterhole can actually make it possible to continue. The waterhole helps develop an idea further and can be used during and at the end of the development process. The time to stop a waterhole was in the midterm of the programme.

Firstly, a major change in Finnish innovation policy was met when the Strategic Centres for Science, Technology and Innovation (SHOKs) were launched in 2006. The first SHOK company was founded in 2007, and the most recent were established in 2009. The SHOKs run industry-academia R&D in areas such as metal products and mechanical engineering (FIMECC Ltd.), the forest industry (the Finnish Bioeconomy Cluster, FIBIC Ltd.), energy and environment (CLEEN Ltd.), health and well-being (SalWe Ltd.), built-environment innovations (RYM Ltd), and information and communication industry and services (DIGILE Ltd.).

Tekes as a main funding body for SHOKs has provided EUR 472 million for SHOKs during 2008-2013. During the same period, the allocated budget for Tekes programmes has decreased from 40 percent to 25 percent, affecting the Functional Materials programme too. The original volume of the programme decreased from EUR 215 million to EUR 150 million. Additionally, the work done or planned in SHOKs and other Tekes programmes, especially FinNano (2005-2010), Fuel Cells (2007-2013) and Groove (2010-2014), were taken carefully into account to make sure the Functional Materials programme, being the key driver of the materials field in Finland, fills the critical gaps and creates new added-value for Finland.

Secondly, in 2008 the world economy faced its most severe crisis since the Great Depression of the 1930s. The global financial crisis, which started in the United States, spread to Europe during summer and autumn 2008. In Finland, the main impact was felt during 2009. Finnish stock market indexes fell around 50 percent at the beginning of the crisis. Gross domestic product fell by 7.5 percent, led by declining export volumes, which fell by close to one-third. This extraordinary collapse in trade was attributed to the composition of Finnish exports, with a high dependence on information and communication technology and capital goods.

Thirdly, the change in the global division of labour has been reflected in notable shifts in the labour market of all developed countries. During the financial crisis, the multinationals' job cull in Finland hit the Finnish economy and employment hard. These trends are not unique to Finland – manufacturing has been declining in most OECD countries. The decline of Nokia, once the main economic hope as the biggest payer of taxes and a large provider of jobs, combined with the decline of Finland's traditional paper industry, had a strong influence in the Finnish economy and its innovation ecosystem. From 2007 to 2010, the 30 biggest Finnish multinational corporations reduced their personnel in Finland by approximately 32,500, from 215,000 down to 182,500. At the same time, these companies increased their personnel abroad by approximately 8,000, from 298,000 to 306,000.

In the turbulent economic and innovation policy environment, the Functional Materials programme was reformed to offer suitable services to fulfil domestic customer needs.

Vision – Energy freedom: surface optimization for energy harvesting.

1.5 Road map and thematic groups

In 2009, the focus of the Programme was sharpened through the strategy work of the programme steering group, followed by extensive vision work led by the Spinverse programme co-ordination team, involving more than 300 key players in the research and industry working together on four main themes:

- Biomaterials for medical applications
- Material and process solutions for low-cost structures
- Novel materials for energy technologies
- Responsive materials, and

Each focus area was divided into three to four application-oriented sub-themes, and the key challenges and tasks to be clarified were prepared with a group of experts in the area (about ten people). The industrial end-user view and future needs were set as the starting point for the work. The key players in each area, both from research and industry, were mapped and committed to join the work. A multi-disciplinary approach was emphasized to exploit synergy and learning across different industries and technology areas.

Each thematic vision work consisted of gathering the relevant interest groups, making a specific survey (commercial and research value chains now and in five years, gaps and needs, strengths, opportunities, etc.), analyzing the survey results, arranging a hands-on workshop to deeply discuss the findings and build a roadmap as well as an action plan. This proved to be a highly important activity, not only due to the results giving guidelines for the R&D work and upcoming funding calls, but thanks to the process itself. A well set-up meeting place for people with different backgrounds and active discussions on important topics motivated and activated people and laid the seeds for building relevant new R&D co-operation projects and thematic mini-clusters.

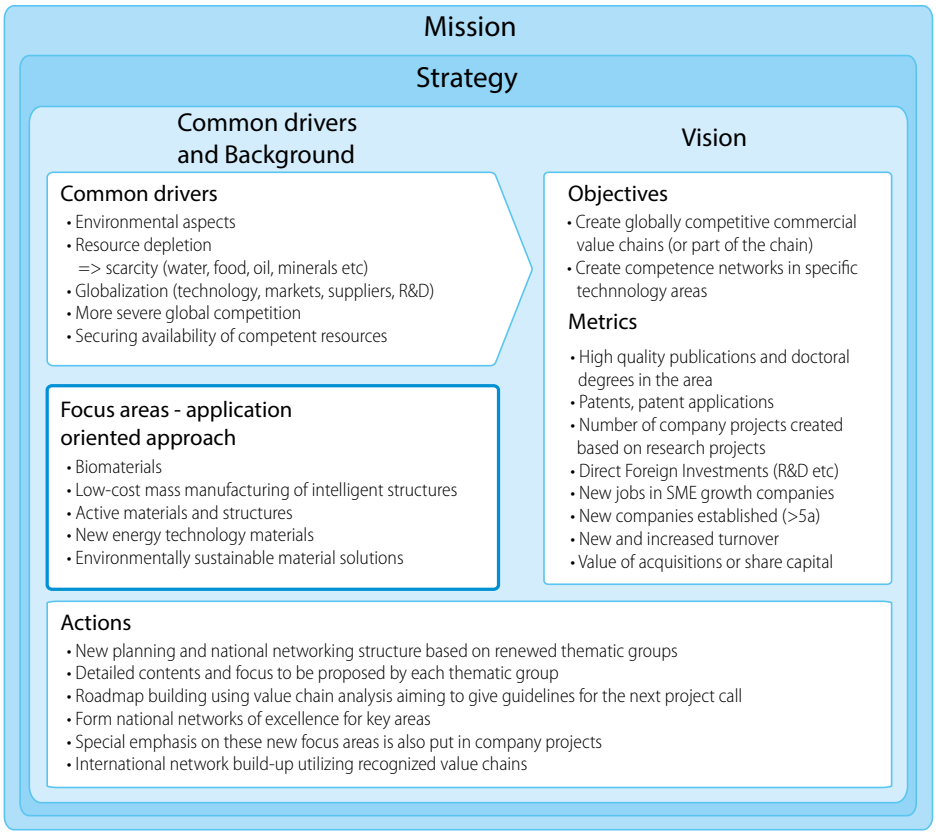


Figure 1: Strategic framework of the Functional Materials programme.

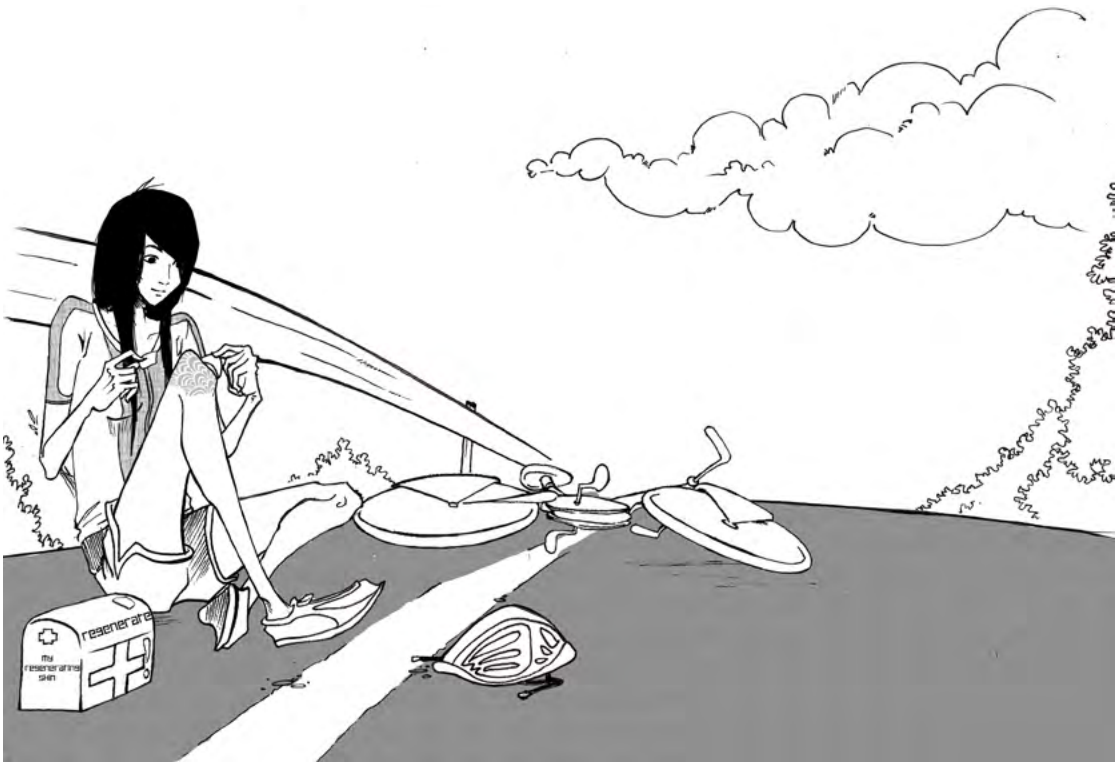
1.6 Main objectives

The extensive roadmap work in 2009 crystallized the programme strategy and the action plan for the remaining programme period of 2010-2013. These selections were also supported by the recommendations of the mid-term evaluation report done by Ramboll Management Consulting in 2010. It was seen that resource efficiency and a sensible use of natural resources to bring a sustainable competitive edge will create sustainable economic growth in Finland.

The vision and roadmap work was done for four initial focus areas. It was decided that environmental sustainability (including life-cycle thinking, material and energy efficiency) was to be included in all topics, but not taken as a separate study. The two main objectives:

- Create globally competitive commercial value chains (or part of the chain)
- Create competence networks in specific technology areas.

During the last years, the Functional Materials programme has been the driver of application-oriented materials R&D in Finland, gathering extensive, multi-disciplinary expert networks over programme and organization barriers to discuss, plan and act together. The key issue has been to build an active industry and academia R&D cooperation network with projects working on relevant need-based research problems. The programme has systematically built new research openings, thematic clusters, international cooperation and an environment to foster fast implementation of the results. This has provided critical competences, key enablers, and a base for new business in global markets, particularly for Finnish SME companies.



Vision – Personal health care: on-site diagnosis and care with tailored bio-plaster.

2

Turning Tekes strategy into actions

As today's main industrial sectors and the companies operating in them increasingly gravitate abroad and relocate their operations in growing markets outside Finland, the creation of industrial jobs will rest on rapidly growing companies in new growth sectors. In the last few years, the overall emphasis of enterprise policy in Finland has shifted from incumbents to start-ups.

In order to meet existing and future challenges, Tekes renewed its strategy at the beginning of 2011. In the strategy, resource allocation was outlined by client segments; research funding concepts for universities and research institutions as well as enterprise funding requirements were renewed; new focus areas and more flexible procedures for programme activities were specified; and the objectives for future work environments were determined.

The current Tekes strategy is focusing on forerunners and renewal. The main target group is SMEs seeking growth in internationalization. Tekes funding and flexible operating practices will challenge Tekes' customers to take their radical ideas and reforms forward. In public research funding, Tekes

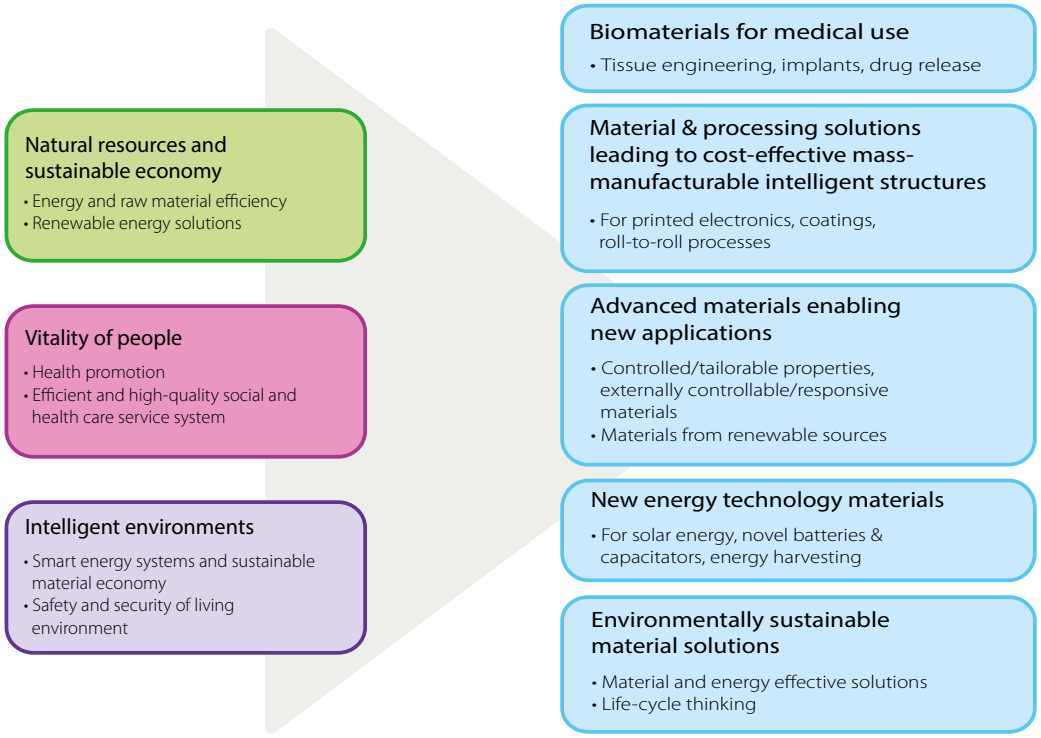
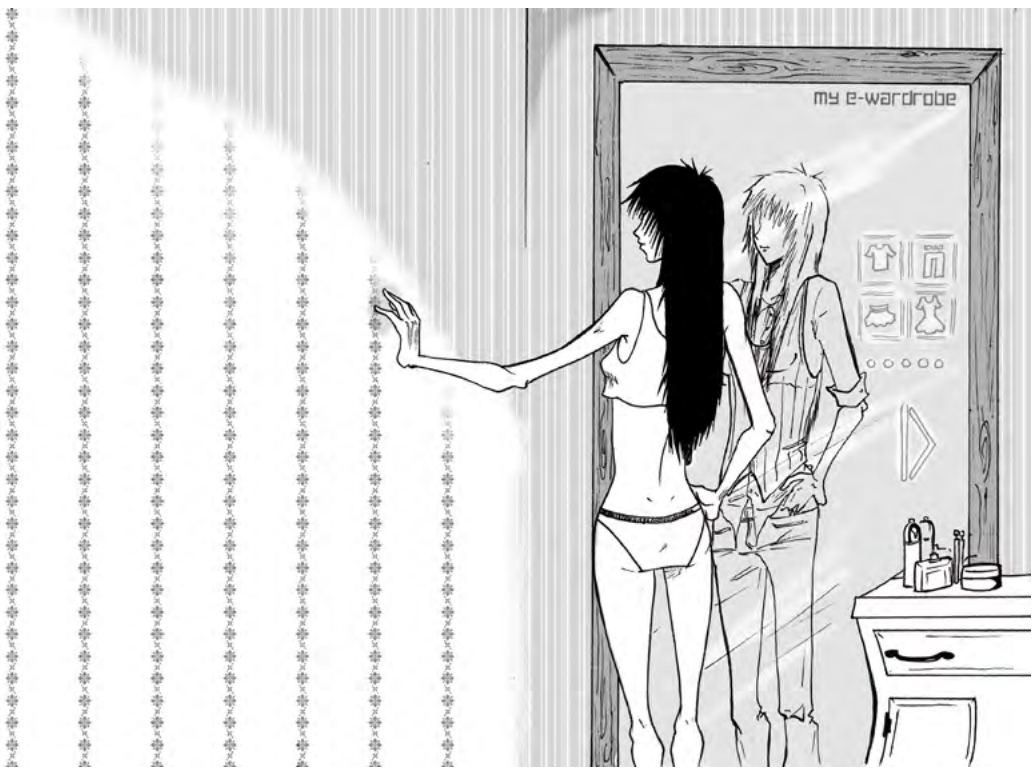


Figure 2: Main themes of the Programme strongly supporting Tekes strategic focus areas.

focuses on multi-disciplinary teams capable of creating a good foundation for research-driven business activities and companies and new areas of spearheading expertise. Business in global value networks, value creation based on service solutions and intangible assets, and renewing services and production by digital means are shared success factors for the Tekes focus areas (Figure 2).

The government and its agencies, including Tekes, have assumed active roles in promoting risky new businesses and their global expansion. The New University Inventions Act (2007), the Young Innovative Companies programme, the Growth Channel service, and the Vigo Accelerator programme are some examples of recent policy measures to foster the boom in growth entrepreneurship.

The Functional Materials Programme has been driving the above-mentioned issues, building a relevant research base and fast tracks from research to international business. According to the Tekes strategy, the Functional Materials programme will serve the goals of the natural resources and sustainable economy focus area.



Vision – User experience: Controllable and adaptive materials.

3

The Functional Materials programme's key figures

The Tekes board decided to launch the new Functional Materials programme on 26 May 2007. The programme was scheduled to last for six and a half years, starting in June 2007 and ending in December 2013. Total volume of the Functional Materials Programme was almost EUR 150 million. Tekes innovation funding covered EUR 79 million, or 53 percent of all project costs. The portfolio consists of 61 research consortia projects and 90 company projects and covers a wide range of material and application fields, with a special focus on material solutions for energy technologies and advanced manufacturing – especially coatings, printed intelligence, and biomaterials.

Figure 3 indicates Tekes innovation funding for enterprises and research organizations as well as the organizations' own contributions to the projects (2007-2013). Figure 4 shows the distribution of Tekes innovation funding for different organizations.

3.1 Enterprise projects bringing renewal and new innovations

The total value of company projects reached the level of EUR 98.5 million. Tekes innovation funding was EUR 41.5 million, divided into grants of EUR 26.8 million and loans of EUR 14.7 million. Companies' self-financing for the projects was EUR 56.9 million. The last ongoing company projects (total of 16 ongoing projects) will end by 31 March 2016. Figure 5 shows Tekes innovation funding for enterprises and total costs of projects annually (2007-2013).

Large enterprises played a major role in the early stage of the programme. When the Strategic Centres for Science, Technology and Innovation was established in the Finnish innovation ecosystem, applications from large enterprises decreased. Only projects outside the strategic research agendas of the SHOKs remained inside the Functional Materials

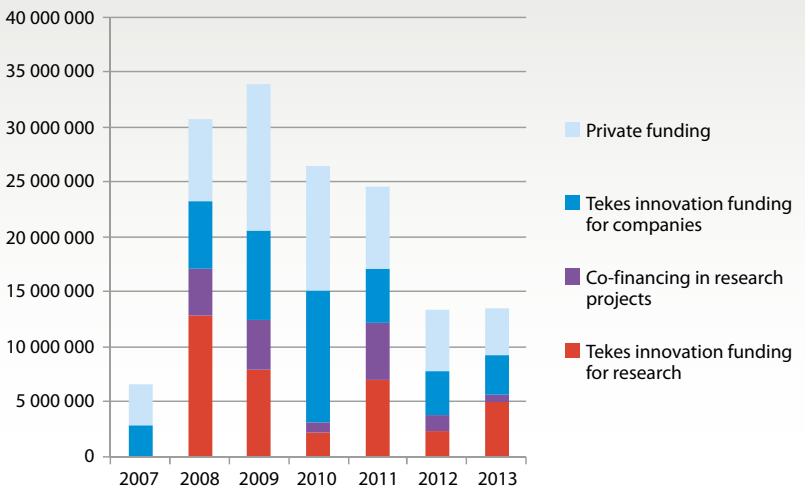


Figure 3. Tekes innovation funding for enterprises and research organizations and the organizations' own contributions to the projects between 2007 and 2013 (Euros).

programme. The impact of the global financial crisis was notable after 2010, with a declining number of company applications. Figure 6 shows the distribution of Tekes funding for companies in the Functional Materials programme.

3.2 Special focus on SMEs

In the last few years, the overall emphasis of enterprise policy in Finland has shifted from incumbents to start-ups. The government and its agencies, including Tekes, have assumed active roles in promoting risky new businesses and their global expansion. The Functional Materials programme also put special attention on start-ups and SMEs. Tekes innovation funding for SMEs was 56% in all company funding in the Functional Materials programme. Companies seeking international growth were especially active, with 43 projects and total costs of EUR 39 million and Tekes funding of EUR 20.6 million (Figure 7).

Since 2007, fourteen new, recently established start-up companies joined the programme to develop and commercialize their technologies. Among others, these included biomaterials companies ONBONE Oy and Ozics Oy; material and coating companies Varicoats Oy, Coligro Oy, MJ Optima-Sport Oy, Silvergreen Oy Ltd, and The Active Paper Company Oy; solar energy companies PolarSol Oy and Savo-Solar Oy; and battery material recycling company Rec Alkaline Oy.

Figure 8 shows SMEs' self-funding type in the Functional Materials programme projects. In addition to their own funding, the micro and small companies of the Programme have attracted direct investments of over EUR 60 million during the programme duration. A large part of the investments are foreign direct investments. The first case is Beneq, a supplier of production and research equipment for advanced thin film coatings – including dedicated coating equipment for barriers and transparent conductive oxide (TCO) for solar cells, OLED

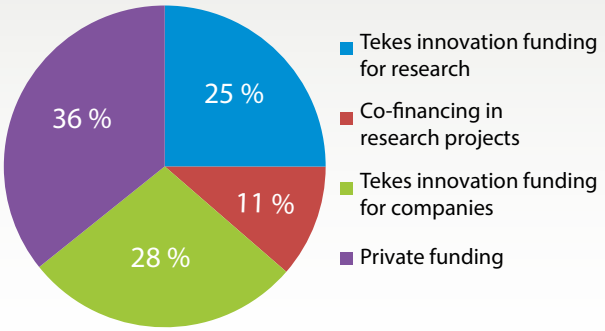


Figure 4. Tekes innovation funding for enterprises (28 %) and research organizations (25 %) as well as the organizations' own contributions (36 % and 11 %, respectively) for all Functional Materials projects (2007-2013).

displays and the lighting industries. In 2011, Beneq raised EUR 9 million from Danish Via Ventures and Finnish Industry Investment Ltd. In 2012, Russian Corporation of Nanotechnologies, RUSNANO, invested EUR 25 million in the company. The second case is Carbodeon, Enso Holding Ltd [Guernsey], which acquired a majority of shares in Carbodeon Ltd Oy and made a significant equity capital injection into the company in 2010. The total amount in the agreement package is several million Euros. The third case is Canatu Oy, a nanotechnology company that commercializes carbon nanomaterial thin films for the electronics, optics and energy sectors. The company announced in March 2013 a USD 9 million (ca. EUR 6.7 million) equity investment led by Troika Ventures with participation from the existing investors Inventure Ltd. and Infosto Ltd. This was Canatu's third investment round since 2007 and brought the total equity investment in the company to USD 15 million (ca. EUR 11 million). The fourth case is Picodeon, Enso Holding Ltd, which also made a significant investment in Picodeon Ltd Oy. The total amount in the agreement package was EUR 2.5 million (published in 2012).

Materials production requires long-term investments and involves a high failure risk. Sharing risks is characteristic for all Tekes innovation funding. This means that Tekes is prepared to accept greater risks than other funding organizations. All investments involve risks, including potential loss of principal. Tekes funds risk-intensive projects that create new know-how and innovations. A promising business may encounter unexpected challenges and obstacles rapidly and dramatically, due to factors affecting individual companies, particular industries or sectors, or general market conditions. European Batteries Ltd. (founded 2003) joined in the Functional Materials programme in 2007 to develop rechargeable lithium-ion based prismatic cells and battery systems. In early 2011, European Batteries received in a directed issue a total of EUR 13.7 million. The company has used at least EUR 75 million for battery development and construction of the plant. In 2013, the company was declared bankrupt after failing to collect new investments of around EUR 20 million. The estimation of losses on the rise throughout the period of operation is EUR 33 million, according to an article of Kauppalehti newspaper.

3.3 Research projects

The Functional Materials programme had a call for universities and research institutes in the years 2008, 2009, 2010 and

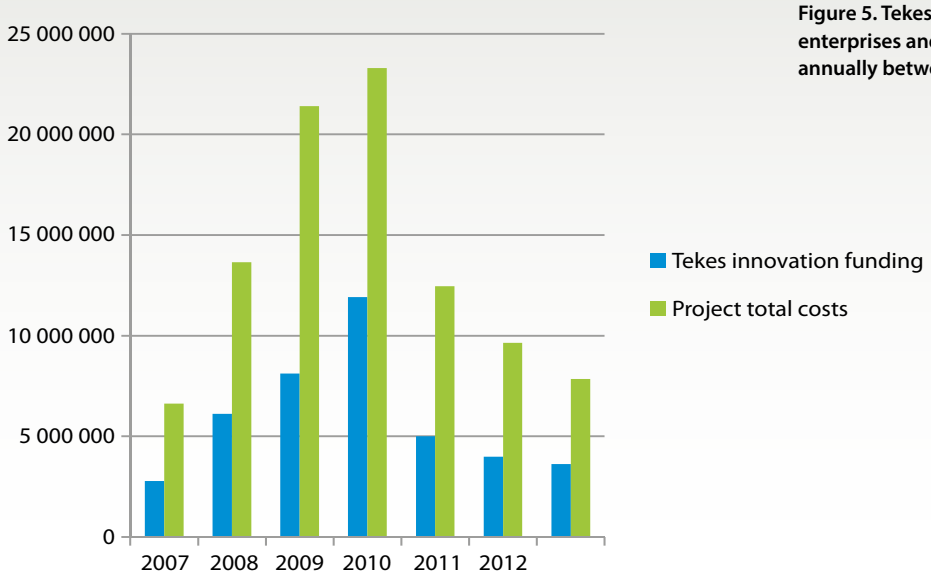


Figure 5. Tekes innovation funding for enterprises and total costs of projects annually between 2007 and 2013 (Euros).

2012. The last ongoing research projects (a total of 22 ongoing projects) will end on 31 December 2014.

The total value of research projects was EUR 54.2 million, and Tekes innovation funding was EUR 37.3 million. Research organizations self-financing was EUR 12.7 million and companies' co-financing was EUR 4.2 million. Typically, the participating companies co-financing varied between 5-10% of the total projects budget. Figure 9 shows the Tekes innovation funding for research organizations and total costs of projects annually (2007-2013). Figure 10 shows co-financing sources for the projects. Table 2 contains a list of the most significant private partners that have financially supported the research projects.

Commercialization of the research results was an important aspect of the programme. The programme has its own commercialization toolkit for the programme's research groups, which is delivered by IP Finland Oy. This service was replaced in 2011 with a new Tekes funding instrument. Tekes allocate specific funding to research that seeks new business opportunities right from the initial idea phase. Ten projects aiming to commercialize research findings got grants of EUR 2.8 million (total cost, EUR 3.8 million) between 2011 and 2013.

Research projects:

- 61 research projects or consortium projects
- Total cost of the projects was EUR 54.2 million
- Tekes grants were EUR 37.3 million
- Research organizations' self-financing was EUR 12.7 million
- Companies' co-financing was EUR 4.2 million
- 535 research group participations (17 research organizations)
- 423 company participations (153 companies)

3.4 Regional distribution of Tekes innovation funding

In Finland, there are four strong well-established industrial sectors for which the development of functional materials is foreseen as enabling renewal of the sector and its business potential and as assisting in finding new positions in the global value chain. These sectors are the metal industry, the mechanical engineering sector, the forest industry and the energy industry. Finnish companies and universities are located mainly in the major cities.

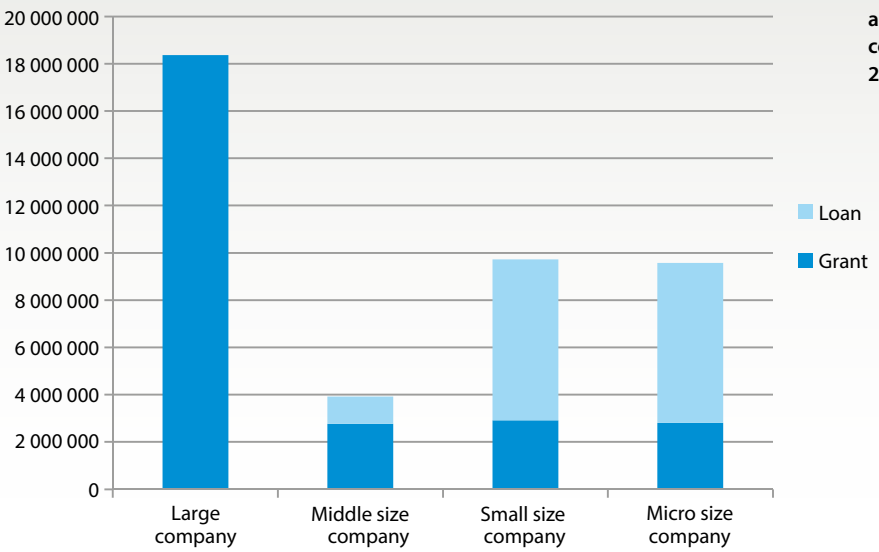


Figure 6. Tekes innovation grants and loans for large and SME companies between 2007 and 2013 (Euros).

Therefore, it is not a surprise that beneficiaries of Tekes innovation funding are also located in these cities. The capital area (Helsinki, Espoo and Vantaa) gained 40 percent of all funding in the programme (Figure 11).

The total funding of EUR 6 million from the European Regional Development Fund was channelled throughout the programme to support ten public research projects in eastern Finland. Research in smart active materials, continuous Atomic Layer Deposition (ALD) process and optics are examples of the research topics.

3.5 International collaboration

From the beginning of the Functional Materials programme, international cooperation was recognized as an essential requirement to gain benefits from the public investments. For this reason, the building of international visibility, networks and a framework for long-term cooperation was emphasised in the programme's operations.

Both company and research projects included international collaboration with many countries, ranging from Australia to Peru. It varied from research mobility to the exchange of information. International collaboration was made with 40 foreign countries. The top ten countries were Germany, USA, Sweden, Japan, UK, China, the Netherlands, Switzerland, Italy and France. Research mobility was one criterion for the approval of research project proposals. Research mobility to and from Finland increased to a level of 42.5 person-years: 18.0 person-years to Finland and 24.5 person-years from Finland (Figure 12).

The programme participated in the European cooperation networks MATERA, MATERA+, and M-ERA.NET. A total of six MATERA projects and three M-ERA.NET projects were funded under the programme's umbrella. The costs of Finnish partners in the ERA-NET projects were 4.6 million, and the Tekes innovation funding was EUR 3.2 million. Additionally, the Functional Materials programme was the participating programme from Tekes to organise joint calls together with the Academy of Finland and the Japan Science and Technology Agency (JST). Tekes supported four high-level research projects with EUR 590 000. Collaborative calls with the National Science Foundation (US) were carried out in the frame of the Materials World Network but without Finnish success.

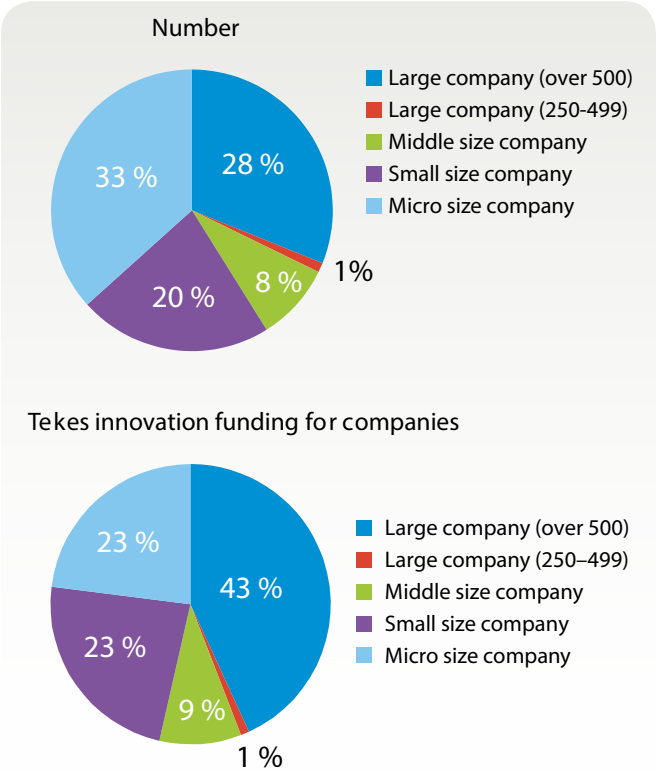


Figure 7. Tekes innovation funding for large and SME companies: (a) number of project type, and (b) Tekes innovation funding for companies (%).

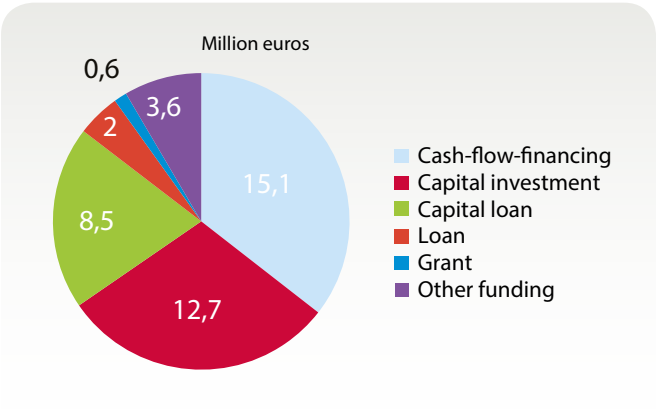


Figure 8. SMEs' self-funding type for the projects between 2007 and 2013 (Euros).

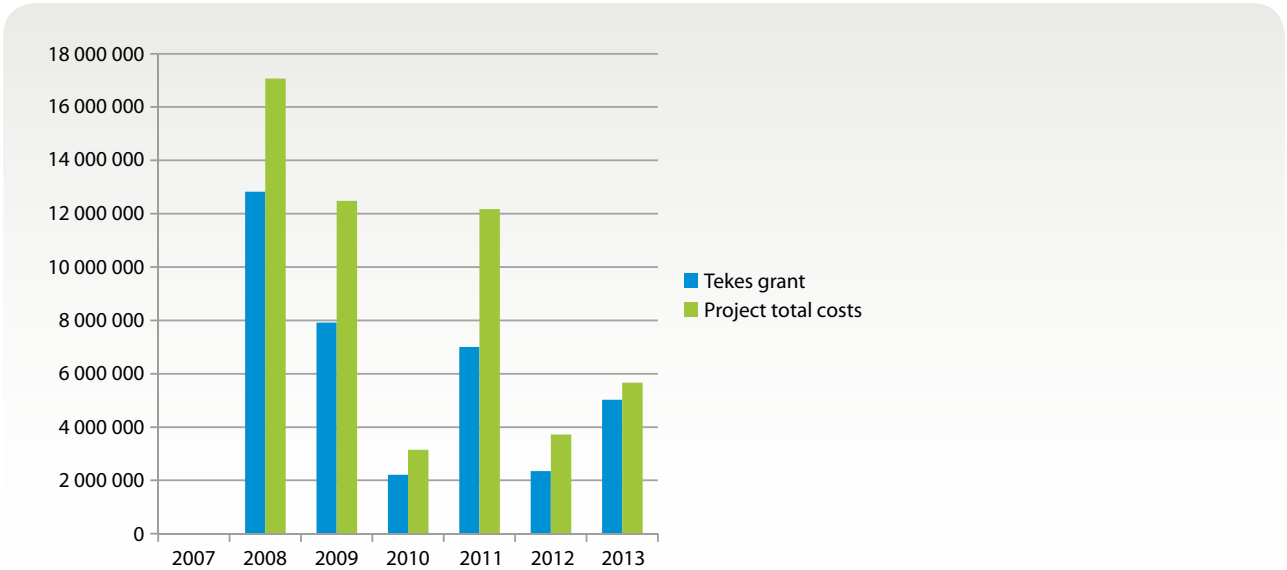


Figure 9. Tekes innovation funding for research organizations and total costs of projects annually between 2007 and 2013 (Euros).

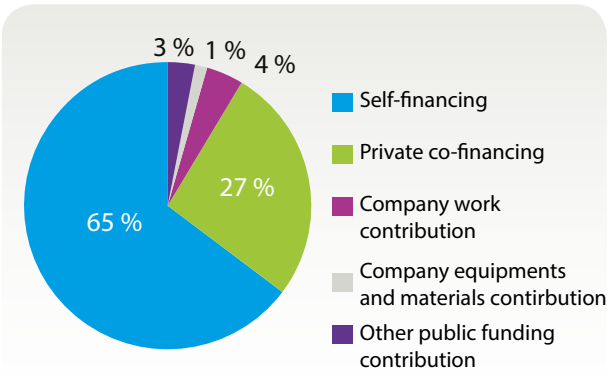


Figure 10. Distribution of the project funding sources – other than Tekes innovation funding in the research projects.

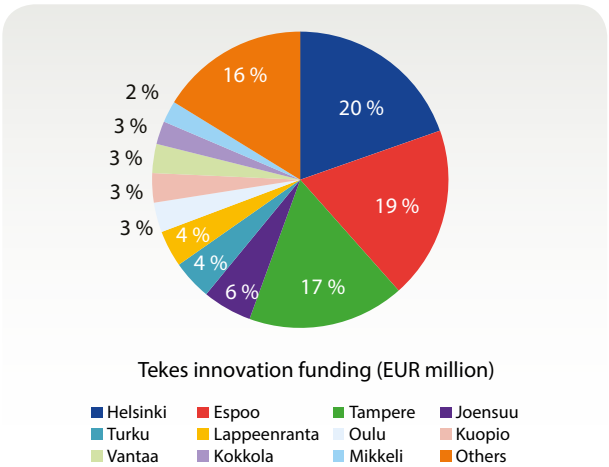


Figure 11. The distribution of the main beneficiaries of Tekes innovation funding. The figure includes both companies and research organizations (Euros).

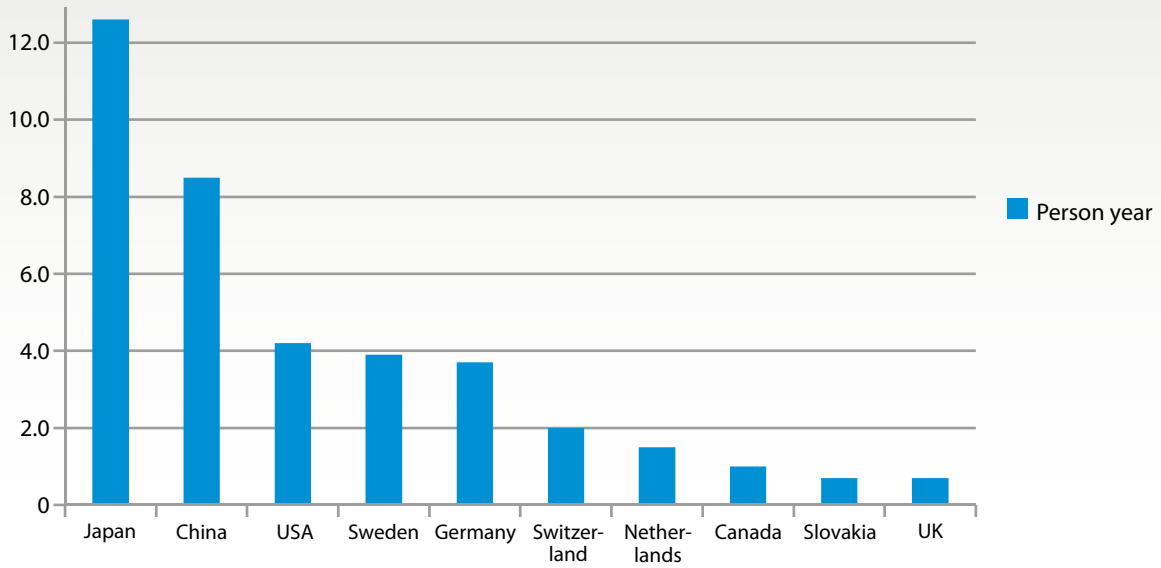


Figure 12. Top ten countries in research mobility in the Functional Materials programme (person-year).

Table 2. The most active co-financers of research projects in three categories. Total private contributions for research projects were EUR 4.2 million.

300 000 < EUR > 100 000	100 000 < EUR > 50 000	35000 < EUR > 50 000
Stora Enso Oyj UPM-Kymmene Oyj Okmetic Oyj Olympus Corporation Fortum Oyj Sachtleben Pigments Oy Rautaruukki Oyj	Oy Panimolaboratorio - Brygger Ciba Finland Oy FibroGen Europe Oy Metso Paper Oy Nokia Oyj ECOCAT OY Suomen Elektropinta Oy Tervakoski Oy Beneq Oy European Batteries Oy Wärtsilä Finland Oy BOREALIS POLYMERS N.V. KEMET Electronics Oy Metsäteollisuus ry Tikkurila Oy	Detection Technology Oy Endeas Oy OMG Kokkola Chemicals Oy Oxford Instruments Analytical Perlos Oyj Rados Technology Oy SAFT Savcor Group Ltd Oy VTI Technologies Oy Teknologiateollisuus - Teknol LUXeXceL Metso Oyj Orion Diagnostica Oy Rahapaja Oy
Sum. EUR 1.11 million	**Sum EUR 0.94 million**	**Sum EUR 0.65 million**

4

The way we did it

4.1 Gathering the materials community together

Material science and technology is a wide field and by nature an enabling technology related to all other technologies and application areas, from biomedicine, packaging, consumer products, and electronics to heavy-duty engineering applications, construction, energy production, etc. Knowing the materials characteristics and controlling the production and processing steps are key success factors in applying advanced materials in any application. One major activity of the programme has been gathering the materials community in Finland widely together. And, this means not only Finnish materials experts from research and industry, but also people working with design, application engineering, and business development – and linking our experts to key players abroad.

4.2 Tailored events and mission trips

Our focused events, ranging from small thematic workshops to larger annual seminars and showcase events, have served as a practical tool to create value networks, thematic mini-clusters, new multi-disciplinary competence networks, and active R&D or business cooperation. Every event has had a mission – a clear target and motivation for people to participate.

Kick-off day

– Brisk start with public promises

For starting projects: presenting target-setting, the research problem to be solved, expected results, possible technologies, and partners needed

Impact Day

– Effective harvesting and exploiting of results

For ending projects: disseminating and selling results, discussing their impact and paths to transfer towards implementation, coaching on commercialization, and next steps

Scientific Day

– Get young stars together, encourage them and let them shine

Bringing young scientists on stage, coaching on communication and presenting results, positive challenging and learning from each other, expanding one's own network (multidisciplinary)

Thematic events

– Boosting specific technologies and applications fields

Disseminating results, building clusters, value chains and new cooperation on a specific theme

Examples:

- Printed electronics – Fostering proof of concept activities
- Solar energy – Integrating new solar technologies in the building sector
- Biomaterials – fostering research to industrial applications

Annual seminars

– Gathering the community, boosting interaction, building the next steps

- showcase events with scientific presentations, posters and concrete results (demos, piloting)
- wide networking for the Finnish materials community
- discussion on selected critical topics, key themes, industrial impact – and building together

Annual Seminar 2010

Exciting and enthusiastic speakers

Prof. H. Fujita, Tokyo University of Technology, VP Anne Stenros, Kone, Prof. Z. Hu, Shanghai University

Recognizing good work

Discussing and challenging each other

Cooperation:

SHOKs, Academy of Finland, Nanocluster, etc.

Annual Seminar 2012 turned into two-day summer festivals

Showing a bunch of results with impact, creating an atmosphere for interaction and a building together spirit

Functional Materials – Four seasons 2013

Boost integration of new technologies with building

11.2.2013 – Wanha Satama, with the Tekes Groove programme

- Recent research highlights and technology developments on solar energy, batteries and capacitors presented and demonstrated.
- Concrete case examples and discussion on the needs and opportunities for built environments.

"Hands on" – from demos to commercialization

22.5.2013 – Startup Sauna, Otaniemi, with Aalto University and VTT Technical Research Centre of Finland

Showcasing and discussing the potential of bio-based materials such as nanocellulose, biopolymers and novel composites for packaging, construction, furniture, consumer products, automotive, biomedical, and electronics.

Fresh science and US cooperation

3.9.2013 – US Embassy Innovation Center, with US Embassy

- Fresh results on materials SCIENCE: biomaterials, tissue engineering, diagnostics, switchable magnetic materials, printed intelligence, graphene, lasers.
- Bringing together a multidisciplinary group of experts, state-of-the art and emerging technologies for generating new scientific knowledge, product ideas and business cases.

Providing key enablers for sustainable future

11.12.2013 – The Circus, with the Academy of Finland

- Key messages, lessons and results overview of the programme (final seminar)
- Result highlights on printed intelligence, coating technologies, energy and material efficient additive manufacturing.
- Snapshots of projects in Programmable Materials programme (Academy of Finland).
- Discussion on next steps: Vision work Material technology 2025, interactive demos and networking session.

Tailored events and mission trips

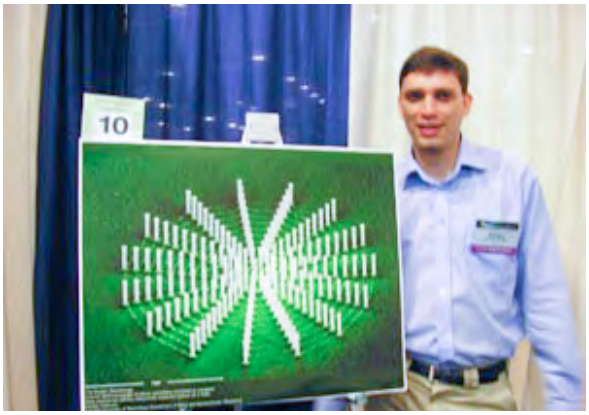
Focused mission trips

- specific theme-oriented delegation trips arranged to sell Finnish core expertise
- bringing participating SMEs and research groups high visibility, the right target audience and potential partners
- arranged in the spirit of Team Finland together with other stakeholders

Examples:

- Flexible and printed electronics to UK 2010, Japan 2012, Korea 2013
- Biomaterials & Printed Functionality Workshop with Japan Science & Technology, Kyoto, 2010
- Biomaterials – Finland-Akron Technology Bridge, USA 2011 and 2013
- Renewable Energy, Clean Technologies and Environment, India, 2009
- Materials Research Society (MRS) Spring Meeting, USA 2009
- International Nanotechnology exhibition & conference (Tokyo Nanotech), 2012
- China Jiangsu Conference for International Technology Transfer and Commercialization & CHINANO Forum 2010
- Europe: EuroNanoForum Dublin 2013 and Budapest 2011, Industrial Technologies, Aarhus 2012

MRS, San Francisco, 2009



Nikolai Chekurov, Aalto University at MRS2009 – Winner of the Science as Art competition

Part of a group visit to Berkeley after MRS (photo Prof. Jyrki Vuorinen)

It´s Great with Britain

ICFPE, Korea, 2013

VTT-Konkuk University Joint session

Case 1: BioFinland Technology Bridge between Finland and Akron, USA

The cooperation between Finland and the Akron area on Life Sciences has been prepared and started with pilot projects during the last five years. The topic of advanced biomaterials has especially attracted the US players to look for partners in Finland. The aim has been to boost business and research co-operation activities to a new level.

Akron has been designated by the State of Ohio as its Biomaterials Commercialization Hub and has long been well-known for high-level expertise in polymer science and technology, including a network of about 3,000 companies.

The Tekes Functional Materials programme has arranged partnering trips in 2011 and 2013 to Akron Ohio's Biomedical Corridor for selected Finnish companies and leading research scientists dedicated to "Biomaterials for medical use", specifically orthopaedics and wound care. This activity has been a core part of the development of the BioFinland Technology Bridge Programme between Akron and Helsinki.

The purpose of the cooperation has been to actively link Finnish business executives and leading research scientists to key players (research, clinical testing, customers and distributors) in the northeastern Ohio area.

Our delegation trips programme offered:

- Presentations from key Akron stakeholders and outside experts designed to educate members of the delegation on doing business in northeastern Ohio and on FDA approval, among other things.
- An individually structured meeting designed to begin to develop specific value-added projects for each company and researcher with experts from the Akron Region.

Mr. Kari Ruutu, Tekes and Akron Mayor Don Plusquellic

Dr. Seth Greenwald, Director of Orthopaedic Research Laboratories

Case 2: Showcase events in Japan, September 2012

"Bringing Printed Intelligence from Roll to Business"

Mission: Promote key offering of Finnish companies and research groups on Printed Intelligence and Photonics to build new R&D and business relations and boost new business opportunities

Three dedicated events in Tokyo led by the Functional Materials Programme

Mikko Nelo, University of Oulu, won the ICFPE poster award

Part of the menu of VTT Technical Research Centre of Finland at the ICFPE Exhibition

High visibility at the ICFPE2012 conference – the key event in the field

We had our own session"Printed intelligence – From roll to products" to highlight the recent advances in the field in Finland focusing on cost and energy efficient roll-to-roll processing, advanced materials and emerging applications. Four companies (Canatu, Beneq, Iscent, Nanocomp) presented their offering regarding novel carbon-based thin films for touch screens, new barrier coatings and process solutions for electronics and solar energy, smart packaging applications, and diffractive optics. The invited research presentations from Prof. Harri Kopola, VTT's PrintoCent and Prof. Ronald Österbacka and Jouko Peltonen, FunMat research centre, Åbo Akademi Univeristy extended the view towards future applications.

In addition, six posters, four exhibition stands (VTT Technical Research Centre of Finland, Beneq, Iscent, and SaimaFlex), and six other Finnish presentations in other sessions supported the mission.

Our own session at ICFPE 2012, "Printed intelligence from roll to products", was a success

From know-how to show-how (Jaakko Raukola, Iscent)

Pre-event workshop for top-notch Japanese companies

"Printed Intelligence & Photonics Workshop – Building Finnish-Japanese Business and R&D Cooperation"
(arranged together with the Nanocluster programme)

- **Invited participants:** 40 key experts from Japanese electronics, optics, packaging, materials, and process companies, as well as selected professors
- **Finnish players on stage:** Beneq, Canatu, Iscent, Nanocomp, Okmetic, Picodeon, Tekes' Functional Materials programme, VTT's PrintoCent, Photonics Finland Cluster, Tampere University of Technology, Lappeenranta University of Technology, Åbo Akademi University and University of Oulu

Our programme provided

- Sharp pitch presentations to show what, poster and demo exhibition to show how, and active networking session to act
- Immediate results: new contacts, next meetings scheduled, business negotiations, business and R&D cooperation started, sample evaluations, joint test runs planned, etc.

Pre-event workshop: Selling, buying and building together

Networking reception at the Finnish Embassy

Hosted by Prime Minister Jyrki Katainen

The event facilitated partnering and deeper discussions between the Finnish participants and their most relevant Japanese guests and gave an important extra dimension to our export activities, in addition to the conference and seminar.

Discussions with the prime minister and a well-known sumo wrestler Baruto-san, was highly appreciated by the Japanese guests.

This set of well-planned and organized events gave our participants (especially SMEs) high visibility and led to excellent results in terms of new partners and practical activities for scientific and business cooperation.


Cross-cultural interaction at the embassy with the famous sumo wrestler, Baruto-san

5
Four cornerstones

5.1 Green from inside

LCA, material and energy efficiency built-in

Global competition for raw materials is fierce. Productive land and clean water are becoming scarce resources, while the demand for biomass is expected to increase. Finland has relatively rich natural resources and a high level of know-how and competencies, which is a good basis for the sustainable and innovative use of resources to secure national well-being. The Tekes strategy emphasizes six content areas expected to play a key role in the success of Finnish enterprises and research. The sustainable use of energy and natural resources, as well as the versatile and responsible exploitation of renewable natural resources, are highlighted as competitive factors in building a sustainable economy for businesses, offering diverse opportunities both in Finland and abroad. Four priorities in the area are:

- Energy and raw material efficiency
- Renewable energy solutions
- New forest and biomass solutions
- Sustainable solutions for mineral resource use and water consumption

Traditional definitions of natural resources often focus on raw materials. They highlight the following three key points: the existence of natural deposits, being of value to people and consisting of exploitable material. In new definitions, the commercial and exploitative perspective is supplemented by environmental impact.

These focus areas are reflected throughout the Functional Materials programme. Materials and energy efficiency and life-cycle thinking are elemental issues and the starting point in our research projects.

Material efficiency means that products and services are produced competitively with a smaller material input, so that harmful impacts are minimized throughout the product life cycle. Efficient use of materials also generates significant cost savings. Understanding the overall environmental impact of a product during its whole life cycle is important in making good choices of functional materials early on. Today, the consumption of materials in industrial countries is around 31-74 tons per capita. Sustainable functional materials and efficient, additive manufacturing technologies will play a key role in reducing this figure and making full use of materials.

Life-cycle thinking and life-cycle analysis (LCA) methods are already utilized today by big responsible global companies. LCA has been understood as an important tool, not only to be utilized in marketing ("greenwashing" in worst cases), but as a necessary element in product strategy. A careful analysis of the environmental impact of a product throughout the supply chain ("from cradle to grave") can find risky raw materials, process stages, partners and bottlenecks regarding energy consumption, but it can also reveal the potential for remarkable cost savings, which should interest every company.

However, the methodology is generally still underutilized, partly due to complexity (several methods, lack of input data, required know-how) and lack of knowledge in the companies. The FINLCA project was set up in the Functional Materials programme to gather together the main Finnish research units and a wide industrial steering group with the aim of simplifying the LCA methodology and bringing it into practical use more widely in Finnish industry, especially SMEs. Taking life-cycle thinking already as part of the R&D phase (of materials, processes, products) is necessary and will be a key competing factor for companies in the near future. Together with the FINLCA group, we have raised awareness through workshops and articles and inbuilt LCA as a concrete part of our recent research projects.

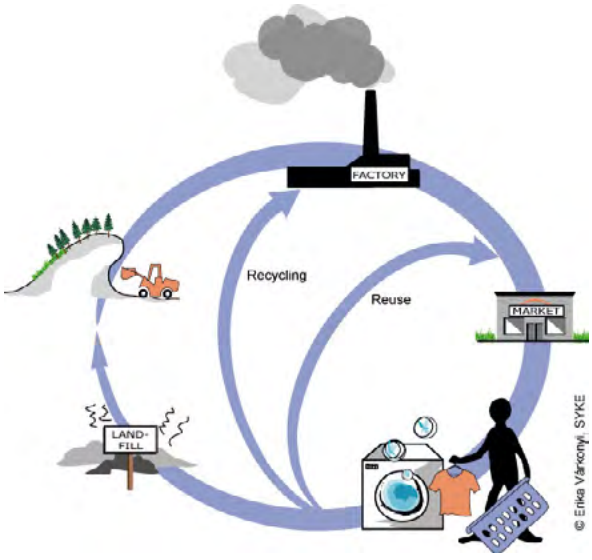
Case FINLCA project

Life-cycle management brings environmental benefits and cuts costs

The aim of the FINLCA project (coordinated by Dr. Riina Antikainen, Finnish Environment Institute, www.syke.fi) was to improve the use of life-cycle management in companies. Life-cycle Assessment (LCA) and other life-cycle management tools are generally well-known and relatively widely applied in large companies. The challenge is to encourage more small and medium sized companies (SMEs) to apply these methods to help improve their environmental performance and also to cut direct costs.

The FINLCA project produced information on the applications of life-cycle thinking and the use of life-cycle methods, including case studies and methodology development. The theoretical part focused on the recent development in life-cycle impact assessment methods and uncertain analysis, and on how to use process technical methods in the LCA context. The study provided an overview of how life-cycle methods can be used to support long-term work in companies, i.e. determining strategy and supporting operative activities. In order to apply life-cycle management in the everyday situations of society, the life-cycle methods should be considered as support tools for eco-design and strategic decisions in companies. The case studies included new metal materials; utilization of waste and by-products from the viewpoint of industrial ecology; the impact of biomaterials on land-use; the life-cycle management of construction; and the challenges of the paint industry. Finally, several recommendations on how to apply life-cycle methods and take different aspects into account in their application were presented in order to improve know-how for conducting life-cycle thinking in Finnish society.

As an example, the case study of new metal materials revealed that use of new, lighter materials in a semi-trailer's tank reduces 8% of total greenhouse gas emissions, and saves fuel worth EUR 50 000 during a five-year use period. A more durable product is profitable for the customer. This type of assessment using life-cycle tools provides companies a solid basis for an environmental assessment of their products and services and a competitive advantage in marketing and communications with customers.

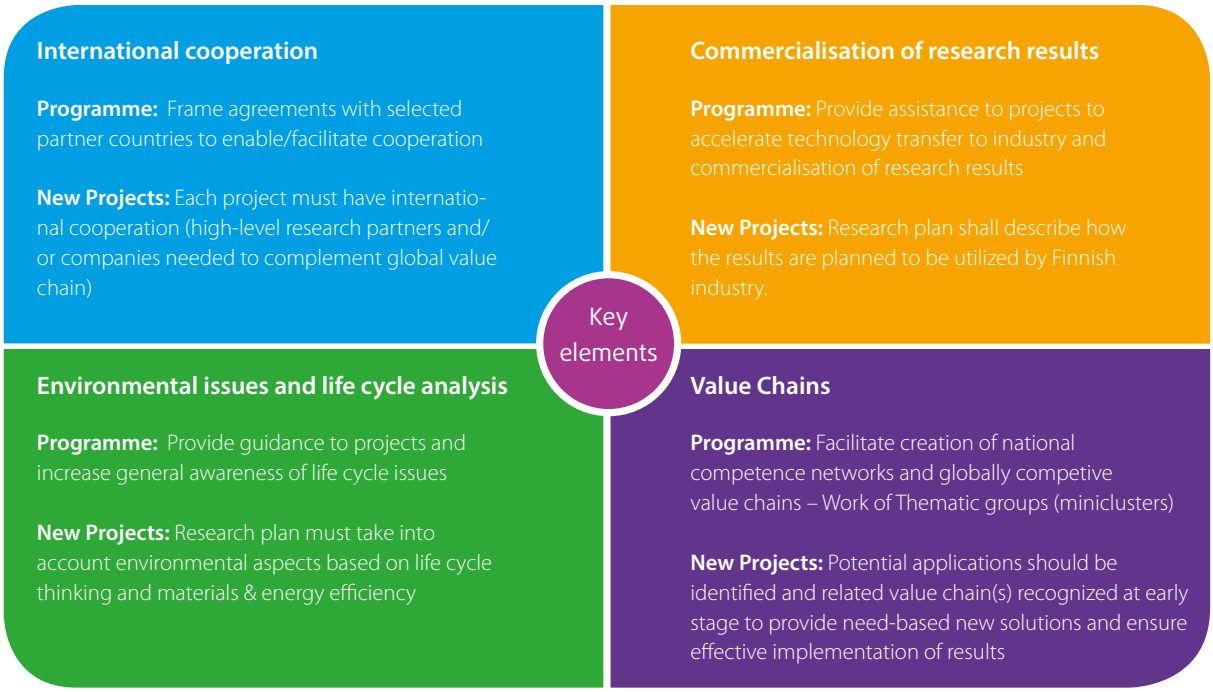


5.2 From deep science to real business

Value chains and Commercialization

Advanced materials and manufacturing is expected to provide the critical enablers to overcome the great challenges our society is facing related to renewable energy, environment and well-being. These key enabling technologies are also highlighted in the Horizon 2020 framework programme. The Functional Materials programme has driven focused application-oriented R&D on materials and nanotechnology to create new solutions for several application areas such as biomedical, renewable energy and novel manufacturing technologies. The broad portfolio of 56 multidisciplinary research consortia projects and about 100 company-driven R&D projects has already provided a variety of unique scientific results and significant industrial novelties with a potentially high impact on business in the near future. Our active events have been an important tool to speed up technology transfer from research to industry and to build new multidisciplinary cooperation, both for research and for business.

The programme has fostered the development and partnering of the key players closely together in selected areas like printed electronics, biomedical applications and solar energy. The seed for these competence clusters was laid in the vision work of the thematic groups. Value-chain thinking has been emphasized and extended from company activities to research cooperation. When building new R&D projects, end-user needs are taken into account and product value chains are recognized to find the most critical research areas and opportunities. Including the right international partners is elemental for each project to form a world-class research consortium capable of transferring the results towards real applications. Today we have an active multidisciplinary network of specialists from different fields in academia and industry working closely together, which is also an asset for the future.



5.3 Born global

International cooperation

Building target-oriented international cooperation, both on a research and a business base is an essential part of our actions. Every research project has relevant foreign partners in the consortia, and international cooperation is active. Tekes has also made frame agreements with some countries to facilitate research cooperation. We have had joint calls with Japan Science and Technology Agency (JST) and the Academy of Finland, which has enabled high-level research projects regarding printed electronics, battery materials and tissue regeneration. Similar mutual activities have been realized with the Ministry of Science and Technology of the People's Republic of China (MOST) and the U.S. National Science Foundation (NSF).

The programme has actively boosted results sharing and partnering through specific events and mission trips serving both research and industry. We have helped "selling the results" of several active SME companies who have developed new technologies in the programme. It is great to see that today we have a generation of new SMEs who are born global – building their activities as part of global value networks entering highly competitive markets. The right mindset, partners and know-how created through the R&D projects are key enablers.

FACTS regarding Finnish participation in EU FP 7

- Nanosciences, Nanotechnologies, Materials and new Production Technologies (NMP)
- Success rates ca. 30 %
- Applicants in retained proposals: 255
- EC financial contribution in retained proposals to applicants: ca. 103 MEUR
- Participants: 261; SME participants: 59
- EC financial contribution for applicants: ca. 92 MEUR
- EC financial contribution to SME participants: ca. 16 MEUR

European collaboration:

Today Europe is the most important area for Finnish export and international research cooperation. The Functional Materials programme has promoted activities to increase and utilize European R&D cooperation more effectively. Information on the EC framework programmes has been actively distributed, and Finnish companies and research organizations have been encouraged to participate in FP7.

ERA-NET frames have been the main tool in the Functional Materials programme to activate Finnish enterprises and research groups to get into closer cooperation with selected European partners. ERA-NETs are EC co-funded projects where national and regional funding organizations aim at increasing cooperation between national programmes and strategic activities and decreasing the fragmentation in Europe. The Functional Materials programme has participated annually in the calls organized by MATERA, MATERA+, and M-ERA.NET.

As a result, there are 19 European projects with Finnish partners launched in these calls. All together, EUR 7.5 million in public funding will be distributed via Tekes to 29 Finnish companies and research organizations in these ERA-NET projects.

Examples of projects:

Functional nano- and microporous carbon based coatings for tools and components

- Partners: Aalto University (Finland), VTT Technical Research Centre of Finland, DIARC-Technology (Finland); Institute of Science and Technology for Ceramic Materials, National Research Institute (Italy), Wolframcarb S.p.A (Italy), and Utensili Filettatori Sparone UFS (Italy)

Regenerative biofilm sensors

- Partners: VTT Technical Research Centre of Finland, Aalto University (Finland); CREST, Centre for Research in Engineering Surface Technology (Ireland), Trinity College (Ireland), and STREP (Ireland)

Novel inorganic inks for hybrid printed electronic demonstrators

- Partners: University of Oulu (Finland), Jozef Stefan Institute (Slovenia), Institute of Electronic Materials Technology (Poland), and NOF Corporation (Japan)

5.4 Bringing technology alive and tangible

Communication is the key

Scientific articles in highly respected journals and presentations in relevant conferences are the most natural ways of communicating for the researchers. Of course, this is also the way our research projects make their contribution to the scientific community.

However, in today's world, it is important to be able to share relevant messages with a wider audience in an understandable manner to get other people interested in your work and results. And, there may be many different parties needing this information: other researchers (for starting new multidisciplinary cooperation), industry and business people (for exploiting the results, finding new partners, and recruiting competent people), your own research partners and boss (to understand the real meaning), funding authorities (to see the impact of the R&D investment), investors (looking for possible pearls) and other readers (general picture).

We have put a consistent effort in the programme to systematically prepare and bring articles to the Finnish professional media about the main research themes, fresh research results, scientific novelties, industrial success stories, new start-up companies, active SMEs, international activities, etc. In addition, the Functional Materials monthly newsletter (about 2,000 subscriptions) and Web page have been actively providing news, press releases, success stories, event materials, etc.

In our events, we have been mostly favouring short and sharp presentations to make the messages clear and interesting to the audience (typically 7-10 minute pitches focusing on "What/Why/So what?"). Before some events, the speakers have been coached on presentation skills. In addition, the considered words and attractive pictures (said to be worth 1,000 words) have been supported by tangible objects (surely worth 10,000 words) showcased in the interactive demo sessions to promote active discussion and utilization of the results achieved.

Take a look

Articles, Success stories, Seminar and workshop materials

www.tekes.fi/toiminnalliset-materiaalit-aineistot/

Vision "Stories from the future" (animation)

www.youtube.com/watch?v=wfNvjySHqYk

Result videos of Vivoxid, Canatu, Aurubis Finland, Matox

www.youtube.com/playlist?list=PL4DD1F1FACCE5A4C9&feature=mh_lolz

Energy efficiency

Photo: VTT

Flexible electronics

Biomedical

Photo: Esa Kyyrö

Design & performance)

Making headlines

6
Key themes & result highlights

Novel materials for energy technologies

Solar energy – harvesting both heat and light

Energy storage

- Enabling technologies for photovoltaics
- Market-ready solutions for solar-thermal
- Building a value-chain for batteries (R&D and business)

Advanced manufacturing – energy efficiency and high performance

Printed intelligence

Coatings

- Energy, material and cost-efficient industrial-scale manufacturing
- Critical enabling technologies for flexible and organic electronics as well as solar cells

Biomaterials

Bio-based materials – from nature to industrial applications

For medical applications – Human spare parts

- Focused spearhead research projects resulting in top-notch solutions for bone and soft tissue regeneration
- Nanocellulose, novel biopolymers and composites

Functional materials – there is still room for development at the bottom

- Creating a solid basis for the next big thing
- Graphene, 3D optics, hybrid materials, etc.

6.1 Solar energy – harvesting both heat and light

Solar energy is the key to solving global energy challenges. Each year, over 1,080,000,000 terawatt hours of solar power shines on the Earth – about 60,000 times the current global electricity use. Today, the solar energy field is hot, both in terms of research and practical operations, but still more efficient and robust solar cells and thermal collector systems are needed. We have boosted R&D by effectively utilizing specific know-how on coating technologies. This has already brought several significant novelties in R&D and industry.

Solar-thermal collectors – taking the heat of the sun into use

Architecturally integrated solar thermal copper façade

Aurubis Finland Oy

Aurubis has developed a novel solar thermal system called Nordic Solar, which is based on prepatinated copper and copper's ability to transfer heat extremely efficiently. Nordic Solar can provide solar heat in buildings, where architectural and aesthetic appearance demands subtle and invisible solutions. Impact: Nordic Solar can be fully integrated architecturally into different copper facades and roofs. It alloys a variety of forms, sizes, and patinas and gives the architect and constructor much wider opportunities than conventional solar thermal collectors.

A premium example of this system is installed on the new public swimming complex in the City of Pori, Finland. The total of 1,000 m² of prepatinated copper façade includes 80 m² of Nordic Solar collectors invisibly hidden in the façade. Additionally there are flat plate solar thermal collectors and photovoltaic panels on the roof of the building, making it the single largest solar energy building installation in Finland. Aurubis Finland Oy is part of the Aurubis Group, which is the leading integrated copper producer and the largest copper recycler in the world. In Pori, Finland, the company employs about 200 people out of the group total of 6,300.

Contact: Mr. Ari Lammikko, Sales Manager, Aurubis Finland Oy, www.aurubis.com/finland


Photo: Esa Kyyrö

The most efficient collectors are born in Finland

Savo-Solar Oy

Although a newcomer to the solar industry, Savosolar has already carved out a place for itself in the solar thermal industry, creating the most efficient absorbers and collectors in the market. This can be achieved thanks to a patented highly selective coating and advanced absorber designs. The annual energy yield from Savosolar collectors can be over 20% higher than using standard absorber technologies.

The fast-growing Finnish company is going further, providing heat for large district plants and elegant architectural solutions. The key to success: a unique product range where only the highest quality meets efficiency. Savosolar is the only company in the world capable of coating complete large area absorbers up to 18 m² with highly selective optical coating.

This year, Savosolar and its customer, Ruukki, launched the first fully integrated solar thermal roof for family houses. At the same time, Savosolar provided its thermal collectors to the German construction company, FASA AG, to create ENERGETIKhaus100®, a solar house where almost 100% of the hot water and heating demand is covered by solar thermal energy.

Savosolar, with headquarters in Mikkeli, Finland, currently supplies customers across Europe as well as in Japan and South Africa and is actively expanding its footprint in the markets.

Contact: Mr. Jari Varjotie, CEO, Savosolar, www.savosolar.fi

Fully energy autonomous solar house in Germany, ENERGETIKhaus100® autark, with Savosolar large area solar thermal collectors.

Solar-thermal collector systems for the far north

PolarSol Oy

PolarSol Oy, founded in 2008, produces stand-alone heating systems utilizing unique heat exchangers made of ultra-thin stainless steel by cold-forming. Today the Polarsol system is the world's only fully automated system utilizing all alternative sources of heat in a building's heating, covering up to 100% of the demand for heat, cold and hot water all year round. Given that in the Nordic countries, up to 80% of energy consumed in a building is spent on heating and hot water, the proposed system solution by Polarsol is very important. The system is scalable and can be applied in private housing construction, in apartment buildings, and at industrial installations (industrial premises, warehouses).

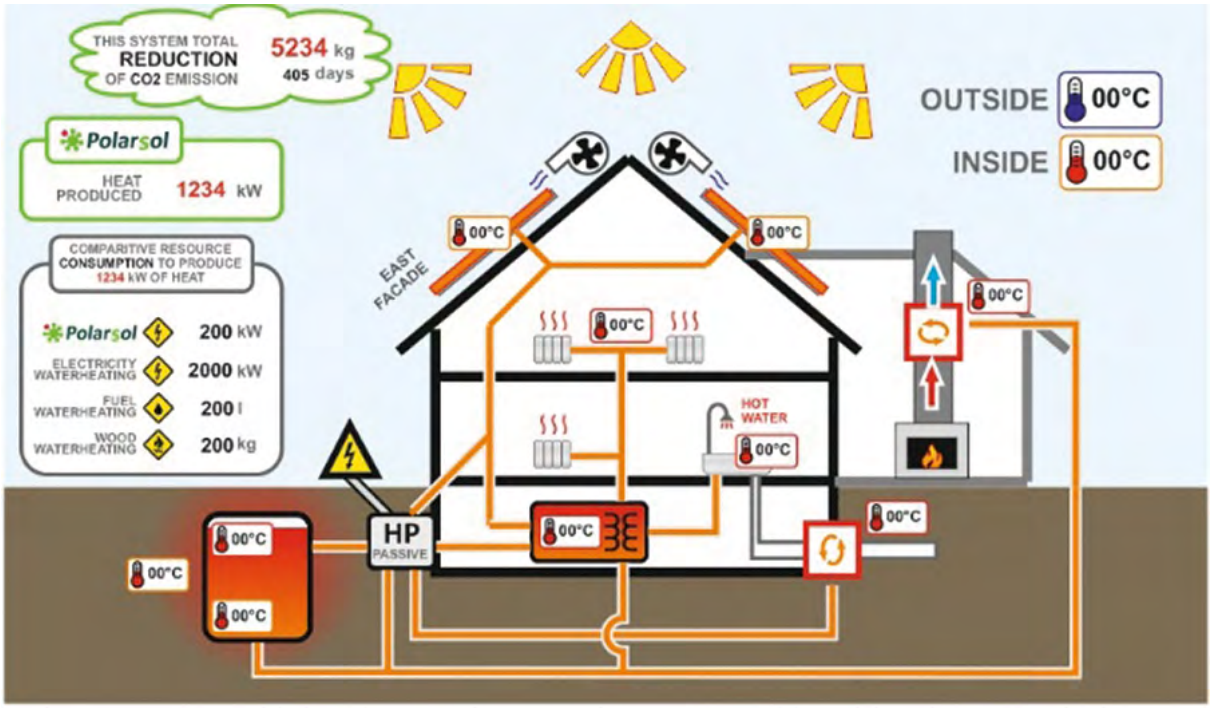
The system is energy-efficient:

- absorbs and stores heat from the sun effectively,
- absorbs the heat of atmospheric air in the absence of direct sun,
- returns up to 50% waste heat (ventilation and drainage),
- can collect waste heat from other sources (stoves, fireplaces, saunas, etc.), and
- can even work in cooling mode when it still produces hot water.

And cost effective:

- 5-7 times more cost-effective than electric heating in operational costs,
- up to 2 times more cost-effective than pellet heating (depending on the quality of the pellets), and
- fully autonomous, fire-resistant, long life span (up to 25 years).

Contact: Mr. Anton Serbin, CEO, PolarSol, www.polarsol.com



PolarSol solar-thermal heating system

Materials for metallic energy roof

Building integrated solar energy

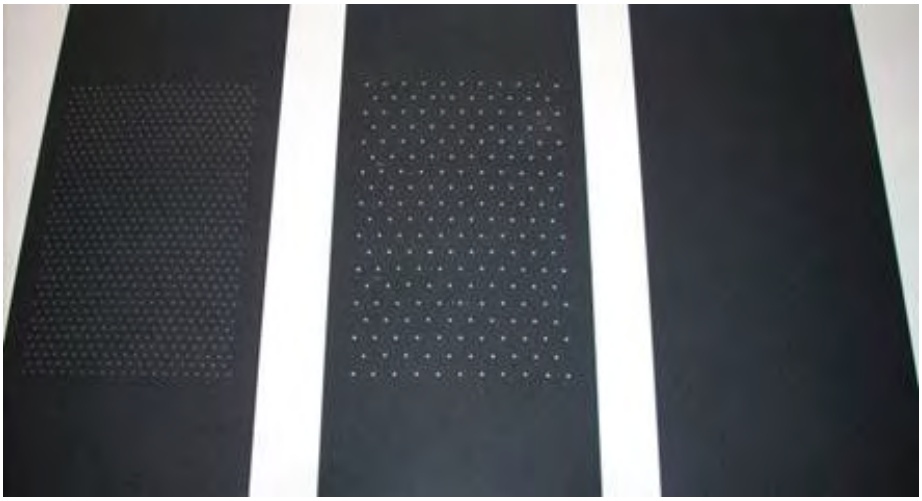
Direct utilization of solar energy is in key role when zero-energy houses are designed and built. During the last decade solar energy industry has grown dramatically. Increasing interest in renewable energy has created solar markets with exponential growth. The main markets are for non-integrated thermal collectors and photovoltaic panels. However, the interest in building integrated solar energy systems has grown and new approaches have been introduced. The fully building integrated solar energy systems provide material savings, since the energy system is part of the construction.

Integration of solar thermal or photovoltaic system on a thin steel or copper plate requires composite structures consisting of different types of materials. Combination of metallic, polymeric, and semiconductor materials is often challenging due to potential compatibility issues.

This research project was focused to develop functional coatings onto thin metal plates in order to create fully integrated solar thermal collector and thin film photovoltaics. The essential outcomes from the project were absorber for unglazed thermal collector and prototype of a silicon thin film solar cell on polymer coated steel plate.

The developed selective coating for thermal absorber showed enhanced performance compared to their commercial counterparts. In addition, control of mass transfer in the unglazed thermal collector was found to increase yield of heat that is interesting in relation to solar assisted heat pumps. A working laboratory scale prototype of a thin film silicon solar cell was prepared onto polymer coated steel thin plate. Further development of these material solutions may open opportunities for fully building integrated solar energy systems.

Contact: Dr. Eero Haimi, Aalto University and
Dr. Tommi Vuorinen, VTT Technical Research Centre of Finland



Termal absorber plates for an unglazed thermal collector prototype

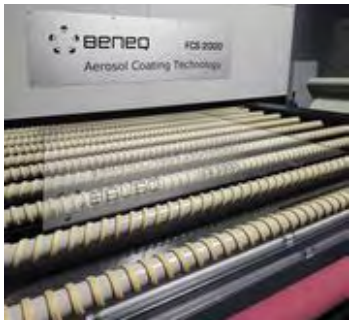
Company projects for photovoltaics – Critical coating technologies:

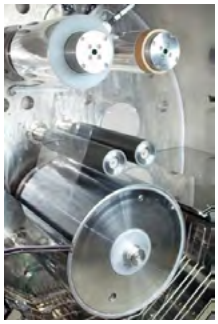
Transparent conductive oxide TCO coating technology for solar cells

Improved efficiency of thin film solar cells is enabled through transparent conductive oxide (TCO) coated glass. Beneq has developed its aerosol coating technology nAERO® into an industry-proven coating method for advanced thin films and large-scale production. (Read more on page 58.)

Dense, pinhole-free barrier layers for flexible photovoltaics with Roll-to-Roll Atomic Layer Deposition (ALD)

ALD provides completely conformal, dense and pinhole-free barrier layers against moisture and contamination, which are crucial for the performance and lifetime of organic photovoltaics. Beneq has developed the first real industrial-scale ALD equipment to make high-performance devices cost-effectively. (Read more on page 59.)



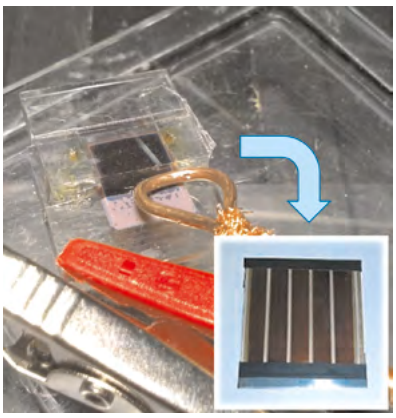


Dirt cheap printed flexible dye solar cells without transparent conductors

You've probably heard about cheap nano solar cells developed as an alternative to silicon cells, but did you know that they are almost always made with silver, gold or some other rare and expensive materials like indium tin oxide? Actually, even silicon solar cells use a fine pattern of printed silver lines to conduct current out of the cell with minimal resistive losses, while passing most of the incident light to the underlying silicon wafer. The transparent conducting oxide (TCO) coating, used whenever silver lines are not an option, is one of the biggest obstacles to lowering the manufacturing cost of solar cells.

Our project aims to solve this problem in the case of dye-sensitized solar cells (DSSC) by replacing the expensive titanium foils and indium tin oxide (ITO) coated plastics, used in commercial DSSCs, with cheap stainless steel foils and non-transparent metallic conductors. Using the so-called back-contact design, we hide all electrical conductors behind the cell's light absorbing layer, which completely removes the need for transparent conductors. Dealing with challenges related to corrosion, printability and chemical stability of materials, we are building a stable, efficient, TCO-free and flexible sub-module prototype using techniques suitable for roll-to-roll production.

Contact: Dr. Janne Halme, Aalto University School of Science, Department of Applied Physics



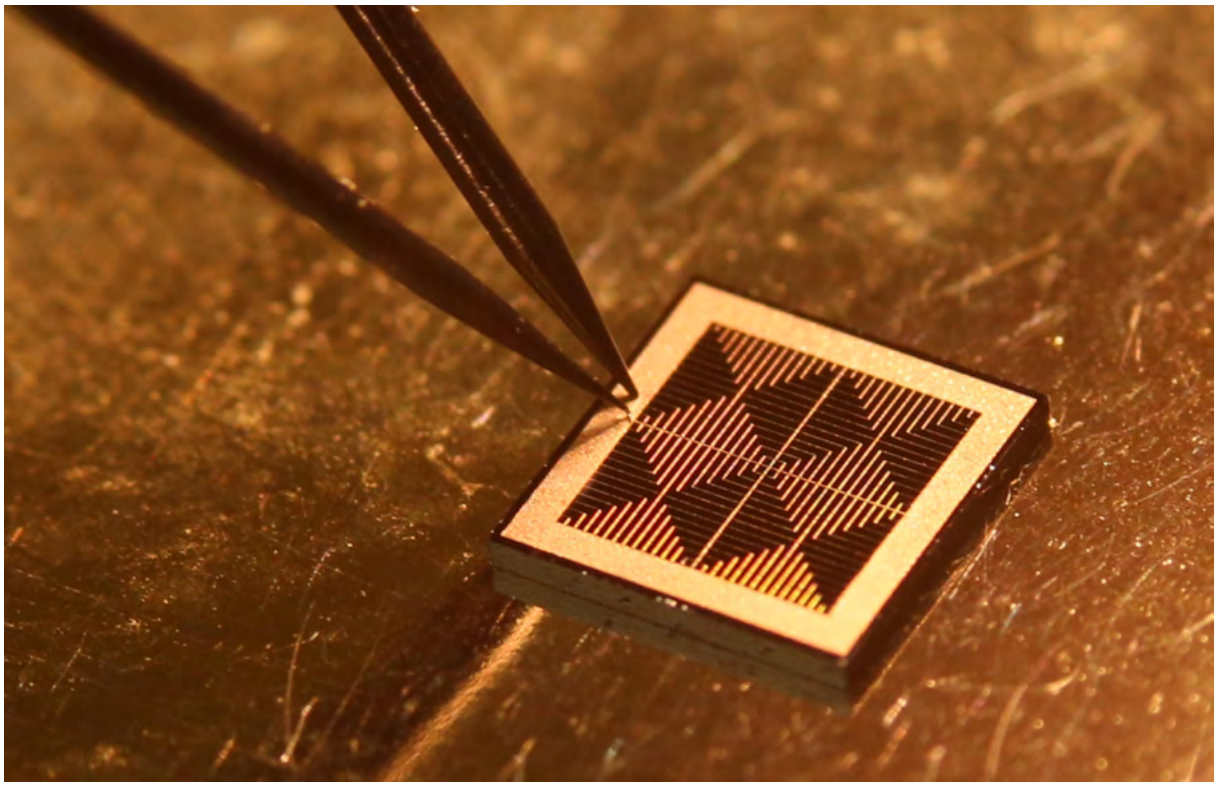
Demo of monolithic back-contact dye solar cells. The goal is to realize a 10 x 10 cm2 sized sub-module prototype using printing and deposition techniques suitable for roll-to-roll production.

Advanced III-V semiconductors for multi-junction high efficiency solar cells

The Solar III-V project (2009-2012) laid the foundation for a strategic research direction in Finland focused on the development of high-efficiency solar cells based on novel III-V semiconductor compounds. The work was carried out jointly by the Optoelectronics Research Centre (ORC) at Tampere University of Technology, Aalto School of Science, and University of Turku, with financial support from Tekes and four industrial partners. The main goal of the project was the development of novel compound semiconductor heterostructures incorporating nitrogen (i.e., InGaAsN), which efficiently absorb the solar radiation at around 1 eV spectrum. When used under concentrated illumination, these materials are instrumental for boosting the conversion efficiency of multijunction solar cells above the 40% level.

They also render possible important opportunities for the development of next-generation satellite solar cells. The main outcome of the project was the demonstration of high-quality GaInNAs junctions generating more than 12 mA/cm² for normal terrestrial illumination. This demonstration promoted ORC at the frontier of developing novel III-V materials for high-efficiency solar cells in Europe. Current research that spun out from Solar III-V aims at advancing GaInNAs technology by demonstrating new fabrication approaches that would provide routes for practical applications.

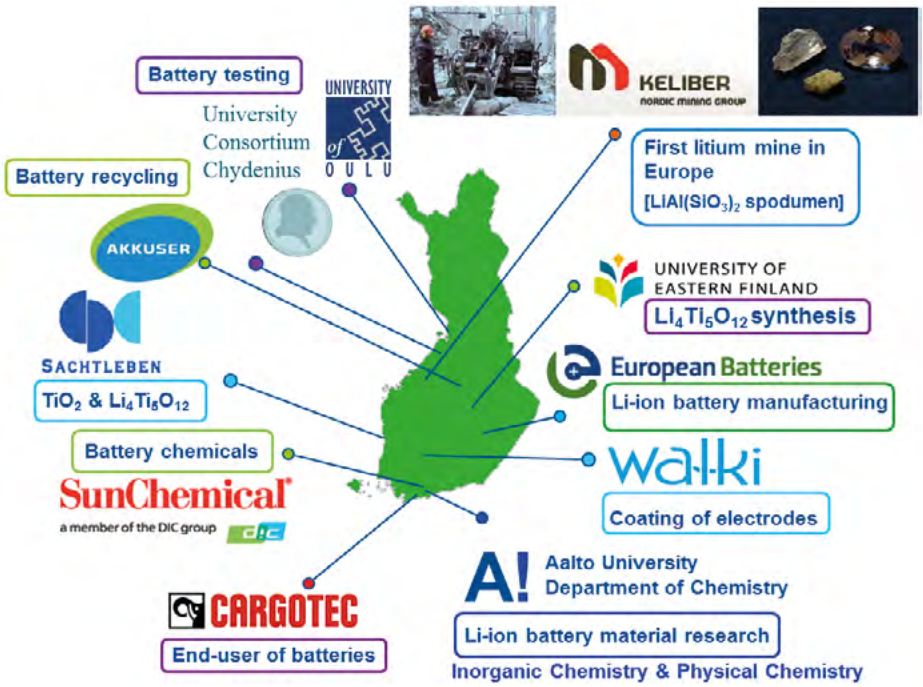
Contact: Prof. Mircea Guina, Optoelectronics Research Centre, Tampere University of Technology



Processed III-V solar cell under test

6.2 Effective energy storage - Batteries, capacitors and recycling

Effective energy storage is necessary to fully utilize the power of the sun and more efficient novel solar cells. Electric/hybrid cars, consumer electronics and other appliances demand more and more electricity, which has to be easily and readily available. This calls for novel batteries and capacitors that are lightweight, stable and safe, and have high energy and power density. Our battery research serves as an example of a comprehensive effort towards next-generation energy storage covering research on new chemistries for anode, cathode and electrolyte materials and fabrication processes for lithium-ion batteries as well as industrial development of novel battery designs and recycling processes.



Value chain for battery research and business

OMG Kokkola Chemicals Oy (now Freeport Cobalt Oy)

The company has developed next generation cobalt-based lithium-ion battery cathode and precursor materials to respond to the increased need for portable power and especially lithium-ion batteries in different application areas. The development includes battery-testing capability and has led to a significant expansion in production capacity.

Contact: Janne Marjelund, www.freeportcobalt.com

European Batteries

European Batteries has developed large-format rechargeable lithium ion polymer cell technologies for energy, industrial, and vehicle use in close cooperation with international process and component manufacturers. The research on new electrode structures, cell design concepts and new advanced materials has resulted in the industrial implementation of battery cells and systems based on lithium-iron phosphate technology exhibiting high energy density per weight with optimized safety and operational reliability.

Green materials and cost-effective fabrication methods for safe and durable lithium-ion batteries

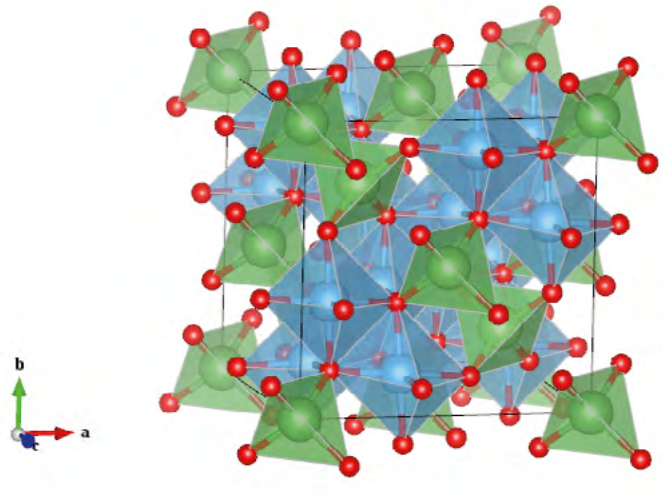
Despite the triumph of lithium-ion batteries as state-of-the-art power sources in consumer electronics, obstacles still exist to displacing currently used energy storages in larger-scale applications (such as electrical vehicles and aviation applications) – but this inherently lightweight technology still exists. For all these applications, the packing of energy in a small volume is of the utmost importance in making lithium-ion batteries an attractive solution. However, concerns still exist about the safety, durability and cost of current lithium-ion batteries. Therefore, research has focused on the development and investigation of environmentally benign materials and fabrication methods for safer and more durable lithium-ion batteries that show high power density.

In NoMaLi and NoFaLi projects funded by Tekes, new materials have been introduced and fabrication methods have been proven in practice for making electrode fabrication of lithium-ion batteries simpler and more cost-effective, as electrodes can now be fabricated without any harmful and potentially hazardous organic solvents and using fewer components and fabrication steps. This has been achieved by replacing traditional additives and electrode materials with novel ones and by developing the three-dimensional electrode structure so that some traditionally used additives can now be discarded. New surface treatments have also been introduced for active electrode materials in order to further increase the safety of the batteries without sacrificing performance. Successful pilot-scale experiments show that these inventions are not limited to laboratory-scale production; they are also important for industry.

The success of the projects has been possible by close collaboration between academia and industry with companies from every level of the value chain – from lithium mining to chemical and battery manufacturers and battery end-users to recycling companies. The project partners located across Finland are presented in the value-chain map.

With the above-described technical achievements obtained in the NoMaLi and NoFaLi projects, the production costs of lithium-ion batteries utilizing safer and more durable materials can be lowered, offering new interesting opportunities for Finnish companies working in the battery field.

Contact: Prof. Maarit Karppinen and Adj. Prof. Tanja Kallio, Aalto University



Lithium titanate anode material: compact structure, stable and fast to charge

Whole life-cycle in our hands – Taking responsibility and the benefits of battery waste

AkkuSer has been collecting and recycling batteries and accumulators from the EU since 2006 in an environmentally sustainable way and on an industrial scale. The proprietary Dry Technology™ is suitable for rechargeable batteries, and it enables a high recovery rate and the reuse of elements such as cobalt, copper, iron and nickel – identified by element, crushed, sorted and supplied to industry as raw material. Recently the company has been developing energy-efficient chemical processing technology for recycling used alkaline batteries. The results promise a significant increase in the recovery of valuables such as zinc, manganese and iron in alkaline battery waste compared to other available technologies. A new spin-off company, Recalkaline Oy, was established to take this technology to the commercial scale. The crucial issue in both cases is that the metals are processed in such a manner that the product can be easily and economically refined by metal producers.

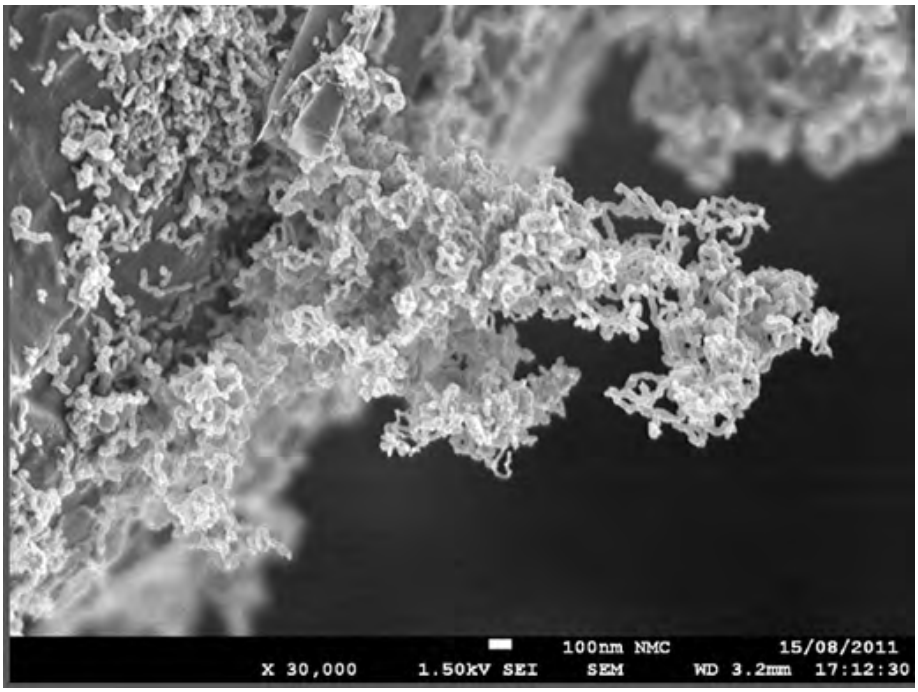
Contact: Mr. Jarmo Pudas, AkkuSer (& Recalkaline)
www.akkuser.fi , www.recalkaline.fi

Recycling of all kind of batteries

High-performance lithium-ion batteries with novel carbon nanomaterials

Carbon nanomaterials such as carbon nanotubes (CNTs) and nanofibers (CNFs) are widely accepted as conductive additives for lithium-ion batteries (LiB) to improve the electrical conductivity of the negative electrodes. However, it is difficult to prevent aggregation of carbon nanomaterials in raw slurry that is prepared in a manufacturing process of the electrodes. Aggregation of the nanomaterials in the slurry results in not only a less conductive connection between active materials (i.e., graphite particles, GPs) but also structural defects in the prepared electrode. Therefore, it is desirable to hybridize the carbon nanomaterials onto the graphite surface to solve the aforementioned problems. We have synthesized carbon nanofiber (CNF) coated graphite particles (GPs) by catalysed chemical vapour deposition CCVD. Both fixed and fluidized bed CCVD reactors were used to grow tailored nanocarbons onto GPs. The effect of the suspension used for the adsorption of catalyst nanoparticles on the graphite surface on the production of CNFs was investigated to achieve high surface coverage of CNFs on GPs. In addition, we produced metallic catalyst nanoparticles in situ during the CCVD via thermal decomposition of metal salt deposited onto graphite particle surfaces. The coverage of CNFs on GPs was quite small in the case of water suspension of catalyst nanoparticles with a hydrophilic surface, while with a toluene suspension of catalyst nanoparticles with a hydrophobic surface, CNFs with almost full surface coverage on GPs were produced after the CCVD process. The electrical conductivity of lithium-ion batteries studied at Toyota Central laboratory was significantly improved when growing nanocarbons on the graphite powder particles surfaces.

Contact: Prof. Esko Kauppinen, Department of Applied Physics and Center for New Materials, Aalto University



Carbon nanomaterials provide wide surface and high performance

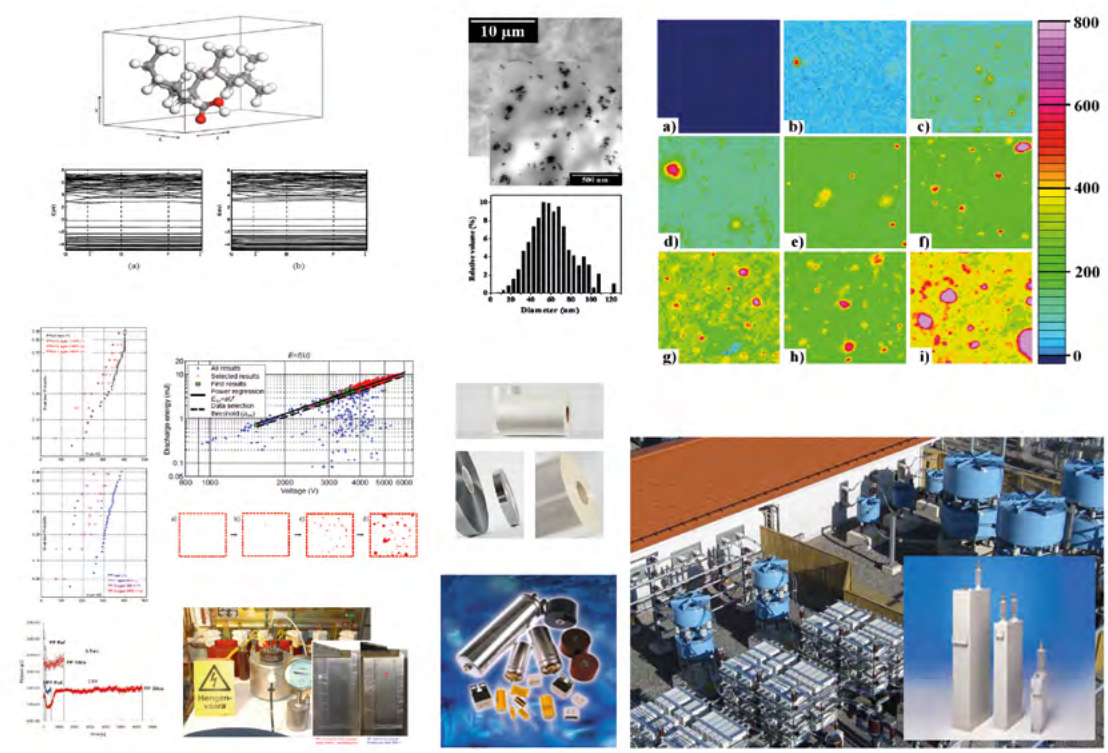
Novel polymer nanocomposites enabling high energy density power capacitors

Project research partners: Department of Electrical Engineering and Optoelectronics Research Centre, Tampere University of Technology; VTT Technical Research Centre of Finland, Process Chemistry, Functional Plastics team; and Department of Chemistry, Nanoscience Center, University of Jyväskylä.

In the projects NANOCOM and NANOPOWER, we have successfully developed methods for designing, manufacturing and characterizing tailored, high-quality polymer nanocomposites with improved electrical insulating properties compared to the base polymer. This goal has been achieved by utilizing advanced tools and resources, ranging from molecular modelling and electronic structure calculation methods to Raman microscopy, X-ray tomography and state-of-the-art electrical testing of both short- and long-term properties, not to forget an extensive knowledge of polymer processing and compounding in the manufacturing phase. The developed materials and manufacturing methods have also been transferred from laboratory up to industrial-scale capable production, enabling the manufacture of actual pilot applications.

Electrical improvements achieved with polypropylene (PP) -silica nanocomposites include improved AC and DC breakdown strength and considerably improved resistance to discharge erosion, while dielectric losses remain lower or equal to PP. Our primary target has been more cost-effective, energy-effective and environmentally better thin film insulation for power capacitors widely used in the electrical and electronics industry, while the developed interdisciplinary knowledge and competence among the research parties extends far beyond this specific goal.

Contact: Adj. Prof. Kari Lahti and Researcher Hannes Ranta, Department of Electrical Engineering, Tampere University of Technology



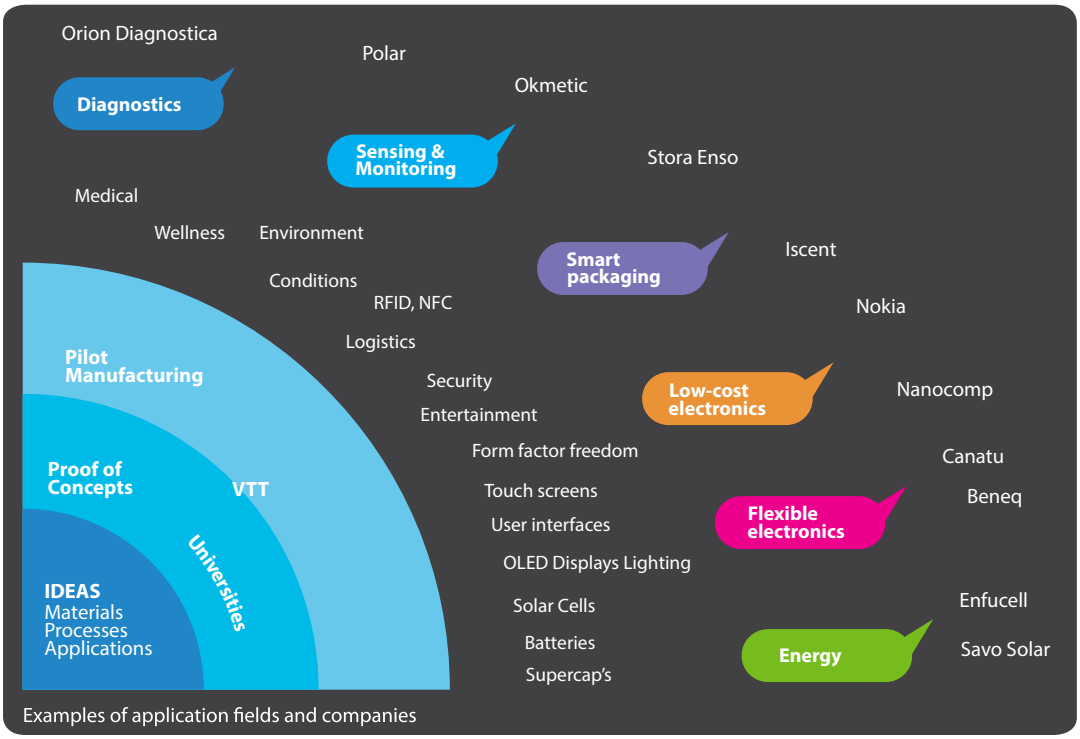
Novel nanocomposites enable miniaturization of power capacitors

6.3 Advanced industrial manufacturing – Energy efficient, roll-to-roll, added value

The Functional Materials programme has driven printed intelligence R&D in Finland, partnering with key players and building target-orientated international cooperation focusing on industrial applications, scalable materials and energy-efficient roll-to-roll processing, proof-of-concept development and creation of business. The key is to combine materials and processing know-how with applications such as smart packaging, diagnostics, organic electronics, organic light emitting diodes (OLEDs), lighting and solar cells. Focused research is conducted at several universities and VTT Technical Research Centre of Finland, which today has excellent pilot-scale manufacturing facilities.

Several SMEs have already transferred their recent research to industrial applications. For example:

- Beneg has developed the first industrial roll-to-roll atomic layer deposition (ALD) equipment, efficiently providing the critical barrier coatings for flexible electronics and photovoltaics.
- Canatu manufactures uniquely flexible, highly transparent, conductive carbon nanomaterial-based thin films for customised touch sensors and formable 3D (three-dimensional) touch modules. This provides a superior alternative to indium tin oxide (ITO), which is brittle and based on scarce natural resources.
- Iscent produces printable holographic-like light-scattering films for smart packaging and security applications by hot embossing technology – without any inks or metals.
- Nanocomp (Diffractive optics applications by thin foil roll-to-roll technology).



Examples of application fields and companies

Emerging technologies – smart packaging

Iscent: Light scattering printings by nano- and microtechnology

The innovation discovered by Iscent Oy is based on the application of hot embossing technology to increase product attraction, authentication and brand-protection purposes. Iscent provides an environmentally friendly optical diffraction solution that can be used on any type of polymeric material and on the surface of paper as a topographic effect by the roll-to-roll method. The effect does not require metal coating or even lacquer, which enables an environmentally friendly and cost-efficient solution. Iscent's solution can be observed as a light spectrum on flexible packaging, on gift wrap and other packaging wrap, on injection moulded plastic items, etc. Iscent's solution can be applied to all known packaging materials: polypropylene, polyethylene, polyester, cellophane, polystyrene, polyamide, printed paper and paper board, etc.

Contact: Dr. Jaakko Raukola, CEO, Iscent Oy, www.iscent.fi

Iscent manufactures light scattering films roll-to-roll

The Active Paper Company makes paper products interactive, engaging and intelligent

The Active Paper Company provides a physical interface between brands and consumers. We make graphics change on printed paper without the use of electronics! A drop of liquid activates a rapid and controlled colour change effect, which will trigger consumers' curiosity to interact with the brand message. Active Paper technology is also a platform for security solutions and everyday diagnostics tests.

The Active Paper Company's first products are interactive coasters, stickers, labels and greeting cards used by leading brand owner customers for interactive consumer engagement. The company's second-generation products introduce a sensing capability to the Active Paper platform for creating easy-to-use tools for consumers to monitor the wellbeing of themselves or their environment. These could also be used in the promotion of products marketed with claims related to wellbeing.

Contact: Mr. Tomi Erho, CTO, The Active Paper Company, www.theactivepaper.com

InterActive Paper

6.4 Success story: Canatu – Next-generation touch-enabled applications from novel nanocarbons

Today, Canatu is a leading developer and manufacturer of transparent conductive films and touch sensors for an entirely new class of touch applications. With its innovative technologies, Canatu offers consumer electronics companies increasing design freedom.

Company based on profound expertise

Canatu's roots lie in the Helsinki University of Technology, where the company was established as a spin-off in 2004. Founding partners include Dr. David Brown, Professor Esko Kauppinen, Dr. Albert Nasibulin and Dr. Hua Jiang. These four founding partners are leading senior scientists from physics, chemistry, materials science, electron microscopy and aerosol technology. They come from Finland, the USA, Russia and China.

From the founding date, Canatu now owns over 150 patents in 17 patent families. In 2010, Canatu focused its market offering to touch.

A novel way to produce transparent, conductive films from carbon gases in a single process step

A novel hybrid material combining carbon nanotubes and fullerenes, namely the NanoBud®, is developed and patented by Canatu. It's properties include higher conductivity and transparency, more controllable band-gap, chemical functionalizability, higher specific surface area, and a lower work function compared to traditional nanotubes.

Direct Dry Printing® is an environmental friendly, fast and low-cost production method for high volume Roll-to-Roll manufacture of transparent conductive CNB™ (Carbon NanoBud®) films directly from carbon gases. CNB™ films are produced on substrates in sheet or roll-to-roll form in a single process step.

CNB™ film enables flexible and 3D-formed touch devices, giving long-awaited design freedom for consumer electronics companies. The film provides outstanding contrast and outdoor readability in touch displays due to ultra-low reflectivity and haze. Alternatively, improved contrast can be used to increase the battery life because a lower display backlight power can be used. Direct Dry Printing® is a green process without any wet or toxic chemistry. The use of common carbon raw materials and a simple one-step deposition process reduces material and process costs in touch devices.

2004	2007	2008	2009
Canatu established as a spin-off from the Helsinki University of Technology.	Partnerships with Sitra, the Finnish Innovation Fund, and secured seed funding to commercialize core technology.	First employees recruited and established the 1.75 million Euro Tekes E-Bud project.	Demonstrated on a small scale the synthesis of carbon NanoBud® (CNB).

Customer expectations and target markets

Electronics hardware companies and brand names are seeking ways to differentiate their touch-enabled products, reduce production costs and increase product performance. Existing materials such as silicon, metals and metal oxides are expensive, not flexible, stretchable or transparent, and require complex and bulky support structures. Moreover, these traditional technologies are reaching their performance limits.

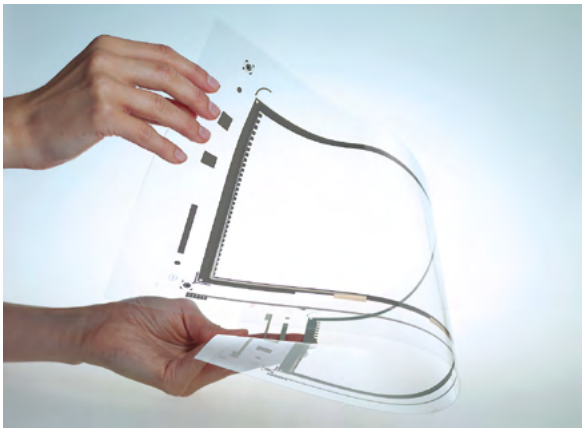
Canatu's first target market is the electronics supply chain for touch interface technologies in mobile and wearable consumer devices, home appliances, white goods and automotive interiors. Canatu's patented innovations have the potential to revolutionize industries by enabling new kinds of printed flexible, foldable and 3D-shaped electronics products while at the same time reducing production costs and environmental impact as well as improving product performance.

Scaling up production

Canatu has now scaled up CNB™ film production to volume manufacturing for high-quality flexible, 3D-shaped and flat projected capacitive touch sensors. The company opened a medium size manufacturing plant in Helsinki, Finland, in September 2013 and is planning to expand the capacity with a mass volume film plant in late 2014.

Contact: Mr. Risto Vuohelainen, CEO, Canatu,
www.canatu.com

Dome-shaped multi-touch CNB™ sensor


Flexible CNB™ sensor


Pilot manufacturing plant

2010	2011	2012	2013
Focusing a market offering to touch and raising EUR 4.70 million A-Series private and government funding.	Moved to new manufacturing facilities in Konala, Helsinki. Scaling the production rate over 1,000 times compared to first development reactors. Demonstrated the first manufacturing scale Direct-on-Substrate carbon nanomaterial deposition on PET in the world. Risto Vuohelainen joins Canatu as a new CEO.	Signed and delivered significant Joint Development Agreements with new customers.	Closed USD 9 million B-Series private and government funding. Pilot plant opened in Helsinki, Finland. Plant is capable of manufacturing CNBTM films and CNBTM sensors in proto, pilot and small/medium volumes.

6.5 Success story: Beneq - The world is getting thinner with Beneq

Beneq is a pioneer in thin film applications. The company was established in 2005, in the wake of the nanotech rise in Finland. The need and especially opportunities for thin films in developing electronics and other related industries had been identified, but the means to harvest the resurgence were still in the making on a global basis.

From the very beginning, Beneq has planned and kept to its own route and methodology, carefully balancing research and industry, offering cutting-edge processes and research tools to academia, whilst simultaneously breaking new ground in industrial thin film production. Industries served include photovoltaics as well as flexible and organic electronics. Industry-grade Beneq equipment is used today for improving the efficiency of crystalline silicon and thin film solar cells, producing transparent conductive oxide (TCO) coated glass and enabling longer product lifetimes for OLED applications. Beneq has introduced several revolutionary innovations within its coating technologies, including high-yield atmospheric aerosol coating (nAERO®) and roll-to-roll atomic layer deposition (ALD).

Contact: Mr. Joe Pimenoff, Marketing Manager, Beneq Oy, www.beneq.com

nAERO for TCO and low-e coatings

During its engagement in Tekes's Functional Materials programme, Beneq has developed its aerosol coating technology nAERO into an industry-proven coating method for advanced thin films and large-scale production. The proof of concept for both in-line and off-line aerosol coating processes was followed by international acknowledgment and success in turning the innovation into concrete business: three units have been sold, spanning solar photovoltaics (TCO, transparent conductive oxide) and energy-efficient windows (Low-e, low-emissivity glass).

In technical terms, the process development project resulted in a thin film deposition process with a record-high material yield (from raw material to ready coating) of around 25%, as compared to competing processes with 10-15%. Also during the project, a wet chemical coating process for anti-reflective coatings was developed, a means to significantly increase the deposition efficiency was conceived, and a new filtering method to handle flue gases was implemented.

Beneq aerosol coating enables both in-line and off-line coating of flat glass. Beneq and nAERO are registered trademarks of Beneq Oy.

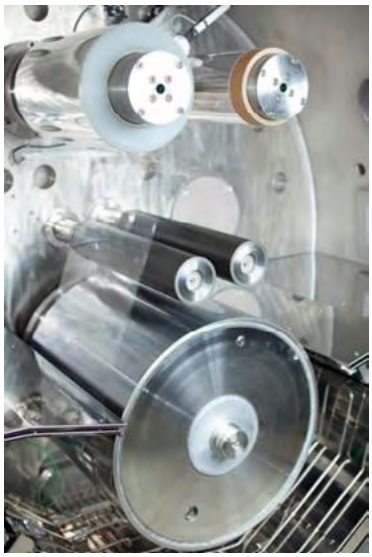
Rolling out results with Roll-to-Roll ALD

Beneq's achievements in ALD are undisputed. Our urge to develop the best ALD tools for research and industry has had us introducing several first-ever processes, coating configurations and production tools. One of the most remarkable ALD milestones Beneq has laid the foundation for is Roll-to-Roll ALD.

When entering the Functional Materials programme with a topic based on spatial ALD, Beneq held as its primary goal the commercialization of Roll-to-Roll ALD (which was until then a missing link in the realm of ALD) and its application to specific industrial sectors. The sectors identified in an early stage to gain the most from this unique coating technology were OLED (display and lighting) and flexible PV.

In OLED, device encapsulation, the means to isolate sensitive organic electronics from its surroundings, e.g., moisture and contamination, is a critical issue that heavily impacts the lifetime of the device. ALD is perfectly suited for encapsulation of OLED, including flexible OLED, because of the intrinsic properties of the ALD film: completely conformal, dense and pinhole-free. For sufficient encapsulation, we have proven that you only need a few dozen nanometers of, e.g., aluminium oxide.

Beneq entered the OLED market by selling ALD equipment to a leading Asian customer in 2012. Since then, we have developed the ALD encapsulation technology to fully embrace our Roll-to-Roll ALD concept. In February 2012, we announced the delivery of the world's first industrial-scale Roll-to-Roll ALD system to the Advanced Surface Technology Research Laboratory (ASTRaL) in Finland, followed soon after by the second unit being sold to the Centre for Process Innovation (CPI) in the United Kingdom. The third unit, sold to an undisclosed customer, is in the building phase. The aforementioned pieces of equipment won't necessarily be used solely for work on OLED encapsulation, but with the milestones we have reached, we see that Roll-to-Roll ALD has tangibly developed from a laboratory oddity into an industrially viable technology that is being used for a range of applications.



Beneq's Web Coating System 500 introduces Roll-to-Roll spatial ALD to the industrial community.

Beneq's Roll-to-Roll ALD system, the WCS 500, can coat a 50 cm wide web in one pass.

6.6 Printed functionality

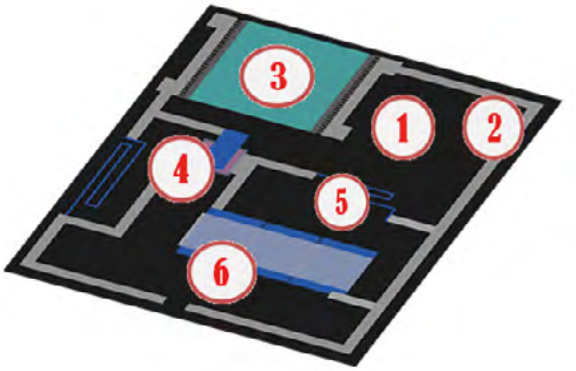
Novel technology platform for mass-produced inexpensive and flexible paper electronics enabling sensing applications

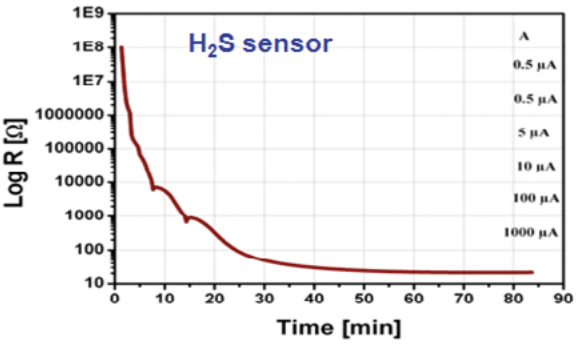
Market analyses and research reports estimate printed and organic electronics to become a huge, several hundred billion dollar business in the future. However, currently printed and inexpensive mass-produced electronics (especially on a paper substrate) is still in its infancy, and only the very first products are entering the market. The main objective of the project Flex-Sens was to create a universal technology platform for inexpensive mass produced ion-modulated transistors that accelerates the development of novel practical device applications.

The work was carried out in four work packages dealing with substrate (paper and synthetic membrane) and component (transistor, display, memory, different sensors) development as well as life-cycle analysis (LCA). Finally, the components were collected to a joint demonstrator.

The design of the actual printing pattern for the demonstrator was based on a model circuit (figure enclosed, both a schematic and a real printed device (series), including a sensor response curve as an example), including (1) paper as a print substrate, (2) printed Ag or Au conductive tracks and electrode structures, (3) printed or coated active sensor material (humidity, NO_2 or H_2S gas), (4) HIFET transistor, (5) printed PEDOT:PSS resistor lines, and (6) a pixel element consisting of printed PEDOT:PSS electrodes with electrolyte gel. The transistor technology will be used in plastic- or fibre-based flexible packages and in technical plastics for switching and sensing purposes.

Contact: Prof. Jouko Peltonen, Åbo Akademi University



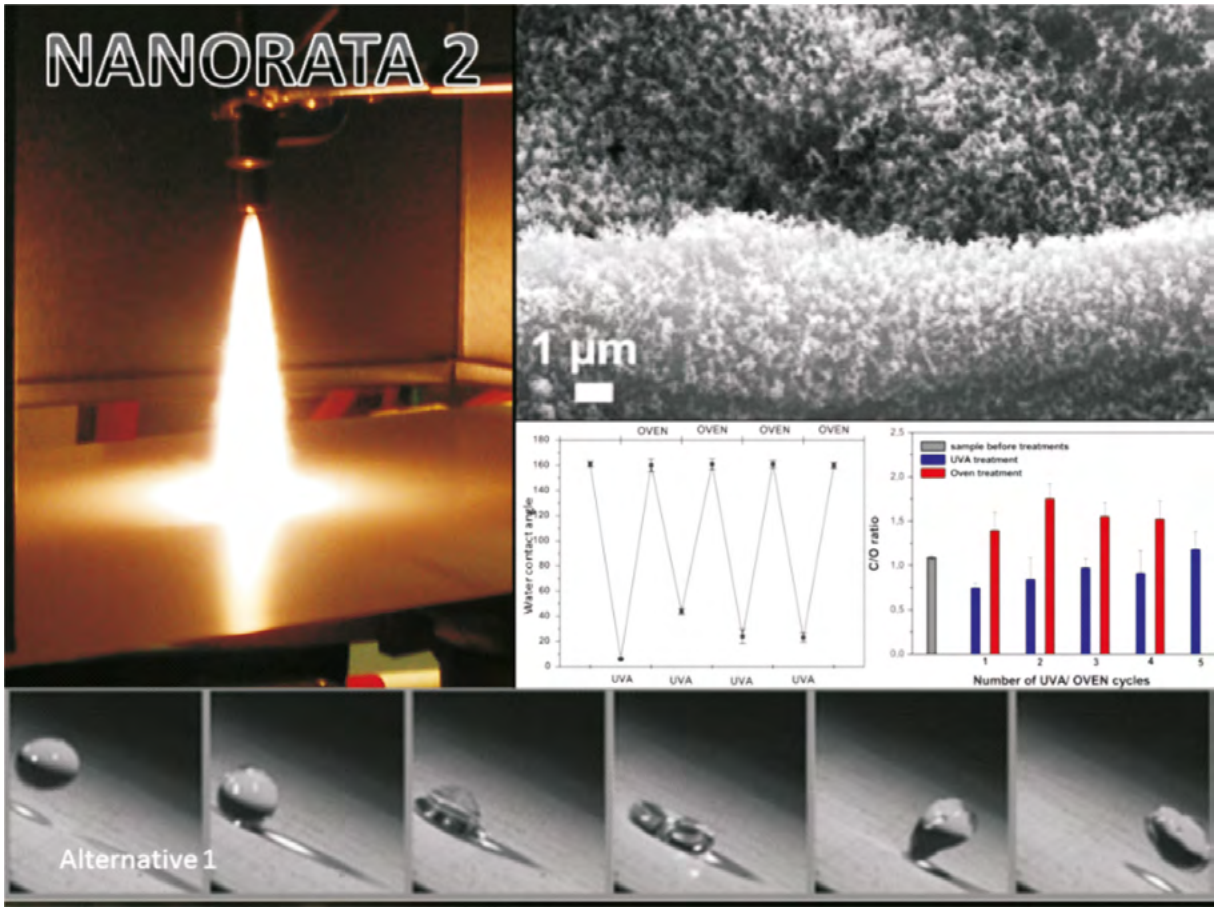


Tailoring superhydrophilic and superhydrophobic surfaces

Full utilization of renewable and affordable flexible roll-to-roll materials such as paper, paperboard and polymer structures, requires controlled tailoring of their surface properties. In this project Liquid Flame Spray (LFS) fabricated nanoparticle structured coatings for flexible web-like roll-to-roll materials were successfully developed with controlled adjustable and switchable wetting properties between superhydrophilicity and superhydrophobicity. In the industrial set up, line speeds in the order of 500 m/min have been achieved to create ultra-thin functional nanocoatings with a mass loading of 10-100 mg/m². The surfaces can be tailored to any water contact angle based on their UV- and heat responsive properties.

Additionally, highly omniphobic surfaces have been successfully fabricated on the same flexible substrates by combining LFS-nanocoating and plasma enhanced CVD. Special effort has been put to characterization of the nanocoating and its physico-chemical properties to provide the tunable functionality and to understand the nanoscale mechanisms controlling the wettability. Moreover, wear resistance and compressibilityof the coating as well as LCA of the coating and potential nanoparticle emission from the surface into air and liquid during disposal have been studied.

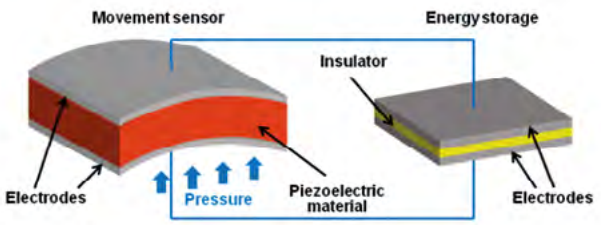
Contact: Prof. Jyrki Mäkelä, Tampere University of Technology



Autonomously working activity sensors by printing

The combination of piezoelectric element with memory unit is a basis of the concept for autonomously working activity sensors. Mechanical energy caused by activity is transformed into the electrical signal by piezoelectric component. The generated electrical power can be stored in the memory element. Depending on the purpose of the use of the activity sensor, a super capacitor or memristor-based memory elements can be used. In order to keep sensor fabrication costs low, we designed and developed all the required materials and component structures in a way that they are compatible with printing-based production methods. Successful development of piezoelectric materials and memory elements (super capacitor and memristor) enables the production of fully printed, low-cost activity sensors for several applications such as human and cattle activity monitoring, smart packaging, and vibration stability monitoring of machines. The developed concept also offers interesting possibilities in energy harvesting applications.

Contacts: Adj. prof. Tapio Fabritius, University of Oulu and Prof. Donald Lupo, Tampere University of Technology



Printed supercapacitors

In general supercapacitors are applied when a power output higher than batteries is needed. We have demonstrated several tens of thousands of cycles for the printed supercapacitors, which clearly exceeds the typical cycle life of batteries. In the project, the developed supercapacitors are used in various demonstrations including, e.g., RFID tags and packaging.

The project facilitates the supercapacitor manufacturing process by roll-to-roll printing technology. The materials choice and development focuses on inexpensive alternatives. These enable cost-effective production that is important to widen the application range of supercapacitors.

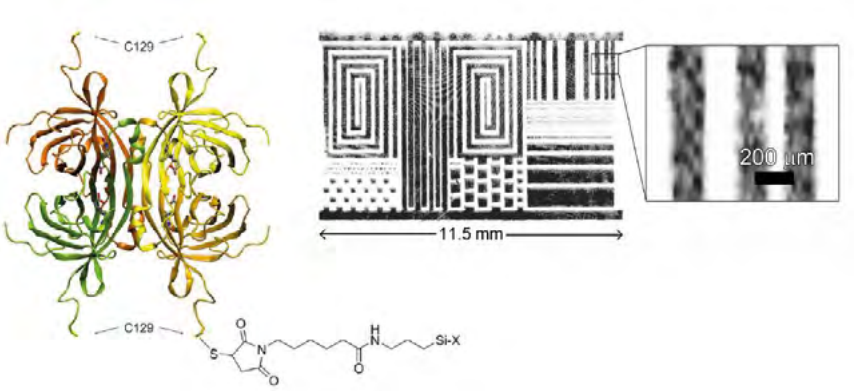
The supercapacitor structures are printed on various foils and laminates. As electrode material, activated carbon and manganese dioxide are the main choices. The electrolytes are applied as gel or bound to polymers. The basic structure of the supercapacitor cells is designed to be applicable both in small- and large-scale components.

Contact: Senior Scientist Jari Keskinen, VTT Technical Research Centre of Finland

Generic binding surfaces for biosensors

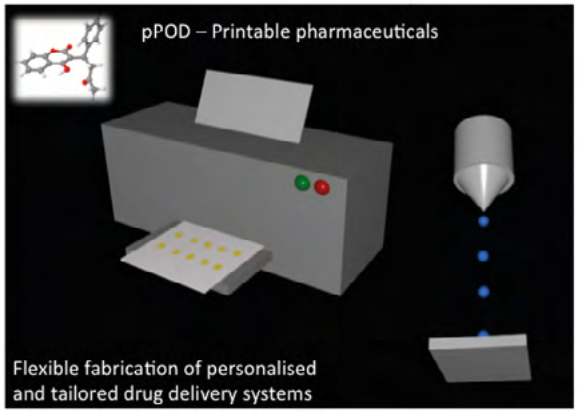
One of the big challenges in manufacturing biosensors is the immobilization of the biological element on the sensor surface. In the "Printable Biosensor Surface" project (BioFace), new generic, versatile solutions for tailored sensing surfaces were developed. The developed generic binding surfaces were based on the use of genetically engineered, chimeric avidin, which can bind biotin and biotinylated molecules extraordinarily tightly. It also shows improved thermal and chemical stability, therefore having a superior ability to withstand the environmental conditions met during the printing processes. Chimeric avidin was covalently immobilized on the biosensor surface, either by direct functionalization of the polymer surface or with the help of sol-gel technology. These new surfaces can be utilised for further development of low-cost, mass-manufactured lab-on-chip devices.

Contact: Researcher Liisa Kivimäki, VTT Technical Research Centre of Finland



Printed drugs

The project "pPOD- Printable Pharmaceuticals for Drug Delivery" has developed a drug manufacturing platform based on various printing technologies. The project has generated extensive know-how on fabrication and quality control of printed therapeutic systems. A variety of printable formulations for a wide range of drug substances have been developed and tested. We have also investigated and developed drug carrier substrates to be used as drug-delivery systems. The results of the project provides solutions to produce on-demand medicines and enables the meeting of demands of personalized dosing and the flexible manufacturing of the pharmaceutical products of the future.



Contact: Prof. Niklas Sandler, Department of Biosciences, Åbo Akademi University

6.7 Intensive cooperation with Japan

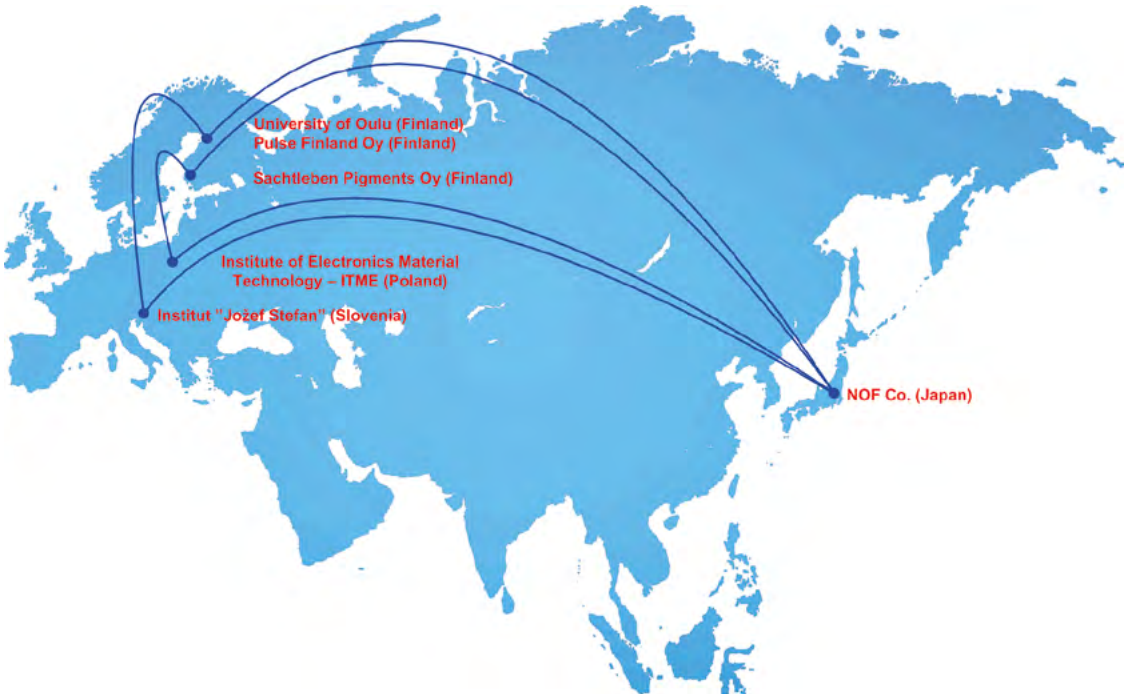
Project example: Novel inks for printable functionalities

For future emerging applications, there is increasing demand for new printable components that enables seamless integration of low-cost electronics into various 3D surfaces while also achieving high performance and a high degree of functionality. The goal of the InnoInks project has been to extend electrical properties of inks beyond existing ones and create new functional materials for the field of printed electronics.

In the project, dielectric, pyroelectric and magnetic inks based on inorganic fillers utilising flake, needle and sphere shaped particles has been developed and demonstrated in different components. The shape of the particles and their processing influence their intrinsic and extrinsic properties and behaviour in electromagnetic fields. By utilizing developed high-k and magnetic permeability inks, which are not yet commercially available, electrical components such as coils, inductors and capacitors for various circuit designs and applications can be realized. Furthermore, active materials like piezo- and pyroelectric inks can be utilized as printable energy harvesters, temperature, pressure and force sensors, which can also be applied as large areas exploiting cost-effective printing technologies.

Close collaboration with Japanese, Polish, Slovenian and Finnish academic and industry partners brought together the necessary know-how to form a complete value chain that enabled the development of low-temperature curable inks. Such development has vast commercial potential in printed electronics as a various level of products like mass producible new raw materials, ingredients for inks, functional inks, ink processing, components and finally devices/applications.

Contact: Prof. Heli Jantunen, University of Oulu



Coatings – examples of company projects

Coligro Ltd:
Sustainable and self-cleaning building materials

The main target was to protect porous building materials, natural stones in first phase, from contamination and by making the materials active self-cleaning, sustainable, water repellent and air-purifying. The benefits for the building owners are evident and can easily be converted into an appealing business case.

Contact: Mr. Panu Miettinen, www.coligro.com

Eforit Ltd:
Tribological Au-deposition

The purpose of the project was to generate a new kind of gold deposition, which allows similar or better tightness with thinner gold layers. The advantages of the coating are improved abrasion durability and less porosity on the gold deposition. The coating extends a product's life and helps to conserve the environment. It also enables research in the most demanding atmospheres.

Contact: Mr. Lauri Virta, www.eforit.fi

Diarc-Technology Ltd:
Functional nano- and microporous carbon based coatings for tools and components

DIARC-Technology Oy develops and manufactures functional coatings with a unique FCAPAD filtered cathodic arc plasma accelerator deposition method. DIARC functional coatings are solutions to improve the surface properties of materials, to sense surface conditions such as temperature and strain or to join dissimilar materials together. In Nanocarbon project DIARC studies the growth and functional mechanisms of nanocarbon films and characterizes their properties and applicability as sensing surfaces.

Contact: Mr. Jukka Kolehmainen, www.diarc.fi

Picodeon Ltd:
Application-Optimized Nitride Thin Films

The focus of the project was on applications: optical coatings for the electronics industry, sustainable LED Phosphors and wear-resistant industrial coatings.

Contact: Dr. Jari Liimatainen, www.picodeon.com

Varicoats Ltd:
New green coating technologies

The purpose was to develop coating materials based on the company's own new patented technology. The main target is consumer goods manufacturing companies that aim to enhance the easy-to-clean and abrasion resistance properties of glass and metals in their products.

Contact: Mr. Jukka Honkanen, www.varicoats.com

6.8 Bio-based materials – from nature to industrial applications

6.9 Success story: UPM Biofibrils – novel biomaterial industrial use

UPM Biofibrils products are based on micro- or nano-sized cellulose fibrils, and they offer a range of possibilities for shaping materials and giving them new characteristics. UPM Biofibrils is one of the key development projects that are an important part of UPM's renewal and Biofore strategy.

The successful development of UPM Biofibrils is largely based on a collaborative effort between UPM, Aalto University and VTT Technical Research Centre of Finland within the Finnish Centre of Nanocellulosic Technologies, established in 2008. The development of novel biomaterials and applications has been carried out utilising a unique virtual collaboration set-up. The key success factors have been defined and commonly accepted targets, clear roles and responsibilities, and trust and openness between the partners.

Different manufacturing methods for UPM Biofibrils products have been developed – the most suitable grade depends on application requirements. Application development for various industrial uses has been ongoing, along with production process development during the whole project.

UPM Biofibrils can be used to make products tougher, lighter or thinner. It can also be used in many industrial applications requiring high stabilization capacity and viscosity. UPM Biofibrils is a novel bio- and nanomaterial that allows development of new fibre-based products with exciting properties for the UPM product portfolio. Collaboration with research and industrial partners enables further development and commercialization of UPM Biofibrils in several industrial applications. UPM's objective is to create the preconditions required for industrial-scale production in the near future.

The UPM Biofibrils development project has been partly supported by Tekes.

Contact: Mr. Esa Laurinsilta, Director, UPM-Kymmene Corporation, www.upm.com/biofibrils

UPM – The Biofore company

As the frontrunner in the new forest industry, UPM leads the integration of the bio and forest industries into a new, sustainable and innovation-driven future. We create value from renewable and recyclable materials.

The company structure consists of the following business areas: UPM Biorefining, UPM Energy, UPM Raflatac, UPM Paper Asia, UPM Paper ENA (Europe and North America) and UPM Plywood. Cost leadership, change readiness, engagement and the safety of our people form the foundation of our success.

In 2012, UPM's sales exceeded €10 billion. The company is present in 67 countries, has production plants in 17 countries and employs approximately 22,000 people worldwide. UPM shares are listed on the NASDAQ OMX Helsinki stock exchange.

UPM – The Biofore Company – www.upm.com
UPM Biofibrils – www.upm.com/biofibrils

Sustainable fibre-based food and drink packaging solutions

Huhtamaki has developed recyclable dispersion coated paperboard solution with a reduced amount of coating and fossil-based materials.

A coating solution was found with similar moisture barrier properties and material hoop strength as in paperboard coated with conventional plastic material and technology. Additionally, the project involved development of manufacturing technology for fibre-based trays (including new age Modified Atmosphere Packaging) for the chilled food market. In conjunction with the project, Huhtamaki developed a comprehensive LCA (Life Cycle Analysis) model that compares the environmental impact of alternative base materials for packaging.

Contact: Mr. Timo Tiilikainen, Commercialization Director
Huhtamaki Oyj, Foodservice Europe-Asia-Oceania
www.huhtamaki.com

UPM Grada® – New thermo-formable wood material

Furniture production and form pressing of wood-based furniture components are labour-intensive businesses, where fully or semi-automated processes or larger economies-of-scale benefits have been difficult to establish. To successfully compete with low-cost competition, the European furniture industry has to focus on developing new competitive advantages. Novel technologies, flexible production and quick distribution with minimal stock holdings are crucial for business success. UPM has developed a new Grada adhesive technology enabling wood panel to be formed with heat and pressure with minimal energy consumption and a negative carbon dioxide balance. Grada technology renews the forming of wood and opens up new opportunities for efficient and flexible furniture production. Additionally, UPM Grada's unique forming properties enable high quality and ecological designs that are also visually appealing.

Contact: Mr. Mikko Tilli, Manager, UPM Grada®, UPM Plywood,
www.upmgrada.com

The ON chair designed by Tapio Anttila and manufactured by Pedro Ltd in Finland.

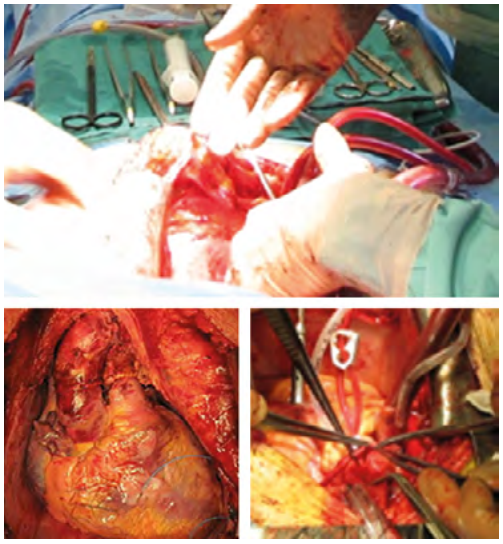
6.10 Biomaterials for medical applications – Human spare parts

Cell therapy for heart failure

For more than a decade already, cell therapies have been developed to enhance the treatment of heart failure.

Unfortunately, the efficacy of these therapies has not been optimal. Nevertheless, the studies have demonstrated that transplantation of a patient's own cells (e.g., during bypass surgery) is a viable therapeutic option. The major issues remain with the isolation, selection and optimal administration of cells. The eSEED collaboration project between Finland and Japan utilized the strong clinical expertise of the participating teams to help solve these issues. As a result, a novel cell therapy option for heart failure patients was developed. Clinical evaluation of this therapy for more widespread use is conducted at the Helsinki Academic Medical Center.

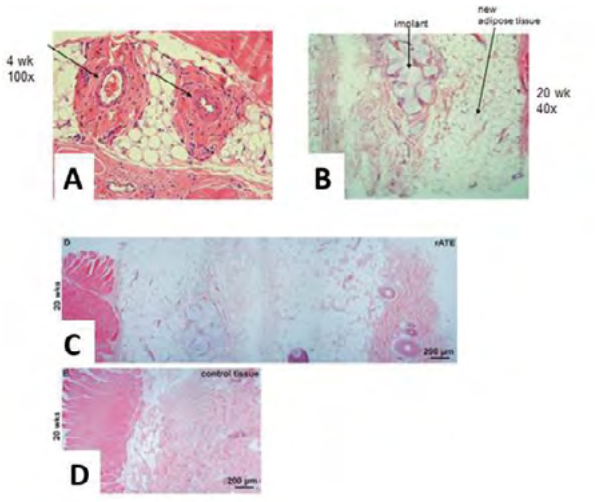
Contact: Doc. Esko Kankuri, Institute of Biomedicine, Universisty of Helsinki



Bioactive implant for wound treatment and plastic surgery applications

We have developed a novel bioactive substance that induces angiogenesis and adipogenesis in vitro and in vivo in a dose-dependent manner. It has the potential to be used for inducing revascularization of ischemic tissues, for correcting soft tissue defects, and for wound care. None of the current soft-tissue and wound-care products share the same properties. We have established the GMP production (clean room) process for the substance. The substance has been characterized and shown to be safe and bio¬compatible. As a final goal, we are developing the innovation into an off-the-shelf clinical product.

Contacts: Prof. Timo Ylikomi and Dr. Riina Sarkanen, School of Medicine, University of Tampere

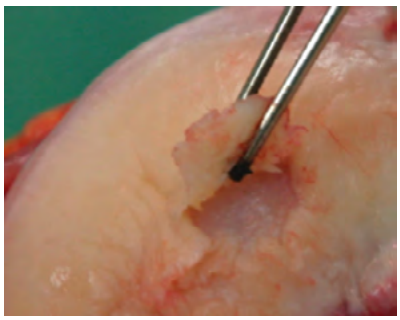


A bioactive substance was mixed with hyaluronic acid and implanted in the subcutis of a rat. (A) After 4 weeks, the increase in angiogenesis was observed. (B) After 20 weeks, new adipose tissue was seen to be formed at the implantation site. (C) A volumetric gain (increase in subcutaneous soft tissue) was observed during the experiment. (D) The thickness of the subcutaneous tissue in the area where there was no implant.

Novel solutions for cartilage tissue engineering

Cartilage injury causes pain and disability, diminishing the quality of life of the patient. If untreated, it leads to osteoarthritis (OA). An ageing population and the need for functionality in elderly people drive the need for better treatments. Current repair techniques for cartilage injury are inadequate and need development. Successful early treatment of cartilage trauma and disease can restore the function of the joint and even eliminate the development of OA and the need for an artificial joint replacement in later age. To date, it is not possible to repair a large lesion (<4 cm^2), and up to 30% of the treated lesions form fibrous repair tissue of poor quality and durability. The major limitation in the development of regenerative cartilage repair methods is the lack of appropriate biomaterial scaffold. We have created a novel solution for the repair of cartilage defects. Our treatment concept consists of an innovative 3D scaffold composed of non-animal derived bioabsorbable materials. Our scaffold enables the timely treatment of cartilage lesions of substantial size. It also provides mechanical support to the damaged area, and thus makes early weight bearing for faster recovery possible. Our novel treatment concept will provide considerable economical benefit, but will also help patients regain and retain their quality of life.

Contacts: Prof. Ilkka Kiviranta and Dr. Virpi Muhonen, University of Helsinki

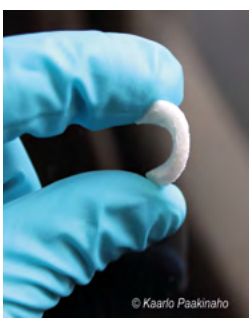


Advanced scaffold technology enabling new and effective surgical operations

Formation of a 3D-structured tissue is one of the cornerstones of tissue engineering. Methods in tissue engineering aim to regenerate new and functional tissues in order to replace or repair absent or damaged ones in the human body. Tissue regeneration cannot be successfully accomplished without a guiding and supporting scaffold structure that stimulates the cultured cells to proliferate and form a natural tissue. As stem-cell technology evolves rapidly, the restricting factor in tissue regeneration is the lack of customized scaffolds for different tissues.

We have created a platform technology for manufacturing tailored bioabsorbable open-pore structured scaffolds that are based on lactide co-polymers and polymer-ceramic composites. The scaffolds are manufactured without harmful solvents by deploying an advantageous processing method, supercritical CO_2 -foaming. The scaffolds have shown their efficacy in cell cultures with human adipose stem cells by stimulating the cell proliferation and inducing early bone cell differentiation. Due to the mechano-elastic properties of the scaffold, they can withstand cyclic loading and can be easily shaped and tailored according to the clinical need. The unique properties of the developed materials will enable development of new, easier and better functioning surgical techniques as well as more advanced treatments for patients.

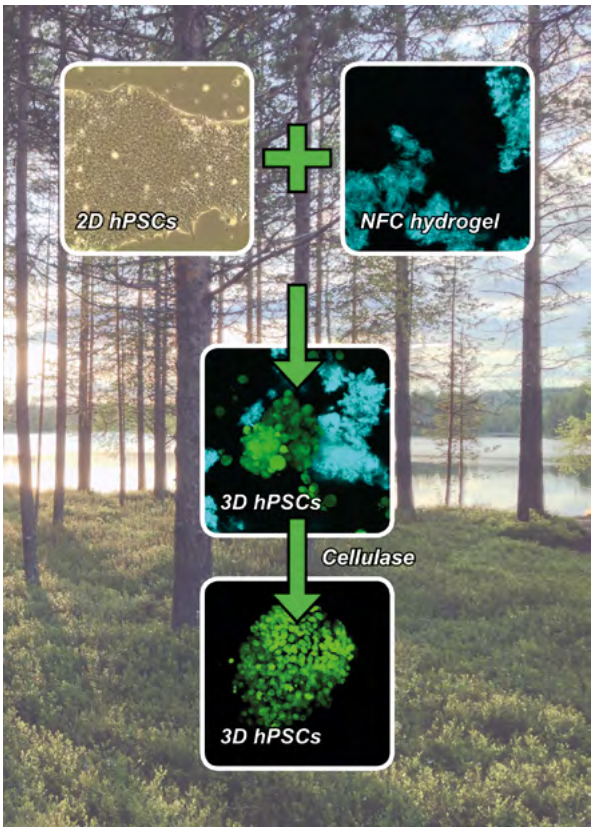
Contacts: Prof. Minna Kellomäki and Dr. Kaarlo Paakinaho, Tampere University of Technology



Nanobibrillar cellulose as 3D cell culture matrix for HepG2 and HepaRG liver cells and human stem cells

We have shown the plant derived nanofibrillar cellulose hydrogel (NFC) to be extremely good support and matrix for 2D and 3D cell cultures by (1) rheological properties that allow formation of a 3D scaffold in situ after facile injection, (2) cellular biocompatibility without added growth factors, (3) cellular polarization, and differentiation of human hepatic cell lines HepaRG and HepG2, (4) using human embryonic stem cells (hESCs) and induced pluripotent stem cells (hiPSCs) to maintain the pluripotency of hPSCs for up to 26 days, (7) human PSCs cultured in the NFC to form 3D spheroids, (8) a cellulose enzyme to degrade NFC and to recover 3D hPSC spheroids, and (8) maintaining the pluripotency of 3D SC spheroids in NFC by in vitro embryoid body formation and in vivo teratoma formation. The developed NFC hydrogel system recapitulates the natural niche of hPSCs and will be useful in cell-based drug research, cell therapy and tissue engineering.

Contact: Prof. Marjo Yliperttula, Faculty of Pharmacy, University of Helsinki



Nanocellulose - from Finnish nature to advanced 3D cell cultures

6.11 Examples of company projects on biomaterials

Fight against infections

Silvergreen Oy

Every year, 30% of wounds get infected in the Western world. The infections produce billions of direct extra costs in doctor visits, the use of antibiotics and other special treatments. On the side, the number of hospital-acquired infections has been growing drastically. Bacteria form resistance against antibiotics, resulting in an increased death toll.

Silvergreen has introduced a patented antimicrobial wound pad, 'SGSOFT', to fight against all known bacteria. The wound pad has been clinically tested at the Helsinki University Hospital heart surgery unit, and it is integrated into the Finnish Red Cross Emergency Rescue Unit.

Silvergreen envisions the next-generation wound dressing, SGSOFT, to be the perfect tool for shifting the focus from treatment to prevention.

What if the majority of wound infections can be prevented? What if billions of dollars and thousands of lives can be saved? What if creating a good and profitable business on a global scale can best make this all happen?

Silvergreen launched SGSOFT wound dressing in Medica 2013 Dusseldorf to contribute to this vigorous challenge.

Contact: Mr. Tommy Salomaa, CEO, Silvergreen Oy, www.silvergreen.fi

Vivoxid: Strongest fibre-reinforced fully bioresorbable composites for implants

Novel bioresorbable fibre-reinforced composites were developed for load-bearing orthopaedic implants, resulting in the strongest fully resorbable material available for human implants today – up to six times stronger than cortical bone. The strength and biodegradability can be widely tuned to enable appropriate recovery times. Results of pre-clinical studies proved full biocompatibility of the composite material. This unique technology was acquired by Purac Biomaterials in 2012.

Contact: Dr. Jukka Tuominen (Purac),
video: www.youtube.com/watch?v=U9CxEY0Z78Q&list=PL4DD1F1FACCE5A4C9&index=4

Ozics: Injectable load bearing fracture fixation device

The company has developed and commercialized an injectable high-strength bone cement and related instrumentation. The result is an easy-to-use material that will significantly improve clinical outcomes and reduce treatment costs.

Contact: Ms. Heidi Hinkka,
www.ozics.com

Onbone: Development of bioresorbable bone cement

The project focuses on the development and biological characterization of novel biodegradable bone cements. These composites can be used in the same manner as traditional bone cements or bone substitutes to further improve the treatment procedures of fractured bones.

Contact: Mr. Karri Airola,
www.onbone.fi

Finnish Red Cross Blood Service: Scaffolds for Tissue Engineering

The aim was to develop composite scaffold materials for tissue engineering that stimulate cell differentiation instead of the adverse foreign body reaction. Bioactive and suitable glycan and protein structures in bone resorption areas were determined for coating purposes and to provide signals directing bone resorption.

Contact: Mr. Jarkko Räbinä,
www.bloodservice.fi

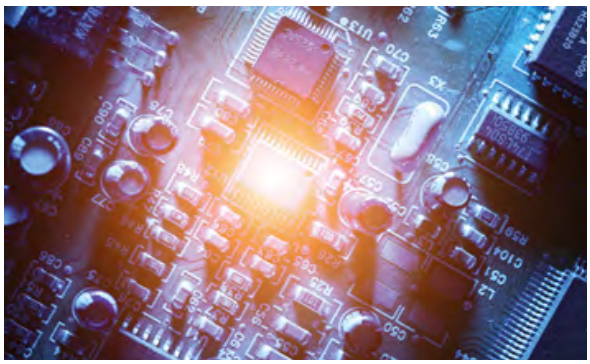
6.12 Functional materials – There is still room for development at the bottom

Unique nanodiamond materials and their compounds for enhanced thermal and mechanical properties

Carbodeon Oy

Lightweight construction, miniaturization and cost reduction are the current megatrends in the electronics and automotive industries, the targets being achievable via classic substitution of metal and ceramic parts with various polymer materials. In this context, both polymer thermal and mechanical properties need to be improved and optimized. Nanodiamonds exhibit the same properties as natural diamond material, namely the highest known hardness and thermal conductivity of all known materials. To meet the challenge of facilitating optimized end-product performance with minimized and industrially affordable cost, Carbodeon has now developed and patent-protected a series of precision-tailored nanodiamond grades, addressing the key present and future polymer composite applications on an industrial scale. The materials development is continuously supported by active application development by Carbodeon and its key industrial partners.

Contact: Dr. Vesa Myllymäki, CTO, Carbodeon Ltd Oy, www.carbodeon.com



Nanodiamonds for industrial use

Maximize antenna gain – Tailored dielectric constant materials for high-frequency applications

Premix Oy

Premix developed a plastic compound product family to address the challenges that radio frequency designers face in their everyday work. The developed PREPERM compound is specifically designed to provide an extremely low dissipation factor together with the possibility of reducing equipment size and giving the product designers the possibility to optimize the performance of their current designs.

Application areas for compounds include any high-frequency equipment, such as antennas and high-speed connectors.

The key benefit of PREPERM is the extremely low dissipation factor of the material. In most cases, the dielectric loss is 0.0005 at gigahertz frequencies, making the material superior to commonly used plastic compounds. The premix solution provides a high degree of customization based on individual customer needs. The PREPERM plastic grades cover the dielectric constant between 2.55 and 21 and allow adjusting the value exactly to the required level. This allows designers to manipulate material properties; increasing the dielectric constant enables miniaturization of antennas.

Contact: Mr. Tuomas Kiikka, Business Development Director, Premix, www.premixgroup.com

Tailored dielectrics for antennas

Graphene and functional materials enabling the Morph concept

Nokia Research Center

New functional materials are important enablers for Morph-like devices. Graphene has an important role in different components of new electronics equipment and structures and the ecosystem needed to make the gateway and context-awareness possible in an energy-efficient way.

Novel materials – such as graphene – and environmentally friendly, low-cost manufacturing – such as printed electronics – are crucial to the future of electronics. The capability of controlling the electrical properties of graphene will enable a new kind of reconfigurable electronics, and most probably Morph can have properties that we might not even have thought of yet.

Graphene and other two-dimensional nanomaterials can enable enhancements in performance and reach THz frequencies for the transistors without having cooling problems, with two distinctive properties of the material: electrical conductivity and heat transfer. This can enable energy-efficient computing in the CPU of a mobile device as well as within the self-powered sensors combined with processing.

Graphene is also transparent, thin and flexible. These properties will lead to new generations of components and materials enablers for novel form factors. At first it will replace Indium Tin Oxide (ITO), which is fragile, toxic and becoming increasingly more expensive. Later on, electromagnetic shielding materials will be transformed to thinner and more versatile structures. Flexible displays are already coming to the market. The stretchable components with a stretchable substrate will enable totally stretchable and transparent electronics with ubiquitous artificial intelligence.

Our recent studies in graphene dual gate GFETs for RF electronics, electromagnetic shielding with nanocarbons, structural nanomagnetic particles for tunable antennas, superhydrophobic surfaces forever clean and non-bacterial surfaces and optoelectrical solutions with a graphene-like camera cell and other photodetectors have been promising a lot of the properties that are needed for ubiquitous Morph-like equipment and the structures needed for it.

Contacts: Dr. Markku Rouvala and Dr. Tapani Ryhänen, Director, Nokia Research Center

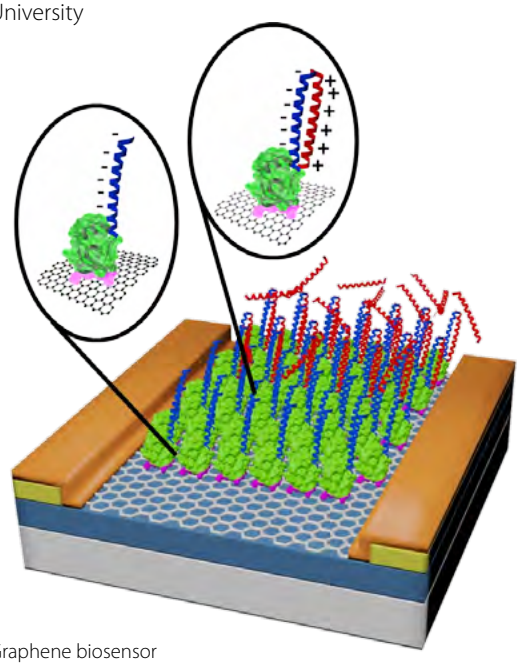
Nokia Morph Concept – showing way to future of mobile devices

Graphene production and emerging applications

Graphene is the first material from the new group of layered 2D crystals, with high technological and commercial prospects. Potential applications of graphene vary from electronics and photonics to energy storage, medical diagnostics and drug delivery. To boost the transition from research to technology, we have developed a new graphene deposition method, photo-thermal CVD, which allows fast and scalable production of single and bilayer graphene for high-tech applications. Together with the state-of-the-art semiconductor processing facilities and graphene processing know-how in Micronova, it provides a platform for graphene device prototyping in electronics, photonics, MEMS and sensing – including all required steps from design, fabrication and characterization to small-scale production.

Applications developed in the project include thin hermetic nanolaminates and strong transparent foils, OLEDs, graphene biosensors with selectivity based on genetically engineered proteins and tunable inverters based on the unique ambipolar conductivity of graphene.

Contacts: Dr. Sanna Arpiainen, Senior Scientist, VTT Technical Research Centre of Finland and Prof. Harri Lipsanen, Aalto University



Graphene biosensor

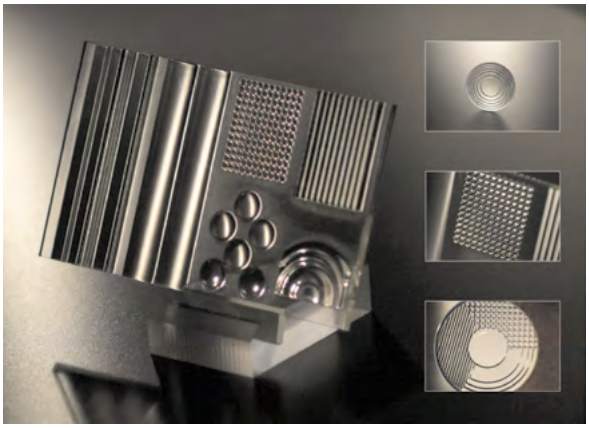
Printed optical elements: Redefining availability, development and manufacturing speed, and the concept of customization

Numerous applications and markets are lacking rapid affordable prototyping and production of optical elements for small and medium volumes. Despite the thrilling progress with 3D printing (also known as additive manufacturing) in mechanics, 3D printing per se cannot produce optically smooth surface quality.

Award-winning Printoptical Technology, invented by Dutch startup LUXeXceL, is a unique digital 3D printing method with the ability to fabricate optical quality components without any post-processing (polishing or painting). The method based on industrial inkjet printing also offers full colour texturing.

The Institute of Photonics at UEF will host the next-generation Printoptical equipment focused on R&D. Collaboration with LUXeXceL is expected to push the technology forward to smaller and more accurate optical elements. The combination with other modern photonics manufacturing methods is aimed at bringing birth to novel optics never seen before. Companies are offered a unique position to design and test the technology for their special needs.

Contact: Prof. Jyrki Saarinen, Institute of Photonics, University of Eastern Finland

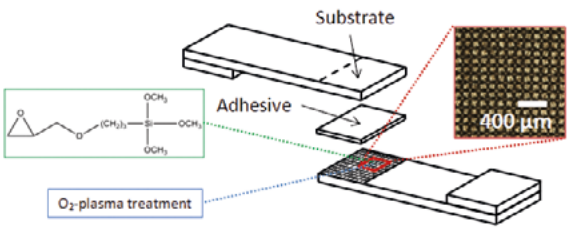


3D printed optical components. Courtesy: LUXeXceL

Controlled micro structuring – Improved adhesion for composite joints

The joint technology has a central role among a production of technical devices. The requirements for the mechanical strength of the joints are stringent. Stability has to be maintained for years under harsh conditions. The results of the project shed a new light into optimizing the mechanical strength of adhesive composite joints. In this work, an increased surface area of the contact surfaces combined with tailored surface chemistry of the substrates has been demonstrated to be a crucial issue for enhanced adhesion between metal and polymer. Surface properties of the substrates have been physically modified with a controlled micro-scale patterning and chemically modified with silane-based coupling agents or oxygen plasma treatments. According to the preliminary studies, optimization of the aluminium and resin surfaces results in a significant improvement in the shear strength of the adhesive joints. The simple and low-cost micro mesh printing technique together with controlled surface chemistry presents a straightforward route for improving shear and tensile properties of adhesive joints.

Contacts: Prof. Mika Suvanto and Prof. Tuula Pakkanen, University of Eastern Finland



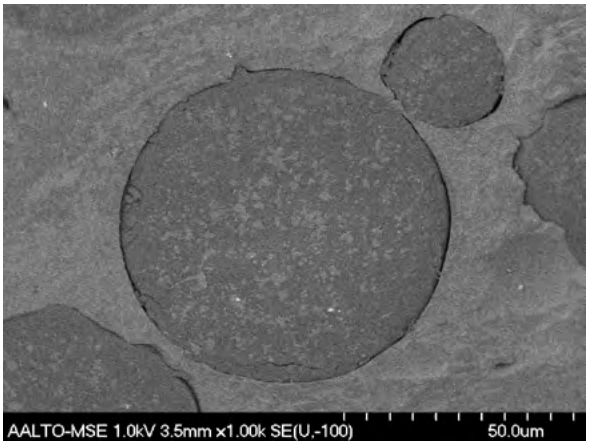
Tailored adhesive joints

Hybrid coatings – Increased shelf-life, safety and reliability for your products

The on-going "Novel responsive coating surfaces utilizing encapsulation technologies (RESCOAT)" project is carried out with the collaboration of VTT Technical Research Centre of Finland, Aalto Univeristy, the Finnish Institute of Occupational Health and IST. We have developed novel active and responsive surfaces based on hybrid paint and thin coatings with encapsulated active agents. In particular, we have created an encapsulation platform that ensures the tailoring of the capsules for different types of coatings or active agents to be released. Economical and health aspects have been taken into account in the development of capsules as well as in the selection of active agents. The polymeric or inorganic capsules release the encapsulated active agents either responsively to the external stimulus or slowly. The responsive release can occur, for example, by increased moisture content, a change in pH, and mechanical or thermal breakage.

The controlled release of the active agents from the capsules may have different functionalities, such as flame retardants, biocides, fungicides, anti-foulants, self-healers and antifreezers. By combining and further developing the coating and the encapsulation technologies, the project has provided feasible hybrid coating solutions, and their performance has been demonstrated to show special features, such as anti-fouling, delayed flare-up, self-healing and anti-ice.

Contact: Senior Scientist Juha Nikkola, VTT Technical Research Centre of Finland



Polystyrene capsules with anti-fouling agents

6.13 Hybrid materials offer new property combinations

Novel materials for future machinery

The focus of the HYBRIMAT and Ecobearings projects was to evaluate, develop and manufacture new hybrid materials that will be used in wear parts and structural components in various applications in machine construction. The projects have enabled wider use of this new group of materials in Metso and created important information about the material properties for designers. A state-of-art review of the currently used components was followed by design/selection of new hybrid materials, which were then integrated into selected wear parts or structural bodies and evaluated. Furthermore, new manufacturing processes, material concepts and product features were introduced during the projects. Hybrid material technology offers an important competitive advantage: it enables customer-oriented product tailoring and differentiation in the markets.

Hybrid materials – Improved performance at competitive cost

- **Hybrid materials technology development (HYBRIMAT)**
- **Environmentally compatible bearing materials (Ecobearings)**

Metso Minerals Oy

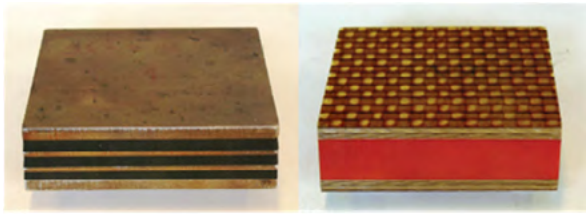
Metso Minerals has developed novel hybrid material solutions based on innovative material combinations. These are tailored for specific applications, such as crusher wear parts, thrust bearings and structural components.

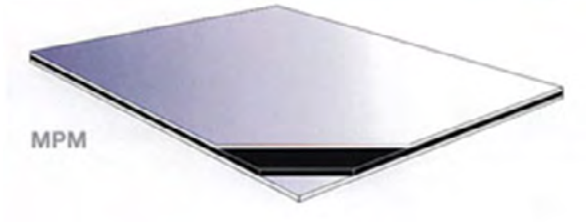
Impact: Novel hybrid materials offer property combinations that are not attainable by traditional materials. By innovative material engineering, the restrictions of current material solutions can be exceeded.

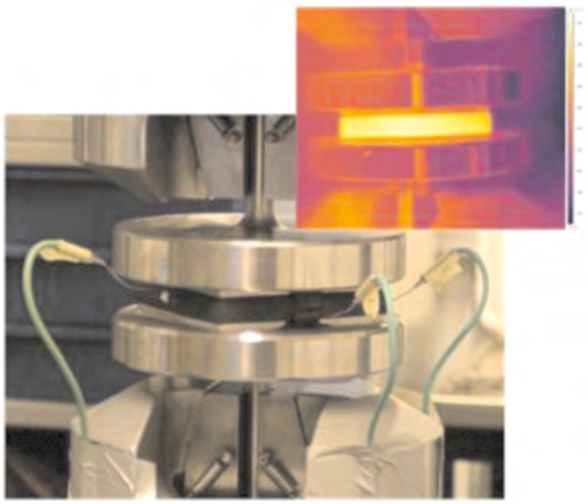
Metso Minerals has developed and evaluated systematically a number of hybrid material solutions during the two projects. As an outcome, an extensive database of hybrid material properties and performance in specific processes has been created. The most promising solutions have proceeded to the product development phase.

Metso is the leading global provider of equipment, solutions and services to the mining and construction industries. Metso's expertise is based on over a century of experience, and today's industry-leading solutions embrace the latest technology and an extensive services offering. In Finland, Metso Minerals employs about 1,000 people of the Metso total of 30,000.

Contact: Dr. Marke Kallio, Project manager,
Metso Minerals Oy, www.metso.com







New hybrid material structures for next generation tyres

Nokian Tyres is the only tyre manufacturer in the world that focuses on customer needs in northern conditions. The company supplies innovative tyres for cars, trucks and special heavy machinery mainly in areas with special challenges for tyre performance: snow, forests and harsh driving conditions in different seasons. Nokian Tyres' product development is consistently aiming for sustainable solutions for safety and the environment, taking into account the whole life cycle of the tyre.

Tyres are surprisingly technical products, consisting of many components and subject to tight requirements. They are active safety factors in vehicles, providing the only contact with the ground. Nokian Tyres also emphasizes the advanced features and originality of its products.

The Functional Materials project focuses on development of next-generation passenger car tyres utilizing novel material and structural solutions as well as advanced testing and simulation methods. The project combines consistently different areas of tyre development, including materials, conditions of use, and various research methods to develop new innovative technical solutions.

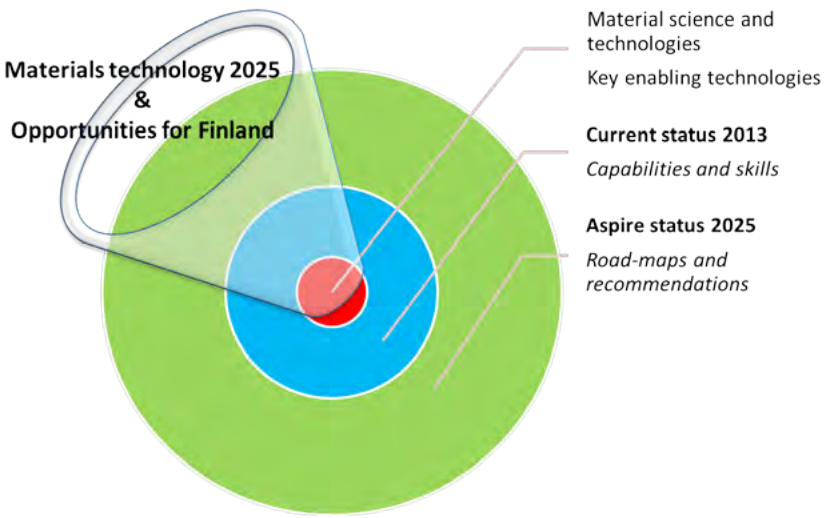
Contact: Mr. Tommi Ajoviita, Nokian Tyres plc,
www.nokiantyres.com

7

Next steps – Materials technology in Finland 2025

The Functional Materials programme has been the key driver of strategic research and development in Finland on advanced materials and manufacturing during 2007-2013, creating significant new multidisciplinary competences and emerging technologies. It is important that this asset will also be utilized in the Finnish innovation ecosystem after the programme.

The programme steering group has been actively discussing the future of materials R&D in Finland. During the last year, 2013, a vision work round was made by the steering group members with a few external experts in selected fields. The idea was to build some pictures of the future: How will the world look like in 2025; what is important for Finland, especially in term of materials technology; and define routes how to get there. The work was not aimed to be comprehensive, but instead give some fresh individual expert views for the discussion and planning the next steps at Tekes. The main outcome of this vision work was presented in the Final Seminar (11.12.2013, The Circus, Helsinki). Condensed summaries of selected topics are presented on the Table 3.



Next steps – Materials technology in Finland 2025

Table 3. Selected vision works done by the steering group members with a few experts.

Solar technology materials

Experts
Petra Lundström and Eero Vartiainen (Fortum),
Prof. Janne Halme (Aalto University),
Karin Wikman (Tekes)

Need

A huge amount of new renewable variable production capacity is entering the global energy system during the next decades. Solar is a great opportunity globally, but Finland is yet to grasp it. Therefore, it needs:

- To reduce system costs, higher efficiency modules and cells are needed. Silicon-based PV continues to dominate but several thin film technologies are emerging. In large-scale installation in sunny areas, concentrating photovoltaic (CPV) is a promising new technology.
- Manufacturing costs need to be reduced further, using cheaper materials and techniques.
- Other system components like inverters need to be more intelligent in order to better adjust to the fluctuations in power production and consumption.
- Energy storage becomes the key technology in balancing as more variable production like solar and wind power enter the system.
- In solar thermal, competition with evacuated tubes will drive new and cheaper flat-plate collectors to be developed.
- Large-scale solar thermal with district heating is gaining more importance.
- Regulation and building codes are driving towards low-energy houses with solar installations. Architectural design requires more building -integrated PV (BIPV) solutions.

Approach

PV cells and manufacturing

- High-efficiency silicon solar cells: Tandem structures, n-type silicon, back contacts
- Cost-effective solar cell manufacturing: Anti-reflective coatings, surface passivation (ALD)
- High-efficiency CPV cells: Dilute-nitride materials in III-V multijunction cells, quantum dots and other nanostructures
- Low-cost, large-area thin film cells: Roll-to-roll manufacturing techniques and materials
- Increased reliability and system lifetime: Better control of material impurities, more endurable materials.

Systems and balancing

- Intelligent inverters: Increased functionality in inverters to control the imbalance between production and consumption
- Cost-effective mounting structures: New solutions and materials for cheaper mounting and construction of PV systems
- Electricity storage: Carbon nanomaterials in battery electrodes- Power to gas: Electrolysis and methanisation with surplus PV production to allow seasonal electricity storage
- Heat storage: Phase-change and other materials to allow seasonal heat storages.

BIPV and solar thermal

- Glass and encapsulation materials: Ultrathin materials for glass-glass BIPV, more durable encapsulation materials
- Coloured BIPV components: Organic and dye-sensitised cells for colour tailoring- High-efficiency solar collectors: High-efficiency flat-plate solar absorber materials
- Lightweight and thinner collectors: Polymeric materials
- Functional insulation: See-through insulation materials

Recommendations

There is a clear need for a Finnish solar research funding instrument, but no need for a special material research program. More emphasis should be put on system issues, e.g., grid integration, storage and hybrid systems.

- Basic research funding for universities should be more long-term and concentrated on key topics and best groups.
- Applied research should be driven by needs of the industries and clearly separated from the basic research.
- Finnish solar industrial cluster should define clear targets together and then employ the best researchers to each topic.
- Networking between the industries and research scientists should be encouraged, e.g., by arranging workshops regularly.

Photonics and optics

Experts
Markku Oksanen, Prof. Seppo Honkanen (University of Eastern Finland),
Prof. Harri Lipsanen (Aalto University),
Goery Genty (Tampere University of Technology)

Need

Finland has a solid scientific and industrial application background in semiconductor lasers, specialized fiber lasers and optoelectronics, traditional optics and modern optics including diffractive optics and nanophotonics and replication of nanophotonics. In general, photonics is one of the key enabling technologies. However, photonics contains often micro- and nanoelectronics, biotechnology or nanotechnology, i.e., combining different enabling technologies. This convergence should be strengthened.

Approach

Atomic Layer Deposition (ALD)
Finland has world-leading expertise on ALD. However, the use of ALD for photonics applications is still in its infancy.

Nanocarbon Materials
New nanocarbon materials have recently emerged and they are expected to play a significant role, e.g., in future electronics and photonics. The first applications are expected to be in the field of photonics, e.g. by using graphene as the enabler of future mode-locked fiber lasers.

Materials for Specialty Fibers
Finland has significant expertise on fabrication of optical fibers and fiber based devices. In addition to the academic players, we have several high-tech companies working in the field. In the future, there will be a high demand for new types of telecom fibers and specialty fibers, e.g., for sensors and materials processing. New materials play a crucial role in specialty fibers.

Recommendations

We recommend initiating a few longer term research projects having partners from selected key laboratories. These projects should obviously be chosen from potentially important themes, in which there can be huge global commercial markets in the future. When dealing with future materials for photonics, the projects should be highly multidisciplinary and international. Selecting projects that are based on strong existing expertise in Finland is of crucial importance. This way we have the potential to be truly competitive in the new emerging markets.

A possible concrete example case, i.e., a project on specialty fibers and fiber. In order to be able to provide meaningful numbers to the tables below, a thorough market study is required. In this particular case we need to invest only in the preform fabrication facilities. Everything else, e.g., ALD, graphene fabrication, fiber drawing, device fabrication and companies utilizing the results already exists.

New manufacturing technologies – High productivity ALD for mass production

Experts
Pekka Soininen, Mikko Söderlund and Sampo Ahonen (Beneq) and
Prof. Harri Kopola (VTT Technical Research Centre of Finland)

Need

Advances in the ALD process and equipment technology, driven by the general need for higher quality thin-films, have enabled ALD to step out from the traditional SEMICON industry ties into new, high throughout and large area application. Today recognized new ALD applications are in EL displays silver passivation, crystalline silicon cell back side passivation, and more recently encapsulation of OLED lighting and display devices. Common demand for all these new applications is several decades faster throughput and consequently lower manufacturing costs (in comparison to SEMICON).

ALD has reached the level where it is fast enough and economically competitive technology for those applications. What is now needed is top-down analysis of the value chains and end-products that benefit from the ALD technology (e.g. smart packaging, flexible electronics, single use medical analysis, …) and creating and implementation of such ambitions projects.

Approach

At first phase the existing ALD reactor technology has to be transferred to fit inline production. This will need reactors with capability to process gen 5.5 substrates in 3 min tact times (sheet to sheet). The fast processing capabilities is the key part to develop. This will need improvements to the technological solutions and process types. The answers are here but those have to be developed further.

Meanwhile the robustness and cost reduction of the R2R technology has to reach the needed level. At best this can be achieved by applying the R2R technology at less demanding (matured) applications. As example these can be used as protection for printed electronics, medical packing, low end barriers, CIGS buffer layer, etc.

In practice this will need defining, piloting, testing and marketing new applications of several business areas like: Nanocellulose, paper, filters, batteries, etc. This work will need close operation with at related business areas through the value chain. The first large area ALD reactors and R2R pilot scale reactors are at pilot phase. Those can be utilized for application development.

New products developments

- End market perspective; what market needs, understanding of the market, understand our role in the value chain
- Utilization of existing R2R, plasma, batch processing capabilities we have in our hands
- Simple and robust production technology to adapt existing business areas

Value chain built-up

- Visio of the product
- The right partners
- Natural part of the product flow
- What is needed to do right to reach the market; precursors, precursor delivery, substrate material suppliers, ALD equipment, integrator (like cluster tool and other sub processes), end user (tool), product, end user.

Recommendations

We have ALD -technology in our hands, market is there, we have a strong position in technological point of view and Finland has other businesses which could benefit of ALD. This position has to be utilized.

We need systematically identified opportunities and combine those and make new value chains where we can utilize our natural strengths.

Also new challenges should be taken instead of just cutting and saving in costs. Challenges have to be big enough to target into mass production markets. Branch of industries and areas could be paper, machinery, energy, bio, climate and detectors.

New manufacturing technologies and Printed Intelligence

Experts
Kari Rönkä, Jukka Hast and Harri Kopola
(VTT Technical Research Centre of Finland)

Note: This is a shortened version of the comprehensive vision and road-map work done by VTT.

Need

Integrated Smart Systems (ISS) provide novel enabling functionalities and as such are currently a driving force behind disruptive product innovation. The heterogeneous integration of multidisciplinary functionalities into single devices promises to open a variety of totally new value propositions. The new products like disposable diagnostics, smart lighting, interactive packaging and large-area sensors will satisfy demands in terms of comfort, safety, style and usability.

Cheap, mass-produced smart systems built around organic, flexible and large-area electronics will create many new business opportunities. The development of low-cost and scalable production techniques with comparably low CAPEX for flexible and large-area electronics will provide a unique opportunity for Europe and Finland, especially for SMEs to capture market share and growth in smart systems manufacturing as well as products and novel services derived from them.

A major challenge is the need to improve business development and commercialization models. There is a clear need for investment in integration capability to launch the first generation of products and, equally, for more effective knowledge transfer from complementary industries such as traditional print media and printed-circuit board as well as silicon front-end and hetero-integration packaging technologies. The latter represent opportunities to engage mature and declining industries in this new wave of electronics.

Approach

Short term objectives for Printed Intelligence and Flexible electronics development focus on the availability and usability of existing components as well as improving high throughput R2R and S2S processes enabling integration and processability of heterogeneous functionalities in one single device or simple system. Medium and long term objectives will lead to really autarkic devices combining high complexity in single autonomous devices through optimum continuous and batch production process integration. The last goal will be manufacturing of multifunctional 3D objects by combination of printing, assembly, lamination, thermoforming and In-Mould Labelling processes.

The development of ISS devices together with companies utilizing technologies for overall different market fields will require a successful finalization of the knowledge and investment arising both from national/public institutes and private leading industries. To achieve manufacturing of functional innovative ISS a strong innovation with a solid orientation on customers' needs, market requirements, and societal demands is requested.

Recommendations

1. Enhance capabilities of integration and end-user companies to utilize Printed Intelligence technologies in their current and future products, services and new innovative business models.
2. Create such an investment eco-system with which a remarkable number, e.g. 100 new SMEs with broad variety of niche market opportunities and openings will be created. The potential Printed Intelligence application range is huge but diverse and therefore, would suit well for broad Finnish SME pool.
3. Finnish/European public procurement to help creating first markets for integrated smart systems in key application segments of i) Diagnostic systems, healing and comfort, ii) Large area sensors, iii) Intelligent Smart Lighting and Optical Systems and iv) Smart packaging and objects
4. Reinforce Global Leadership of Finnish R&D centres & Printocent Pilot manufacturing environments.
5. The supplier push needs to be changed to true user pull for example with application-driven scale-up projects for boosting the user-feedback and user-demand with continuous flow of broad-enough (100 000+pcs) market trial campaigns targeted directly to consumers.

Engineering and machine building - Case: Mining industry applications

Experts
Jari Liimatainen (Picodeon),
Prof. Veli-Tapani Kuokkala (Tampere University of Technology),
Prof. Simo-Pekka Hannula (Aalto University)

Need

Mining industry has been a growth business during last 10 years of materials and metals super-cycle. Industry's key players are OEMs, service providers, end users and academia. Mining industry needs includes extreme requirements for materials and component solutions, however, materials solutions are mainly traditional. Service business i.e., operational expenditure (OPEX) are major business issue for OEMs, service provider and mining and metallurgy companies.

Approach

Materials technology for mining industry

- New materials and manufacturing used in >50% of the applications
- Hybrid materials and structures in use in most of the demanding high wear applications
- Finland is global leader in high performance wear solutions for mining

Qualitative

- Finnish mining industry cluster is global leader and forerunner in development and utilizing materials technology developments
- Finnish universities and research institutes are global scientific leaders in wear materials R&D and related manufacturing technology development
- Wear materials and tribology professor to Aalto or Tampere University of Technology
- Finnish mining industry OEMs and material suppliers carry out >30 % of materials R&D in Finland

Quantitative

- Wear materials & components represent 25 % of total mining industry OEM business and >70 % of services business
- Life cycle costs of mining operators are reduced by -15 % using new material solutions
- New material solutions (e.g. hybrid materials, new elastomers, composites, new steels) represent >50 % of total wear material offering
- Finnish industry´s domestic mining and mineral processing related wear and other material production is 5x present
- The combined materials and component R&D related to mining and metallurgy among industry and academia solutions is three times the present.

Recommendations

Wear parts and consumables

- New wear materials and manufacturing methods for longer life time, improved asset management and lower life cycle costs

More reliable machinery

- Mechanically more reliable structures (fatigue, fracture, creep, bearings)

New process solutions

- Components and materials allowing new processes and equipments

Intelligence

- Self-diagnostics

Activity and functionality

- Vibration and noise damping

Materials enabling improved energy efficiency in buildings

Experts
Niklas Bergman (Paroc), Ari Ahonen (RYM SHOK)

Need

Theme includes all building materials and related solutions that can significantly contribute to increased energy efficiency in buildings e.g., new insulation material with improved insulation properties enabling thinner constructions.

- Future energy efficiency demands will require new building materials and solutions to be developed.
- Building will be at a passive house or zero-energy building level, and compared to current solutions there are significant development potentials.
- Not only products, materials and solutions have to be developed, but also the ways to manufacture them cost efficiently, deliver and install them according to customer needs, and ensuring a long life-span and recycling possibilities at the end of the life-cycle.

Approach

Focus should be put on identifying areas for development and new business opportunities, and on building up the necessary basis for cooperation and carrying out the development projects. Success requires cooperation between many stakeholders, and professional partners in each area.
Research is needed to keep feeding new ideas and technical opportunities
Analyse which are the important areas for future growth, where we can be successful also outside Finland e.g. "arctic building". Take the entire customer and market needs into account.

- Integrate known solutions and materials
- Easy to use and install
- Sustainable, life span and recyclability

Focus on improving the overall solutions

- Insulating, overall constructions and surface materials
- Heating, cooling, heat recovery and heat storage
- Integrating energy supply solutions e.g., solar
- Intelligent control of indoor conditions, adapting to use of the building

Use the right resources. Full range from material research to customer. Ensure we "do the right things" and "do them right".

- Customer and contractor
- Building experts from wide field
- Project management professionals
- Financing and support e.g., Tekes
- Material and manufacturing experts (industry and university)
- Material research

Build up a good basic network consisting of above mentioned stakeholders.

- Make cooperation and project start-ups easy
- Open innovation

Ensure new innovations and technology driven opportunities through research,

- Long term focus areas for research (research programs)

Recommendations

Focus more on applied development and further development of new solutions.
Build up networks and "open innovation", promoting creativity in networks, enabling new innovations and identification of the right projects to proceed with. Be quick from idea to pilot project to ready new concept.

Cellulose based material applications

Experts
Lars Gädda and Markku Leskelä (FIBIC) as well as Prof. Herbert Sixta (Aalto University), Prof. Ilkka Kilpeläinen and Prof. Heikki Tenhu (University of Helsinki)

Need

Several – big and small – material markets are looking for a (bio)renewable alternative.

- Replacing fossil raw materials - rising or fluctuating oil prices
- Market recognition of biomaterials as "green" products
- General sustainability but specifically mitigating global warming
- "Green" policy initiatives by local governments in individual countries.
- Improvements in performance – better technology - widen the opportunities.

Restraints:

- Competition from petroleum-based products, also shale gas and oil.
- Agricultural biomass competes with forest feedstock in some applications: Grows faster, GMO supported cultivation.
- Many of the green policies concentrate or work better for agricultural biomass
- Easier to process; lignocellulose is heterogeneous and costly to break down
- However, seasonal availability and high inorganic content are issues for many agricultural feedstock

The key requirement for biorenewable materials is substantial R&D&T both in petrochemical industry and agriculture related industries. Cellulose-based materials must be price competitive and match in material properties.

Approach

Cellulose

- Continue and expand cellulose basic research
- Explore opportunities in process research: foam forming, ionic liquids, etc.

Textiles

- Expand value chain programs and develop demonstration environments.

Cellulose or wood based new packaging materials

- Organize a discussion round to identify company interest, support it with state-of-the-information.
- Establish value chain programs on selected topics, and later, be prepared for demonstration environments.

Lignin

There is a serious question whether a Finnish lignin research competence should be developed more actively. Current teams and also the company interests are scattered.

- Evaluate the Finnish lignin research
- Organize a discussion round to identify company interest, support it with state-of-the-information
- If there is interest: establish value chain programs on selected topics, and later, be prepared for demonstration environments.

Recommendations

Construction materials offer a range of big opportunities. Current company strategies do not support major efforts in the joint research arena. However, this should be questioned (FIBIC and RYM SHOKs). If common agenda can be identified, actions should follow.

Cellulose and lignin research should be exploited and commercialized also by SMEs for high value biomaterials. Appropriate information dissemination and R&D support funding should be organized. Also other SME funding for expanding successful cases.

Smart packaging (Smart packaging portion, Smart portion distribution, Future Lunch)

Experts
Margareetta Ollila (Pakkaustutkimus-PTR),
Henry Lindell (Lappeenrata Univeristy of Technology),
Noora Nylander (Lahti University of Applied Sciences),
Reima Rönnholm, PALMU, Inc.

Need	Approach	Recommendations
There is a growing demand to spare in public expenses and, on the other hand need to more versatile and healthier public eating. School eating and working place eating distribution, hospitals, care serving, wherever where there are more people to bring bigger deliveries. Servings according to personal wishes and diets, adjusted for different ages and taking allergies considered. Various alternatives, you can even order a supper.	Designing and developing intelligent packaging. The infrastructure is already there, but it must be enhanced and designed to offer service in improving the quality of life. Fast and versatile logistics chain, to combine all small and different pieces together. Designing and developing smart and intelligent packagings: • Biodegradable coatings which can be removed between uses, the packagings will be returned and reused. • The packagings will be personalized to be able to recognize your own. • Organizing the orders, taking into account existing routes in planning the deliveries. • The application will register the portions that have been eaten and the invoicing is based on them. • Also the parents can easily monitor how their children eat. Joining the near-by food production to the system.	Drafting (piloting), service design, school co-operation and workshops will be used to find out the service needs for service design. • Co-design, touch point -matrices • School piloting • Customer journey mapping for using product and service as well as identifying experience bottlenecks

Functional materials awards

Functional Materials recognition awards were given to the following persons and companies in the final seminar of the programme:

- **Young scientist**: Dr. Kaarlo Paakinaho, Tampere University of Technology
  "High scientific quality, good results and communications skills demonstrated"
- **Scientific breakthrough**: Prof. Marjo Yliperttula, University of Helsinki
  "Persistent multi-disciplinary research has proved the potential of nanocellulose in medical applications opening new opportunities for research and business"
- **Leading science and international cooperation**: Prof. Maarit Karppinen, Aalto University
  "High scientific quality, challenging research topics and good results serving industry needs, building of a battery research value chain with important international links"
- **Technology breakthrough:** Canatu Ltd.
  "From deep science to emerging industrial technology solutions needed in flexible electronics; high-performance solutions, green material and manufacturing process, big opportunities"
- **Commercialization breakthrough**: Beneq Ltd.
  "Systematic application and need-driven R&D resulted in two commercial breakthrough products and global business (Roll-to-Roll ALD and aerosol technologies for photovoltaics and flexible electronics)"

Acknowledgements

The following people have contributed to the programme management (different time periods during the programme, 2007-2013)

Programme Steering Group members:

- Chairman: Jari Liimatainen (Picodeon, earlier Metso)
- Lars Gädda, (FIBIC)
- Petra Lundström (Fortum)
- Markku Tilli (Okmetic)
- Heikki Mononen (Finex)
- Margareetta Ollila (Pakkaustutkimus - PTR ry (Association of Packaging Technology and Research))
- Pekka Soininen (Beneq)
- Henrik Österlund (Motiva)
- Pertti Ikäläinen
- Markku Oksanen and
- Tapani Ryhänen (Nokia)
- Väinö Tuomisalo and
- Niklas Bergman (Paroc)
- Markku Lyyra (VTI Technologies)
- Kauko Kurkela (Novagenesis)
- Jari Strandman (IP Finland)

Tekes team:

- Markku Lämsä
- Solveig Roschier
- Reijo Munther
- Jukka Leppälahti
- Teija Lahti-Nuuttila
- Jukka Laakso
- Sisko Sipilä
- Aila Maijanen
- Kari Ruutu
- Mikko Ylhäisi
- Pia Mörk
- Sanna Nuutila
- Pertti Heinonen
- Kalevi Pölönen
- Ritva Taurio (Academy of Finland)

Coordination team at Spinverse:

- Markku Heino
- Anneli Ojapalo
- Vilja Vara
- Laura Kauhanen
- Johanna Saari
- Jesse Koskinen

Thanks to all project partners and the huge group of active participants at our events!

Special thanks to the Blues Bastards for creating a good atmosphere at our events.

Company project descriptions

Project Full Name (acronym)
Fire-Retardant Adhesives [Rakenneliimojen palonkeston parannus] (RAKPOP)

Organisation
Kiilto Oy

Contact Person
Pirjo Laurila

Partners
Åbo Akademi University

Project duration
1.3.2008 – 1.4.2010

Total cost (€)
502 169

Main target
Improve fire resistance of 2-part polyurethane adhesive with halogen free (Cl, Br ect.) solution.

Motivation
More safe adhesive, opportunity for customers to develop better products for maritime and construction applications.

Key results and impact
Significantly better formulation was developed.

Commercialisation status (demos, pilotings, investments, products, services)
Product has acceptance for maritime application (IMO Part 5). Piloting with customers.

Number of patents and patent applications
One patent pending.

Project Full Name (acronym)
Printable electrified air filter (ELFIL)

Organisation
Tamlink Ltd

Contact Person
Jari Erkkilä

Partners
Ahlstrom Tampere Oy, Elixair Oy, Panipol Oy, JokerCard Finland Oy

International partners - if any (country, organisation)
Camfil AB

Project duration
1.5.2008 – 30.4.2010

Total cost (€)
632 000

Main target
The aim of the project is to develop a commercial prototype of printable electrified air filter.

Motivation
Efficient filtration of supply air is one of the major tools for improving indoor air quality. The growing awareness of the adverse health effects of airborne particles has shifted the role of air filtration towards protecting people.

Key results and impact
The ELFIL technology was demonstrated during the project by developing a prototype filter. The efficiency target was achieved and it remained high for about 6 months in field test. However, the stability of the conductive ink turned out to be the biggest practical problem during the project. Therefore some other electrode structures were designed and demonstrated in the project. It was concluded that the field of application of the ELFIL filter will be limited mainly due to high relative humidities in certain environments.

Commercialisation status (demos, pilotings, investments, products, services)
Partners have tested developed technology in several pilot systems. At the moment companies are analysing potential and suitable markets for the product. So far the commercialisation has not been started.

Project Full Name (acronym)
Alkaline batteries for recycling process as well as the development of raw materials recovery rate by increasing

Organisation
AkkuSer Oy

Contact Person
Jarmo Pudas

Partners
Ketek, Outotec, OMG Chemicals, Boliden Zink

Project duration
7.11.2008 – 31.12.2009

Total cost (€)
121 000

Main target
Promote new technology-based business creation. Process of the emergence, development and challenge the international level is high. The project has a high environmental impact.

Motivation
EU battery directive control collection and recycling technologies. Main alkaline battery recycling plants are closed.

Key results and impact
Pre-study of metals and compounds from alkaline batteries. Pre-study of possible new technology road.

Commercialisation status (demos, pilotings, investments, products, services)
www.recalkaline.fi

Number of patents and patent applications
2

Project Full Name (acronym)
Through-Silicon-Via [Piin sähköiset läpiviennit] (Sählä)

Organisation
Okmetic Oyj

Contact Person
Markku Tilli

Partners
Detection Technology Oy, VTT Technical Research Centre of Finland, Aalto University

Project duration
1.9.2007 – 31.10.2009

Total cost (€)
942 846

Main target
To develop electrical contacts through silicon (TSVs) suitable for X-ray detector applications

Motivation
Complex large area X-ray detectors and 3D-integration of components require TSV technology

Key results and impact
Basic process and product was developed, but it was too expensive for original application. Development work has continued since then with new, more cost effective technologies and focus in now in MEMS applications

Commercialisation status (demos, pilotings, investments, products, services)
Development continues and pilot scale deliveries are made, and a new type of mems device is desingned by customer based on Okmetic TSV wafers

Number of patents and patent applications
1 patent application filed

Project Full Name (acronym)
Durable, easy cleaning and hydrophobic surface treatment for natural stones (Coligro - the Future of Surfaces)

Organisation
Coligro Oy

Contact Person
Chairman of the Board Panu Miettinen

Project duration
1.30-2010 – 31.10.2012

Total cost (€)
1 040 000

Main target
To make natural stoner hydrophobic (water repellent), durable and easy cleaning. Project focused on Marble and Granite.

Motivation
Weathering phenomena and aging of Natural Stones (Marble and Granite) causes major problems and thus, the usage of e.g., Marble as façade material has dropped significantly.

Key results and impact
Benefits of utilizing Coligro Solution are evident and can also easily be converted into monetary savings (business case and ROI).

Main benefits and their direct cost saving / value increasing impact
1) Everlasting surface: Prolonged life-cycle and minimal maintenance costs
2) Practically no corrosion – no need to replace the surface material over time
3) Single treatment - no need to repeat the surface treatment
4) Self-cleaning surface – Maintenance free, no need for cleaning and/or removing e.g., graffiti
5) Surface treatment applied at factory at industrial scale – excluding the extra logistics costs and re-treatment need at site
6) Air cleaning effect – Coating also purifies the air around the building
7) Sustainability – Eternal surface made at factory
8) Green values - No additional CO_2 footprint, grown brand image
9) Ecological - Totally environmental friendly solution

Commercialisation status (demos, pilotings, investments, products, services)
Pilot conducted in Finland. Global launch planned to 3Q2013

Number of patents and patent applications
4 patent applications

Project Full Name (acronym)
Sealing Solutions with Sustainable, Advanced Materials (SESAM)

Organisation
Underground Hard Rock Mining Research in Tampere

Contact Person
Markku Keskiniva as a project manager, Mari Tanttari as a coordinator

Partners
Tampere University of Technology. VTT Technical Research Centre of Finland

International partners - if any (country, organisation)
Germany, University of Aachen, Institut für Fluidtechnische Antriebe und Steuerungen (IFAS)
Scandinavian seal manufacturer

Project duration
1.1.2008 – 30.6.2010

Total cost (€)
1 059 000

Main target
In order to enhance the impact device maintenance interval, which is specified by the life time of the seals, better seal material and construction were needed.

Motivation
Efficient sealing is necessary for proper operation of the drill. There are several issues such as the worn of the whole drill rig increases due to oil leakage, the oil leakage creates oil fog which is safety issue for the user and also the environmental issues, which are coming more and more important.

Key results and impact
- The knowledge of the working parameters increased significantly. New construction and new seals were tested and the field tests were started.
- The co-operation and way of working both with research institutes and seal manufactures were improved.
- It was realized and accepted that the research in this area needs to be continuous process not just a project.

Commercialisation status (demos, pilotings, investments, products, services)
The found solutions for both new construction and for new seals have been launched in new products and they are used in market.

Number of patents and patent applications
Solutions developed were not patentable.

Project Full Name (acronym)
Next Generation Lithium-ion Battery Cathode and Precursor Materials

Organisation
OMG Kokkola Chemicals Oy

Contact Person
Janne Marjelund

Project duration
1.4.2009 – 30.6.2011

Total cost (€)
3 384 958

Main target
To develop new business, by new products and better application understanding to be able to react any market changes.

Motivation
Fits OMG's portable power strategy and gives ability to grow with the markets

Key results and impact
Creation of a patent applications: for Mixed Metal hydroxide precursors and for monocrystalline type $LiCoO_2$ and its precursor.

Creation of an extensive cathode material database, which can be used for data mining and serve as the basis for our future precursor material development.
Increased know-how allowing us to have more fruitful discussions with Li-ion battery makers.

Commercialisation status (demos, pilotings, investments, products, services)
Plant expansion ongoing at Kokkola giving a commercial scale capacity for new product commercialization.

Number of patents and patent applications
2

Project Full Name (acronym)
High Power Lithium-Ion Battery Cathodes (Cathode)

Organisation
European Batteries Oy

Contact Person
Mika Räsänen

Project duration
1.4.2011 – 31.5.2012

Total cost (€)
990782

Main target
To develop and design high energy density high power lithium-ion battery cathodes.

Motivation
Both the power and energy density are extremly important in hybrid-electric applications.

Key results and impact
EB was able to develop a new cell energy cell with higher power density.

Commercialisation status (demos, pilotings, investments, products, services)
The improved cathode has been in the production since Q3/2012. The project provides also basic research to EU funded SuperLib project, where the first high power batteries has been piloted in 2013.

Number of patents and patent applications
1

Project Full Name (acronym)
Integrated Emfi Button (IEMFIN)

Organisation
Screentec Oy

Contact Person
Aki Ylönen

Partners
VTT Technical Research Centre of Finland, Lake Group

Project duration
1.8.2010 – 1.2.2011

Total cost (€)
515 900

Main target
Integrated EMFI button into injection molded parts with illumination.

Motivation
Customer requests.

Key results and impact
None, need changed during project due economic constraints and refocus.

Project Full Name (acronym)
Improved diffusion barriers and adhesion technology for demanding thermal and electrical conductivity applications

Organisation
Aurubis Finland Oy

Contact Person
Dr. Petri Konttinen

Project duration
1.1.2008 – 31.12.2011

Total cost (€)
880 625

Project Full Name (acronym)
Environmentally compatible bearing materials (ECOBEARINGS)

Organisation
Metso Minerals Oy

Contact Person
Dr .Marke Kallio

Partners
Tampere University of Technology

International partners - if any (country, organisation)
Spain, Wisco-Mecauto
Spain, Tekniker

Project duration
1.12.2008 – 31.12.2011

Total cost (€)
960 477 (Metso Minerals Oy)

Main target
The aim of the ECOBEARINGS project was to develop a feasible substitute material for the currently used lead bronzes for tribological applications in heavy machinery (e.g., cone crushers).

Motivation
Lead has been widely used in metal industry as an alloying element and as an additive in metallic coatings, solders and brazing alloys. Lead is a heavy metal, which can cause health risks during the production (foundries) and application of lead containing alloys. Lead-containing materials can also cause environmental and occupational hazards in the end-of-life treatment of machines. Due to these hazards, there is a growing demand for finding feasible substitutes for lead in many industrial applications.

Key results and impact
The sliding bearings are the most important single components in cone crushers. Ecobearings project has produced a lot of extremely important new information of the thrust and journal bearing materials and the effects of the bearing design, geometry and surface topography. It serves as a basis on further development of environmentally and energy-efficient sliding bearings. Wisco- Mecauto has also developed and commercialized low-lead bearing bronzes during the project.

Commercialisation status (demos, pilotings, investments, products, services)
The most potential bearing bronzes have been field tested in Metso crusher. However, Metso will not commercialize these alloys but will subcontract the production. Wisco-Mecauto has developed and commercialized low-lead bearing bronzes during the project.

Project Full Name (acronym)
Improved diffusion barriers and adhesion technology for demanding thermal and electrical conductivity applications

Organisation
Aurubis Finland Oy

Contact Person
Dr. Petri Konttinen

Partners
Tampere University of Technology, Coresto Oy

Project duration
1.1.2008 – 31.12.2011

Total cost (€)
880 625

Main target
Main target was to gain deep understanding of the aging mechanisms of copper/diffusion barrier -interfaces, and to develop improved solutions for demanding applications.

Motivation
Aging of copper in higher temperatures causes degradation of properties and reduces adhesion of the coating. Improved diffusion barriers can lower or diminish these effects.

Key results and impact
Deep understanding of the aging mechanism in copper and diffusion barrier. New, improved solutions for better diffusion barriers.

Commercialisation status (demos, pilotings, investments, products, services)
Starting of Aurubis Nordic Brown and other prepatinated copper products into Nordic Solar, development of significantly more efficient solar absorber.

Number of patents and patent applications
Two patent applications

Project Full Name (acronym)
Hybrid materials technology development (HYBRIMAT)

Organisation
Metso MInerals Oy

Contact Person
Dr. Marke Kallio

Partners
Tampere University of Technology, Oulu University

International partners - if any (country, organisation)
University of Bremen (Germany), IFAM (Germany), NRC coordinated project: Improved wear protection for materials handling equipment in mining and mineral processing (Canada)

Project duration
1.3.2008 – 31.12.2012

Total cost (€)
2 722 000

Main target
The focus of the HYBRIMAT project was to evaluate, develop and manufacture new hybrid materials which will be used in wear parts and structural components in various applications in machine construction.

Motivation
The project enables wider use of this new group of materials in Metso and will create important information about the material properties for designers.

Key results and impact
The research has been divided in different areas, the most important were the hybrid wear materials, hybrid light structures and surface hybrid modifications. Several new potential material combinations have been evaluated and tested in lab and field. Extensive amount of material and wear data has been generated for design purposes.

Commercialisation status (demos, pilotings, investments, products, services)
Several pilot tests have been conducted during the project. One new product has been launched and commercialized during the project (Super Jaw). Several other potential products are being evaluated.

Project Full Name (acronym)
Advanced Nano-Carbon Materials (Advamat)

Organisation
Carbodeon Ltd Oy

Contact Person
Dr. Vesa Myllymäki

Project duration
22.11.2010 – 31.08.2012

Total cost (€)
738 770

Main target
The project main targets included development of certain new, application specific nano diamond grades and proving their expected improved performance within thermoplastic thermal compounds, silicone based thermal compounds as well as lower friction, better wear property fluoropolymer coatings.

Motivation
The application fine-tuned nano diamonds accomplish greater reproducibility of further enhanced product properties, with significantly less nano diamond additions and thus, cost efficiently.

Key results and impact
The key results include development of two new nano diamond grades and proof of their improved usability in mechanically enhanced fluoropolymer coatings and polymer based thermal compounds. The project resulted in two new patent applications, one covering novel nano diamond containing thermoplastic compounds, the second mechanically improved fluoropolymer coatings.

Commercialisation status (demos, pilotings, investments, products, services)
Carbodeon is investing in scaling up the production of developed nano diamond grades. The developed materials are currently tested by a wide variety of customers, especially within applications developed within the project.

Number of patents and patent applications
The project resulted in three different patent applications

Project Full Name (acronym)
Osteoplastic Vaihe 2

Organisation
Ozics Oy

Contact Person
Heidi Hinkka

Partners
Mectalent Oy

International partners - if any (country, organisation)
University of Bern, Switzerland

Project duration
1.12.2011 – 30.11.2012

Total cost (€)
430 000

Main target
To investigate, how the material developed in the previous phase of the project suits the needs of more demanding application, i.e. fracture fixation. This will be followed by rigorous testing, both biomechanical and clinical.

Motivation
The purpose of the project is to develop an injectable, load bearing fracture fixation device that can be applied through minimally invasive surgical means.

Key results and impact
The material seems to have sufficient strength characteristics to be used for the intended indication.

Commercialisation status (demos, pilotings, investments, products, services)
Product from Phase 1 CE marked and in the market for a year. Sales started in Europe.

Number of patents and patent applications
2

Project Full Name (acronym)
Tribological gold plating

Organisation
Eforit Oy

Contact Person
Lauri Virta

Project duration
1.7.2010 – 31.5.2012

Total cost (€)
67 770

Main target
Improve the wear resistance of gold plated deposits. Longer service / life cycle for parts being plated.

Motivation
Making parts more durable improves the product life cycle which reduces the use of natural resources.

Key results and impact
Our tests have shown that the wear resistance of tribological gold plating is much better than that in a "regular" gold plating.

Commercialisation status (demos, pilotings, investments, products, services)
We are still doing some tests before we will start to commercialize our new gold plating. The new gold plating that we offer could be a major advantage to our partners that work in the high tech industry.

Project Full Name (acronym)
Second generation Sirius olefin polymerization catalysts (SGSC)

Organisation
Borealis Polymers Oy

Contact Person
Peter Denifl

Partners
University of Joensuu, Department of Chemistry (Professor Tuula Pakkanen); University of Joensuu, Department of Chemistry (Professor Tapani Pakkanen); University of Helsinki, Laboratory of Polymer Chemistry (Professor Heikki Tenhu); Helsinki University of Technology, Laboratory of Chemical Engineering and Plant Design (Professor Markku Hurme)

Project duration
1.1.2008 – 31.12.2008

Main target
The aim of this research project was the development of a family of novel and efficient olefin polymerization catalysts based on Borealis' proprietary Sirius technology. In addition to obtaining a better fundamental understanding of the emulsion based Sirius technology, and consequently to be able to further extend its potential application range, this included also the development of a preparation technology that allows producing these catalysts in commercial scale.

Motivation
The ability to develop and manufacture proprietary catalysts for the production of its most advanced polyolefins lies at the heart of Borealis' polyolefin growth and innovation strategy.

Key results and impact
This project has significantly contributed to increase Borealis' overall knowledge and fundamental understanding on how the Sirius emulsion technology can successfully be employed as particle formation process for the preparation of Ziegler-Natta as well as "single-site" catalysts. This resulted not only in catalysts with excellent particle morphology and consequently a good polymerization process performance but allowed also to optimize the catalyst's chemistry for obtaining the desired polymer properties.

In addition, the technology for the preparation of these emulsion based catalysts was further developed and its suitability for the production of Sirius catalyst in pilot scale was demonstrated.

Commercialisation status (demos, pilotings, investments, products, services)
The construction of the semi-commercial polyolefin catalyst plant in Linz, Austria was completed in August 2012. A first batch of Borealis' Ziegler Natta polypropylene catalyst, based on its proprietary Sirius emulsion technology, was produced in December 2012.

Number of patents and patent applications
8

Project Full Name (acronym)
Cathode Materials for Lithium Ion Batteries

Organisation
OMG Kokkola Chemicals Oy

Contact Person
Timo Kankaanpää

Project duration
20.5.2011 – 31.12.2012

Total cost (€)
Budget 1 940 000

Main target
Develop new battery chemicals for lithium ion battery applications.

Motivation
The usage of portable power and especially lithium ion batteries is increasing in different application areas.

Key results and impact
New materials were developed.

Commercialisation status (demos, pilotings, investments, products, services)
Pilot-scale tests were successful.

Project Full Name (acronym)
Premix's high tech products

Organisation
Premix Oy

Contact Person
Tuomas Kiikka

Project duration
1.7.2009 – 31.10.2011

Total cost (€)
1 684 981

Project Full Name (acronym)
Developing of new joining technics

Organisation
NWE Network Engineering Oy

Contact Person
Kimmo Weissenberg

Project duration
1.3.2009 – 31.1.2010

Total cost (€)
88 700

Main target
To find technics for joining wowen coated PP-plastic fabric to wowen PP or PES strap. Reuirements: breaking strength, weight and durability. Goal: to minimise labour intensive sewing work.

Motivation
Sewing is, besides labour intensive, also risky moment and is not easy to automatize. Light weight and high tensile strength in the joint could replace sewing and then speed up the production as well as improve quality in the cargo securing material we produce.

Key results and impact
Automatic / programmable sewing machines, welding with hot air, hot plate or ultra sound and glueing technics are all containing weaknesses that reduce the quality of the joint when using these materials. A correct combination of sewing thread tension, stitch pattern and material elongation gave the best results despite of high production time and content of manual work.

Commercialisation status (demos, pilotings, investments, products, services)
The product, FIX Cargo Securing System, is commercialized long time ago and the project aimed to find alternatives in joining techniques. Some of these (hot plate & hot air welding) were found to be usefull but not in details were tensile strength is required. On the other hand spin-off products for marine industry (bulk head sealing gears) using the same fabric are produced utilizing hot plate welding.

Project Full Name (acronym)
Intelligent solutions (INTO)

Organisation
Metso Paper

Contact Person
Heikki Kettunen

Project duration
20.2.2009 – 31.12. 2010

Total cost (€)
1 844 875

Main target
New material solutions, advanced structures and intelligent components in paper machine solutions

Motivation
Improve competitiveness with advanced technology and generate new service possibilities for the future

Key results and impact
Simulations to predict performance of paper machine roll covers, improved cover materials, new roll structures to prototyping level, vibration and sensor solutions. Important results to develop further to customer products

Commercialisation status (demos, pilotings, investments, products, services)
Partly commercialized after the project, some products still in prototyping, some failed

Number of patents and patent applications
8

Project Full Name (acronym)
Plypro-1

Organisation
UPM-Kymmene Wood Oy

Contact Person
Pekka Peura (Anna Koski, Raija Rautiainen)

Project duration
1.1.2008 – 26.8.2009

Total cost (€)
1 900 000

Main target
Plywood is a versatile composite of wood and many synthetic materials. The management of properties and functional cooperation between wood and synthetic materials will be improved in the Plypro Programme to generate new applications for plywood and its manufacturing.

Project Full Name (acronym)
Plypro-2

Organisation
UPM-Kymmene Wood Oy

Contact Person
Pekka Peura (Anna Koski, Raija Rautiainen)

Project duration
1.9.2009 – 30.11.2011

Total cost (€)
2 300 000

Main target
Plywood is a versatile composite of wood and many synthetic materials. The management of properties and functional cooperation between wood and synthetic materials will be improved in the Plypro-2 Programme to generate new applications for plywood and its manufacturing.

Commercialisation status (demos, pilotings, investments, products, services)
Commercialised UPM Grada® New Thermoformable Wood Material

Project Full Name (acronym)
R2R ALD

Organisation
Beneq Oy

Contact Person
Mikko Söderlund, tel. 040 848 5036, mikko.soderlund@beneq.com

Project duration
1.9.2010 – 28.2.2013

Total cost (€)
1 851 750

Main target
Development Atomic Layer Deposition equipment and process from batch process to continuous Roll-to-Roll processing.

Motivation
ALD method provides excellent moisture barrier properties, but the batch process is not suitable for production logistics on barrier film manufacturers. Roll-to-roll process enables use of ALD for these applications.

Key results and impact
Roll-to-Roll ALD technology was successfully developed and scaled up to 500mm wide polymer web. First machine based on this technology is already in use at Lappeenranta University of Technology.

Commercialisation status (demos, pilotings, investments, products, services)
Pilot machine ready, now having discussions with multiple companies for production phase.

Number of patents and patent applications
10

Project Full Name (acronym)
Upscaling of fibril cellulose production methods and its applications (Nanosellu IV)

Organisation
UPM-Kymmene Oyj

Contact Person
Esa Laurinsilta

Partners
Aalto University, VTT Technical Research Centre of Finland

Project duration
1.1.2012 – 31.01.2013

Total cost (€)
3 960 000
Actual cost not yet reported

Main target
Development and scale-up of manufacturing processess for nano- and microfibrillated celluloses. Industrial application development.

Motivation
Target is to develop a commercially available bio-based nanomaterial for industrial use.

Key results and impact
Manufacturing processes that can be scaled up to industrial scale. Increased understanding of key characteristics of fibrillated cellulose, concentration and re-dispersion

Commercialisation status (demos, pilotings, investments, products, services)
Pilot manufacturing capability enables application development and testing at industrial scale.

Number of patents and patent applications
9

Project Full Name (acronym)
Nanomaterials for radio devices (NANORADIO)

Organisation
Nokia Research Center: Radio Systems Laboratory

Contact Person
Markku Oksanen, Tapani Ryhanen

Partners
The following departments of Aalto University participated in the project:

- Low Temperature Laboratory (School of Science)
- Department of Applied Physics (School of Science)
- Department of Chemistry (School of Chemical Technology)
- Department of Micro and Nanosciences (School of Electrical Engineering)

International partners - if any (country, organisation)
United Kingdom; Nokia Research Center Cambridge UK

Project duration
1.1.2011 – 31.12.2011 (The NanoRadio project was a continuation for the projects Nanosytems 1 (1.4.2007 – 31.12.2008) and Nanosystems 2 (1.1.2009 – 30.6.2010) within Tekes FinNano –program.)

Main target
1) New RF shielding materials vased on CNTM composites
2) Nanomagnetic polymer composites for RF applications
3) Robust superhydrophobisity: hierarchically patterned surfaces for controlled wetting
4) The simulation of grapheme based optoelectrical systemes: palsmonic sensitized grapheme photodetectors

Motivation
1) Increasing functionality of mobile devices leads packaging a number of electronics components in a very limited space. So far, metallic cans have been widely used as a shielding tool in mobile devices. However, they are expensive. Moreover, new form factors (e.g., Nokia's Morph-concept) request new properties from shielding materials such as flexibility and/or transparency. Thus, new shielding materials are needed.
2) Enables miniaturization of some of the radio frequency components (e.g., antennae and CMOS coils) using magnetic
3) Enables miniaturization of some of the radio frequency components (e.g., antennae and CMOS coils) using magnetic nanoparticle polymer composites with controlled electromagnetic properties (permeability, permittivity, dissipation factor).
4) Keeping surfaces clean with minimal effort is a very attractive property and one approach is to use superhydrophobic and superoleophobic materials, i.e. materials that strongly repel water and oily substances. Such superamphiphobic surfaces, where the liquid contact angle, defined as the angle between the tangents to the surface and liquid-air interface measured in the liquid, is in excess of ~ 150°, have the ability to clean themselves since droplets simply roll off carrying away dirt and contamination with them.
5) Graphene is a very rapidly rising star among nanomaterials. It has great potential in both terms of commercial applications, and for deeper understanding of fundamental physics. The exceptional transport and optical properties of graphene suggest novel photonic devices fundamentally different from conventional arrangements. Among the numerous future applications are graphene based photodetectors.

Key results and impact
1) Due to the large impedance mismatch between air and MCNT yarn, RF transmission, reflection and absorption depend strongly on either CNTN material (yarn) geometry and measurement set up (such as field direction, boundary conditions, etc.). The material still requires further extensive studies, but some particular engineering applications may not need so long time to realize.
2) The work was concentrated on the distribution of the magnetic nanoparticles within the matrix material and measurements of the RF properties at GHz frequencies of the composites. The mixing of the particles to the matrix material was tried in several different ways. Oleic acid stabilized particles and polystyrene were dissolved in toluene that was then evaporated, however, the particles were clustered in the polymer matrix. To reduce clustering via binding particles to polystyrene, oleic acid was replaced with undecenoic acid or docos-21-enoic acid and the particles

were mixed with styrene that was then polymerized. Unfortunately, the particles were poorly soluble and also distracted the polymerization reaction. Hence, the clustering problem remains unsolved at the end of this project.

3) Tapered glass pillars can be functionalised with low surface energy coatings to create superhydrophobic surfaces. These surfaces are resistant to mild abrasion using felt or leather abrader wheels, but the pillars act to increase removal of fibres from the abrader wheels which quickly cover the pillar surface and reduce the observed contact angles. The glass pillars are not hard enough to withstand very aggressive abrasion using alumina abrader wheels.

One of the key issues with creating a low surface energy coating on the pillar structures is to obtain good adhesion between the glass and the surface treatment. For the P2i acrylate polymers this was seen to be an issue since pencil testing showed the adhesion / scratch resitance of the polymer to be very poor.

Sapphire surfaces patterned with pillars were seen to have excellent abrasion resistance, even to the alumina abrader wheels, due to the extreme hardness of sapphire. Again, there was an issue with obtaining good adhesion of the surface treatment material, and the P2i acrylate polymers showed very poor adhesion.

The size of the pillar features created in the glass or sapphire was too large to obtain good optical properties, for instance to maintain transparency of the surface, features of the order of 200 nm period must be created. Ways to fabricate such small features are being investigated. Hierarchical structures having a combination of silicon micropillars and silicone nanofilaments were used to investigate the reversible transition from a 'micro-Cassie' where a micrometer sized air-film is trapped between the pillars, to 'nano-Cassie' where the film between the pillars is forced out and air only remains within the nano-roughness of the sample.The wetting behaviour was studied with a combination of standard optical microscopy, SEM and a novel confocal microscopy technique was developed to determine the presence or absence of the air film using fluorescent nano-beads-

4) The Seebeck coefficients and photocurrents of various graphene based systems were computed. The results were found to agree with previous experimental and computational studies. The actual photocurrents and voltages were computed using both the L-B current formula and a simple Ohmic approximation. The aim was to simulate two different experimental setups: a graphene pnjunction and an interface between SLG and BLG. In case of the pn-junction, the computational results agreed quite well with the experiments. Concerning the transition rates and polarization, the tight-binding computations showed that the polarization angle has a significant effect on the magnitude of the transition propability. In single-layer graphene, the probablity goes to zero when the polarization and the momentum are aligned.

Number of patents and patent applications

1) WO 2011/141895, US 2011/280340 "Frequency synthesis apparatus and method", Pirjo Pasanen, Vladimir Ermolov, Markku Oksanen, Martti Voutilainen, and Eira Seppälä, published.
2) WO 2011/095840 "Generation of differential signals", Martti Voutilainen, Pirjo Pasanen, Markku Oksanen, Vladimir Ermolov, and Eira Seppälä, published.
3) US 8,155,614, WO 2011/048256, US 2011/092247 "Apparatus and methods for signal processing", Eira Seppälä, Vladimir Ermolov, Pirjo Pasanen, and Markku Oksanen, published and granted as US 8,155,614.
4) WO 2011/141885, US 2011/278545 "Manufacture of graphene-based apparatus", Pirjo Pasanen and Martti Voutilainen, published.
5) WO 2011/161305, US 2011/315949 "Apparatus and method for sensing photons", Martti Voutilainen, Markku Rouvala, and Pirjo Pasanen, published.
6) US 2012/001761 "Apparatus and method for detecting radiation", Martti Voutilinen and Pirjo Pasanen, published.
7) WO 2011/001240, US 2010/327956, CA 2766085 "Graphene device and method of fabricating a graphene device", Asta Kärkkäinen, Samiul Haque, Alan Colli, Pirjo Pasanen, Leo Kärkkäinen, Mikko Uusitalo, and Reijo Lehtiniemi, published.
8) WO 2011/067458, US 2011/132438 "Apparatus, methods and devices comprising photoactively functionalized fullerenes covalently bonded to nanotubes", Pirjo Pasanen and Vladimir Ermolov, published.
9) US 2012/075037 "Apparatus and Associted methods" Vladimir Ermolov and Igor Nefedov, published.
10) Apparatus and Associated Methods C Bower, P Andrew, RHA Ras, T Verho - US Patent 20,120,300,282, 2012.

Project Full Name (acronym)
Superhydrofobic coating

Organisation
MJ Optima-Sport Oy

Contact Person
Jari Joutsen

Partners
University of Eastern Finland (Kuopio), University of Jyväskylä

Project duration
1.6.2012 – 31.5.2014

Total cost (€)
200 000

Main target
To improve function of our waxless nanosurface for ski base. Investige possibilities for scaling this innovation to other targets

Motivation
Whit improved surface we can keep up our spot as a technology leader in the waxless skies and make skiing easier for skiers. Better function of waxless skies brings more people in the ski tracks.

Key results and impact
Project is till going on, but we have made some steps on the right direction.

Project Full Name (acronym)
Next generation car tyres [Henkilöauton uuden sukupolven renkaat] (HAUSKA)

Organisation
Nokian Tyres Plc.

Contact Person
Tommi Ajoviita

Project duration
1.5.2012 – 30.4.2015

Total cost (€)
2 919 250

Main target
Project concentrates on development of next generation passenger car tyres utilizing novel materials and new structural solutions.

Motivation
Nokian Tyres is the only tyre manufacturer in the world that focuses on customer needs in northern conditions. Nokian Tyres' product development is consistently aiming for sustainable solutions for safety and the environment, taking into account the whole life cycle of the tyre.

Project Full Name (acronym)
Natural fiber based functional hybrid constructions (LUTO)

Organisation
Oy All-Plast Ab

Contact Person
Antti Vilenius

Partners
Elastopoli Oy, Tampere Univeristy of Technology, Aalto University, Finnish Meteorological Institute

Project duration
1.10.2007 – 31.3 2010

Total cost (€)
321100

Main target
Knowledge to develop optimal tailor-made hybrid constructions based on natural fiber based inserts in injection moulding. Understand the weathering properties of natural finer based hybrid components.

Motivation
To understand better the properties, we are more competitive in sustainable plastics products.

Key results and impact
The capability to develop tailor-made properties to our customers products and thus get them new sustainable possibilities. This has given us entry to new customer groups. It has been as well very important in these bio-products, that we can fast test their weathering properties with high accuracy.

Commercialisation status (demos, pilotings, investments, products, services)
During the project we managed to make some demos and now we have first commercial applications so far, that they are coming to the market year 2013.

Project Full Name (acronym)
Development of Functional Filler (FFiller)

Organisation
Kiilto Oy

Contact Person
Pirjo Laurila

Partners
Åbo Akademi Laboratory of Polymer Technology; Tampere University of Technology, Civil Engineering

Project duration
1.9.2012 – 31.8.2015

Total cost (€)
1 011 500

Main target
Search and development functional fillers for cement based procuts and other adhesives. Fuctionalities like light weight, thermal capasity or acoustic absorbtion are desirable.

Motivation
To develop products with improved energy efficiency and additional comfort of living. New methods of construction using wood create needs for new prooducts.

Key results and impact
A feasible technology to produce light weight fillers will be found. Know how of light weight technology in Finland will be significantly increased.

Commercialisation status (demos, pilotings, investments, products, services)
New product line based on light weight fillers will be launched.

Number of patents and patent applications
Not known yet.

Project Full Name (acronym)
Durable dye materials for dye sensitive solar cells

Organisation
Volatec Ltd

Contact Person
Marja Tiitta

Partners
Beneq Oy, Aalto University, Abo Akademi University

Project duration
9.8.2011 – 31.12.2013

Total cost (€)
150 000

Main target
Develop low cost and stable dye materials for industrial manufacturing of dye sensitive solar cell (DSSC).

Motivation
Solar energy applications have a continues annual growth. DSSC is an emerging technology in the area of solar energy. Low cost and stable dye is the key element of the breakthrough of this technology.

Key results and impact
Novel concept of preparation of dye compounds has been developed. This project has opened new applications of materials that Volatec Ltd is manufacturing.

Commercialisation status (demos, pilotings, investments, products, services)
New method for DSSC preparation based on compounds of Volatec Ltd has been demonstrated in Beneq Ltd. The commercialization will be when the efficiency and other properties of DSSC cell have been optimized.

Number of patents and patent applications
One patent application is under preparation.

Project Full Name (acronym)
Modified Wood Research Program (MoWoP)

Organisation
Stora Enso Wood Products Oy Ltd

Contact Person
Janne Pynnönen

Partners
University of Helsinki, Mikkeli University of Applied Sciences, Finnish Forest Research Institute

International partners - if any (country, organisation)
Germany, Georg-August Universität Göttingen
Spain, CIS-Madeira

Project duration
1.1.2012 – 30.6.2014

Total cost (€)
1 700 000

Main target
The aim of the project is to develop new, ecologically sustainable wood-modification methods. The emphasis is in wood products for the exterior use, such as decking, cladding, and fencing.

Motivation
The health and environmental risks related to the traditional wood preservatives are well known, and the use of these chemicals is being restricted in Europe. In addition, the decreasing availability of certified tropical hardwoods is opening the market for the new modified wood products. Providing non-toxic and environmentally friendly products promotes the change towards ecologically sustainable solutions. This change is essential to maintain wood's position as a reliable material for different end uses, and as a respectable choice for the consumers.

Key results and impact
The project target is to develop 2-3 new modified wood products and sufficient understanding to industrially produce the products. The aim is also to confirm continuous R&D after the project by means of establishing knowledge centres with the academic project partners.

Commercialisation status (demos, pilotings, investments, products, services)
Different modification technologies are first tested in a laboratory scale, followed by the studies which confirm the properties and quality of products. The most promising concepts are selected for the trials piloting the industrial production. Co-operation with the key customers provides valuable information at different stages of product development.

Number of patents and patent applications
The project aims at 2-3 patent applications.

Project Full Name (acronym)
Scaffolds for Tissue Engineering (SCATE)

Organisation
Finnish Red Cross Blood Service

Contact Person
Jarkko Räbinä

Partners
University of Oulu, University of Helsinki, Scaffdex Oy

International partners - if any (country, organisation)
Italy, Nobil bio ricerche S.r.l.
Italy, SAATI S.p.A
Italy, National Research Council of Italy, the Institute on Membrane Technology
Sweden, University of Borås

Project duration
1.1.2011 – 30.4.2014

Total cost (€)
884 184

Main target
The aim of the project is to develop composite scaffold materials for tissue engineering which stimulate cell differentiation instead of the adverse foreign body reaction. Bioactive and suitable glycan and protein structures in bone resorption areas are determined for coating purposes and to provide signals directing bone resorption.

Motivation
There is a need to provide biomaterials industry with specific development in textile manufacturing technology of medical grade composite materials. The project has connected stem cell researchers, materials scientists and scaffold manufacturers in Finland and Italy, combining areas of know-how and expertise needed in preparing and functional testing of new bioactive scaffolds.

Key results and impact
Several types of novel scaffold materials have been prepared. They are currently being tested for bioactivity by utilizing stem cell technologies and other cell-based assays. The main questions of material processing, cytotoxicity/biocompatibility and physiological responses have been defined, showing promising results. In addition, an analytical platform for the analysis of bone surface molecules has been developed. By comparing resorbed and control bone potentially important molecular differences have been discovered, that could have signalling functions in bone formation. During the remaining period of the project, surface treatment and functional coating of the novel materials is going on and being evaluated.

Commercialisation status (demos, pilotings, investments, products, services)
New materials produced by the project partners are under testing utilizing stem cell technologies. Analysis of bioactive glycan and protein molecules in bone resorption areas is ongoing and being finalized. Animal experiments and further mechanical tests are to be started for selected materials. The knowledge aqcuired is utilized for evaluating the commercialization possibilities of the new types of materials and manufacturing methods.

Project Full Name (acronym)
Manufacturing of surface modified, dry nanoparticles

Organisation
FP-Pigments Oy

Contact Person
Sami Haakana

Project duration
4.5.2012 – 30.4.2014

Total cost (€)
991 950

Main target
To develop a new specialty pigment grades that can be utilized globally in various application areas.

Motivation
To create new business.

Number of patents and patent applications
2 patent applications have been submitted.

Project Full Name (acronym)
Development of new joining technique.

Organisation
NWE Network Engineering Oy Ab

Contact Person
Kimmo Weissenberg

Partners
Jyväskylä University of Applied Sciences (JAMK)

Project duration
19.2.2009 – 31.1.2010

Total cost (€)
88 700

Main target
To find alternative methods to join a fabric with a strap that has certain elongation.

Motivation
Present solution is sewing. This is time consuming, requires high level of skills and robust machines. Too many variables that have to be perfect at the same time to achieve highest possible tensile strength.

Key results and impact
Sewing was found to be strongest anyway. Welding can be done, but only with certain materials. Glueing is possible, but has environmental challenges. Sewing was chosen and automatic machines developed to increase quality level.

Commercialisation status (demos, pilotings, investments, products, services)
No commercialisation as the change was only internal in production methods. The product was not changed.

Project Full Name (acronym)
New Innovative Companies pre-phase [NIY Esivaihe]

Organisation
Silvergreen Ltd

Contact Person
Tommy Salomaa

Partners
Venture Capital Corporation VCC

Project duration
6.9.2012 – 31.12.2012

Total cost (€)
54 670

Main target
Business Plan writing.

Motivation
Plan commercialisation and execute plan.

Key results and impact
Ready Business plan and presentation.

Commercialisation status (demos, pilotings, investments, products, services)
Ready plan for excecution.

Project Full Name (acronym)
Ceramic adhesive [Kerameerinen sideaine]

Organisation
A. Graveolens Oy

Contact Person
Mikko Tilli

Project duration
1.92008 – 30.9.2009

Total cost (€)
100 000

Main target
Create non-combustible resin and surface layer solution for wood plastic and composite industries.

Motivation
Fire and smoke kills.

Key results and impact
We created non-combustible resin system and non-combustible sheets.

Commercialisation status (demos, pilotings, investments, products, services)
Unsuccessful – terminated.

Number of patents and patent applications
2

Project Full Name (acronym)
Modelling of the influences of weathering conditions (OVAMA2)

Organisation
Elastopoli Oy

Contact Person
Timo Ture

Partners
Tampere Universtiy of Technology, Helsinki University of Technology, Finnish Meteorological Institute, Oy All-Plast Ab

Project duration
14.9.2007 – 13.3.2010

Total cost (€)
175 100

Main target
To find accurate correlation between laboratory weathering and natural weathering and modelling this correlation to fasten laboratory testing.

Motivation
The more accurate is the modelling between the nature and the laboratory, the faster and cheeper is the weathering testing in laboratory circumstances. This allows much faster time-to-market for the products needing weather resistance. As well the overestimation of weather tolerance can be avoided, thereby reducing unnecessary high costs of production.

Key results and impact
We are able to make faster and more cost effective weathering testing to our customers. This has given us competitiveness in laboratory test sales.

Commercialisation status (demos, pilotings, investments, products, services)
We are selling the competitive weathering services to Finnish industry and as well we have won time in our own material development targeting to natural fiber composite production.

Project Full Name (acronym)
In Mould Label FIlms and Packaging

Organisation
KWH Plast Oy

Contact Person
Annika Sundell

Partners
Premix Oy, MesMec, PJP Engineering

International partners - if any (country, organisation)
Cloeren

Project duration
13.1.2009 – 31.12.2011

Total cost (€)
1 793 110

Main target
Develop new types of packaging concepts by combining multilayer film technology with injection moulding.

Motivation
The packaging concept development addresses market driving forces Food Safety and sustainability.

Key results and impact
Thin wall injection moulded packages with same or better light and or oxygen barrier properties were achieved. The result provides possibility to replace thin cans with light weight packaging.

Commercialisation status (demos, pilotings, investments, products, services)
Piloting, products

Project Full Name (acronym)
New generation of solar collector and solar system

Organisation
PolarSol Oy

Contact Person
Elena Sonne

Partners
SonnSe Oy

International partners - if any (country, organisation)
Ukraine, Integrated Technical Vision Ltd
Russia, OOO Polarsol Vostok
Canada, PolarSol Inn

Project duration
1.5.2010 – 30.12-2013

Total cost (€)
600 000

Main target
To create a brand new innovative heating system.

Motivation
The mankind spends most energy on the water heating. It accounts for up to 90% of all energy consumption in countries with the cold climate. Thus, the PolarSol system was founded on the concept of collecting and preserving the heat given us by the Sun!

Key results and impact
Environmental Impact. Reduction of CO_2 Emissions. Saving energy and money investments.

Commercialisation status (demos, pilotings, investments, products, services)
Pilotings and products.

Number of patents and patent applications
PCT/RU2008/000666. 27 October 2008 (27.10.2008).

Project Full Name (acronym)
Functional nano- and microporous carbon based coatings for tools and components (CARBONBON)

Organisation
DIARC-Technology Oy

Contact Person
Jukka Kolehmainen

Partners
Aalto University, VTT Technical Research Centre of Finland, Metso Automation, Wärtsilä

International partners - if any (country, organisation)
Project is a part of MATERA+ program.
Italy, co-operation has been done with IMAMOTER, UFS and Wolframcarb.

Project duration
20.9.2010 – 31.8.2013

Total cost (€)
198 000

Main target
To develop novel carbon based PVD coatings with optimized nano- and microstructure in order to decrease the friction, improve the efficiency of machines and increase the wear life of tools.

Motivation
The industry needs surface solutions which improve the efficiency of the machines and increase the lifetime of tools.

Key results and impact
DIARC Drylub coating has been developed for conditions where lubricants do not work or they cannot be used. The coating posesses low friction even under dry and at high temperature conditions. DIARC Drylyb efficiently prevents seizure and wear of components.

Commercialisation status (demos, pilotings, investments, products, services)
DIARC Drylyb has been introduced to the market.

Project Full Name (acronym)
Biochemicals program - Future Biofore Competence and Research Program

Organisation
UPM-Kymmene Oyj

Contact Person
Päivi Varvemaa

Project duration
1.6.2010 – 1.7.2013

Total cost (€)
4 452 765

Partners
University of Helsinki, Lappeenranta University of Technology, University of Oulu, Åbo Akademi University, Tampere University of Technology, University of Eastern Finland, VTT Technical Research Centre of Finland , Jyväskylä University of Applied Science, SMEs

International partners - if any (country, organisation)
Greece
Germany
Sewden

Main target
The sidestreams of different forest industry processes were studied and isolated fractions were modified and exploited. Especial interest was laid on economical feasibility of the processes and profit potentials. The strategic goal of the Biochemicals Research Program was to create new production processes for new type of biochemical products and to create fundamental understanding of new bio-based products.

Motivation
The main target of the project was to create the basis for UPM's future business in the area of Biochemicals.

Commercialisation status (demos, pilotings, investments, products, services)
The target of UPM is to commercialize several lignin based products that were developed in this project in the near future, and the IP created during this project will open several business possibilities in the future.

Number of patents and patent applications
16

Project Full Name (acronym)
A new method to create optical effects with hot embossing (TuKuPu)

Organisation
Iscent Oy

Contact Person
Jaakko Raukola

Partners
VTT Technical Research Centre of Finland

International partners - if any (country, organisation)
Uteco

Project duration
11.4.2011 – 30.11.2012

Total cost (€)
550 000

Main target
Development of wide web thermomechanical roll to roll process in printed intelligence. Line design and process development to create light scattering effects on packages.

Motivation
No material demanding process is cost efficient - four colour printing without printing inks.

Key results and impact
Mass production line ready for its purpose to start production.

Commercialisation status (demos, pilotings, investments, products, services)
Product examples, first customer cases on door.

Number of patents and patent applications
2 Patents, 3 patent applications

Project Full Name (acronym)
Fiber Packaging

Organisation
Huhtamaki Foodservice Europe-Asia-Oceania Technology & Development Center (Finland)

Contact Person
Timo Tiilikainen (Commercialization Director)

Partners
VTT Technical Research Centre of Finland, Isega, Fresenius, Frauenhofer Institut, HK, Nekos, Plytec, Plastiroll, Lamican Oy, Sonic Tools Oy, Stora Enso Oyj, PankaBoard, Jepptec Oy, Tampere University of Technology

International partners - if any (country, organisation)
Germany anf Italy, Huhtamaki Flexibles, Pfleiderer

Project duration
8.3.2010 – 31.3.2013

Total cost (€)
2 000 000

Main target
Recyclable paperboard with reduced fossil based material components and fiber MAP packaging to replace plastic and aluminium based food packaging.

Motivation
Main driver is to improve sustainability of food and drink packaging by reducing fossil based material components and by increasing use of renewable fiber based materials.

Key results and impact
Non-PE dispersion coating solution for liquid packaging board + MAP (Modified Atmosphere Packaging) capable food trays.

Commercialisation status (demos, pilotings, investments, products, services)
Negotiations ongoing with coaters on commercialization of non-PE cupstock.

Number of patents and patent applications
6

Project Full Name (acronym)
Fiber reinforced bioresorbable composites (FiberComp)

Organisation
Vivoxid Ltd.

Contact Person
Jukka Tuominen

Project duration
22.3.2011 – 31.12.2011

Total cost (€)
672 080

Main target
Conduct the pre-clinical studies related to novel resorbable composite material to be used for orthopaedic implants.

Motivation
Demonstration of pre-clinical safety is the key requirement in order to be able to start the commercialization of a novel material for clinical use.

Key results and impact
Pre-clinical study results showed and proved full biocompatibility of the composite material. The impact for the company was massive, since after the positive study results the technology was acquired by Purac Biomaterials.

Commercialisation status (demos, pilotings, investments, products, services)
Referring to above, the developed technology is no longer an asset ot Vivoxid Ltd. The commercialization of the technology is currently continued by Purac Biomaterials.

Number of patents and patent applications
2

Project Full Name (acronym)
Investment- and development program 2011-2014 (INKE)

Organisation
Joptek Oy Composites

Contact Person
Aku Lampola

Company partners
Transtech Oy, STX Europe Oy, VTT Technical Research Centre of Finland Expert Service Oy, Jiipek Tmi, Ins.tsto. Kupiainen Oy, Souru Oy, Metlab Oy etc.

International partners (country, organisation)
Russia, Vagonmash Ltd
Russia, VGM Composite
Switzerland, Sconrail UK Limited
Germany, TC-Kleben Gmbh

Project duration
24.5.2011 – 30.6.2014

Total cost (€)
755 000

Main target
The main target is to increace Joptek's competitivity on domestic and international market. The other target is to increace Joptek's technological skills and to put effort to the product development process.

Motivation
The Finnish market is too limited to create growth potential to the Joptek in the future.

Key results and impact
Joptek have made the contract with STX France regarding the delivery of balconies and GRP-floor elements and the contract with Stadler concerning the toilet modules delivery and starting R&D co-operation in the long term. Joptek has established a Joint Venture company with Vagonmash LDT on the Russian market.

Project Full Name (acronym)
Viscous-Elastic Epoxies in mechanical engineering

Organisation
Deltatron Oy

Contact Person
Juhani Lempiäinen

Other research organisations in the project consortium
VTT Technical Research Centre of Finland

Company partners
Junttan Oy, Metso Paper Oy, Konecranes Heavy Lifting Oy, Wärtsilä Finland Oy, Sandvik Mining and Construction Oy, Noisetek Oy

Project duration
26.10.2007 – 30.4.2010

Total cost (€)
1 953 427

Main target
Technical target is to develop the know-how on material properties of viscous elastic epoxies for sound and vibration control in machinery applications. The economic motivation target was to establish new business for producing the epoxies for machinery manufacturers.

Key results and impact
Noise and vibration solutions were achieved by design of machine structures by modelling and damping concepts by materials and structures.

Results by constrained layer damping
- Epoxy based high vibration damping materials and components for different temperature conditions
- Lower noise and vibration levels in case products: diesel engines, gantry cranes, mining and drilling equipment, paper machines, piling equipment
- Typically 5-10 dB lower noise levels can be achieved
- Epoxy based solutions are commercialized by Noisetek with trademark ELASTE

Results of the projects are expected to be in commercial use within how many years
The results were introduced commercially just after the project by Noisetek Oy.

Key publications

1) Lamula, L., Parviainen, H., Saarinen, K., Lindroos, T. Determination and validation of viscoelastic material model for an epoxy compound in constrained layer damping applications, ICSV18 Intrenational congres of sound andvibration. Rio de Janeiro, Brazil, 10 – 14 July 2011. Inter-Noise 2011 (2011)
2) Kinnari, L., Aalto, S., Lamula, L., and Lindroos, T. Adjustable epoxy based vibration damping material (CLD) with an extremely high loss factor, Inter-Noise 2011. Osaka, Japan, 4 - 7 Sept.2011. Inter-Noise 2011 (2011), 2077 – 2084

Number of publications
2

Number of patents and patent applications
1

Number of M.Sc.Thesis
1

Project Full Name (acronym)
Solar Thermal Collectors (SOLARCO 1-2)

Organisation
Savo-Solar Oy

Contact Person
Kaj Pischow

Other research organisations in the project consortium
University of Jyväskylä

International partners (country, organisation)
University do Minho, Portugal

Project duration
21.4.2010 – 30.4.2011 and 3.5.2011 – 30.4.2012

Total cost (€)
833 194 and 849 414

Main target
To develop a coating, industrial coating process and direct flow absorber with industrial manufacturing process for producing state of art flat plate collector.

Motivation
Only high quality state of art solar thermal products can be produced in Finland and in Europe. Instead of decreasing price we must increase the quality and collector efficiency.

Key results and impact
Savo-Solar is now able to produce innovative high tech solar thermal collectors. Our effort has been internationally recognized by the Intersolar innovative Product Award committee which nominated our product among the 10 best applications.

Results of the projects are expected to be in commercial use within how many years
5 to 10 years

Number of publications
3

Number of patents and patent applications
3

Number of M.Sc.Thesis
2

Research project descriptions

Project Full Name (acronym)
Nanocoatings with tailored roughness for controlled surface bonding (ALEBOND)

Organisation
VTT Technical Research Centre of Finland

Contact Person
Riikka Puurunen, Hannu Kattelus

Other research organisations in the project consortium
University of Helsinki, University of Jyväskylä

Company partners
Okmetic, Picosun, VTI Technologies

International partners (country, organisation)
Japan, University of Tokyo
Japan, Nagoya University
France, Institute d'Electronique Fondamentale (IEF) – CNRS, Université de Paris Sud
France, Laboratoire d'Analyse et d'Architecture des Systèmes – CNRS, Université de Toulouse

Project duration
1.7.2008 – 30.6.2011

Total cost (€)
1 172 000

Main target
Develop ALD (Atomic Layer Deposition) nanolayers with tailored roughness for: the bonding of surfaces, controlled (temporary) bonding of surfaces and anti-stiction of surfaces.

Motivation
There are markets for more specialized wafers with buried oxides/other layers. Improved approaches are needed to prevent stictionrelated failure of during operation MEMS.

Key results and impact

- Bonding of smooth ALD layers possible. Knowledge has been created for creating high-quality SOI wafers with buried Al2O3 (> 2000 mJ/m²). Problem is not trivial: bonded wafer quality depends on the ALD layer and process details.
- Anti-stiction ALD technology for MEMS: proof-of-concept demonstrated.
- Results of the projects are expected to be in commercial use within how many years? We don't know yet; possibly within 1 year, or 3 years, or 5 years - or maybe never.

Key publications

1) Miikkulainen V., Leskelä M., Ritala M., and Puurunen R. L., Crystallinity of inorganic films by atomic layer deposition: overview and general Trends, Journal of Applied Physics, 113 (2013), Art. 021301 (101 pages).
2) Puurunen R. L., Suni T., Ylivaara O., Kondo H., Ammar M., Ishida T., Fujita H., Bosseboeuf A., Zaima S., and Kattelus H., Silicon full wafer bonding with atomic layer deposited titanium dioxide and aluminum oxide intermediate films, Sensors and Actuators, A: Physical, 188 (2012) 268 – 276.
3) Puurunen R. L., Häärä A., Saloniemi H. Dekker J., Kainlauri M., Pohjonen H., Suni T., Kiihamäki J., Santala E., Leskelä M., and Kattelus H., Reducing stiction in microelectromechanical systems by rough nanometer-scale films grown by atomic layer deposition, Sensors and Actuators, A: Physical, 188 (2012) 240 – 245.
4) Puurunen R. L., Sajavaara T., Santala E., Miikkulainen V., Saukkonen T., Laitinen M., and Leskelä M., Controlling the crystallinity and roughness of atomic layer deposited titanium dioxide films, Journal of Nanoscience and Nanotechnology, 11 (2011) 8101- 8107.

Number of publications

8

Project Full Name (acronym)

Printable Array Platform for Cell Studies (PrinCell & PrinCell II)

Organisation

University of Helsinki

Contact Person

Prof. Marjo Yliperttula

Other research organisations in the project consortium

Åbo Akademi University

Company partners

UPM Kymmene, CelllQ, ChipMann, Orion Diagnostica, Enfucell, Wallac (PrinCell)

International partners (country, organisation)

Robert Langer, MIT, USA

Project duration

1.9.2008 – 31.12.2009 PrinCell and 1.1.2010 – 31.8.2012 PrinCell II

Total cost (€)

265 000 (14 months) and 735 000 (24 months)

Main target

Learn to print cells with various technologies
Printing of both platforms and cells with different technologies

Motivation

Fast and easy to prepare different type of platforms for 2D/3D cell culture for chemical and toxicity tests

Key results and impact

New printable biomaterial for cell 2D/3D cell culture => GrowDex indutry project

New technology to print on paper at 2D only by chancing the polarity of the surface with printing

Results of the projects are expected to be in commercial use within how many years? GrowDex ready

Paper priting technology allready partially available

Key publications

1) Madhushree Bhattacharya, Melina Malinen, Patrick Lauren, Yan-Ru Lou, Saara Kuisma, Liisa Kanninen, Martina Lille, Anne Corlu, Christiane GuGuen-Guillouzo, Olli Ikkala, Antti Laukkanen, Arto Urtti, and Marjo Yliperttula, Native plant cellulose nanofiber hydrogels support 3D cell spheroid

formation without bioactive matrix components, J Control Release (2012) July (IMF 7.164).

2) Y-R Lou, L. Kanninen, T. Kuisma, J. Niklander, L. Noon, D. Burks, A. Urtti and M. Yliperttula, Enzymatic removal of cellulose nanofibril hydrogel for the study of intact human embryonic stem cells. Manuscrpit submitted for publication to Nature Biotechnology.
3) Helka Juvonen, Anni Määttänen, Patrick Laurén, Petri Ihalainen, Arto Urtti, Marjo Yliperttula, Jouko Peltonen, Biocompatibility of printed paper-based arrays for 2D cell cultures Manuscrpit accepted for publication BioChimica et Biophysica Acta.
4) Melina Malinen, Harri Purhonen, Arto Urtti and Marjo Yliperttula, Peptide nanofiber hydrogel induces formation of bile canalicular structures in hepatic cell line, Tissue Eng Part A. (2012) July.

Number of publications
4

Number of patents and patent applications
2

Number of M.Sc.Thesis
5

Number of Doctoral Thesis
2

Project Full Name (acronym)
Novel Biomaterials for Cartilage Tissue Engineering

Organisation
University of Helsinki

Contact Person
Prof. Ilkka Kiviranta

Other research organisations in the project consortium
Åbo Akademi University, Tampere University of Technology

Company partners
Bioretec Ltd., FibroGen Europe Ltd., Vivoxid Ltd.

International partners (country, organisation)
China, Shanghai, Fudan University, Zhongshan Hospital, Department of Plastic Surgery
Ireland, Galway, National University of Ireland, Network of Excellence for Functional Biomaterials
The Netherlands, Rotterdam, Erasmus University Medical Center, Department of Orthopaedics

Project duration
1.8.2009 – 31.12.2012

Total cost (€)
1 190 000

Main target
The main aim of the project was to develop a novel biomaterial that would fulfill the requirements for a scaffold to be used in cellbased articular cartilage defect repair. Our biomaterial would supersede the current commercial products by fulfilling all the requirements for a good scaffold, i.e., 3D-structure with open porosity, non-animal -derived materials (xeno-free), chondrocytefriendly scaffold surfaces, reduced operation and rehabilitation time, and good biomechanical properties and mechanical durability.

Motivation
Articular cartilage lesions do not heal spontaneously and untreated defects often lead to osteoarthritis, which is one of the most common causes for disability in developed countries. The prevalence of cartilage pathogenesis is expected to rapidly increase in the following decades due to aging population as well as increased rate of obesity. Cartilage lesions and osteoarthritis lead to loss of function, pain and reduced quality of life for the patient. Successful early treatment of chondral lesions can restore the function of the joint, and postpone or even eliminate the development of osteoarthritis and the need for an artificial joint replacement in later age. However, current repair techniques for cartilage lesions are inadequate and need development. The major limitation in the development of regenerative cartilage repair methods is the lack of appropriate biomaterial scaffolds and their use together with cells.

Key results and impact

We have successfully developed a novel biomaterial for cartilage repair and a method to use the scaffold with cartilage or chondrogenic stem cells. Our scaffold meets all the above mentioned criteria for good biomaterial for cartilage tissue engineering.

We will continue to bring this novel innovation for commercial use.

Results of the projects are expected to be in commercial use within how many years?

The path for commercialization of our novel biomaterial innovation will be laid down within the new Tekes-funded project (New knowledge and business generated from research ideas -funding instrument) that will investigate and fulfill the steps needed for creating new businesses around our innovation and to help patients with potentially disabling articular cartilage defects.

Key publications

1) Haaparanta A-M, Järvinen E, Cengiz I, Ellä V, Kokkonen H, Kiviranta I, Kellomäki M (2013), Characterization of collagen/chitosan/PLA hybrid scaffolds for use in cartilage tissue engineering, submitted.
2) Järvinen E, Muhonen V, Haaparanta A-M, Kellomäki M, Kiviranta I (2013), Optical projection tomography can be used to investigate spatial distribution of chondrocytes in three dimensional biomaterial scaffolds for cartilage tissue engineering, submitted.
3) Kontturi L-S, Järvinen E, Muhonen V, Collin EC, Pandit AS, Kiviranta I, Yliperttula M, Urtti A (2013), An injectable type II collagen/hyaluronic acid/TGFbeta1 hydrogel vehicle for chondrocyte delivery in cartilage tissue engineering, submitted.
4) Muhonen V, Vahasalo E, Järvinen E, Paatela T, Pyhältö T, Vasara A, Meller A, Haaparanta A-M, Kellomäki M, Kiviranta I, A novel biomaterial scaffold for cell-based cartilage tissue engineering - a proof-of-concept study in a porcine model, to be submitted.
5) Muhonen V, Vahasalo E, Järvinen E, Pyhältö T, Haaparanta A-M, Uppstu P, Rosling A, Kellomäki M, Kiviranta I, Novel biomaterials for subchondral bone repair – a proof-of-concept study in a lapine model, to be submitted.

Number of publications

For peer-reviews international journals:
Submitted 3
To be submitted 7
Publications/presentations for scientific community: 18
B.Sc. Thesis: 2

Number of patents and patent applications

Invention disclosures:

1) Kiviranta I, Muhonen V, Järvinen E, Kellomäki M, Haaparanta A-M, Ellä V, Biohajoava kolmiulotteinen istutemateriaali COPLA, 2012.
2) Kiviranta I, Muhonen V, Skog M, Nystedt J, Korhonen M, Xenovapaa rustoerilaistamisteknologia mesenkymaalisille rustosoluille (MSC-RUSTOX), 2012.
3) Kellomäki M, Haaparanta A-M, Ellä V. Freeze-dried hybrid structure for cartilage tissue engineering, 2012.
4) Kellomäki M, Haaparanta A-M, Ellä V. Freeze-dried hybrid structure for bone tissue engineering, 2012.

Number of M.Sc.Thesis

7

Number of Doctoral Thesis

5

1) Ellä, Ville, Effects of processing parameters on P(L/D)LA 96/4 fibers and fibrous products for medical applications, Tampere University of Technology, Department of Biomedical Engineering, 2012. *
2) Uppstu, Peter, Biodegradable polymeric scaffolds for regeneration of bone and cartilage tissue, estimated completion at 2014. **
3) Haaparanta, Anne-Marie, Natural and synthetic biodegradable scaffolds for bone and cartilage tissue engineering, estimated completion at 2014. **
4) Kontturi, Leena, Cell encapsulation in hydrogels for long-term protein delivery and tissue engineering applications, estimated completion at 2015. **
5) Vahasalo, Eve, Biomaterial scaffolds in orthopaedic surgery, estimated completion at 2017. **

* Thesis was finalized during the project and the results are related to the project although it does not directly contain publications published from the project.
** Theses contain material produced during the project.

Project Full Name (acronym)

Model based tribologically optimised thick multimaterial coated surfaces (MOTRICOT)

Organisation

VTT Technical research Centre of Finland

Contact Person

Prof. Kenneth Holmberg, kenneth.holmberg@vtt.fi

Other research organisations in the project consortium

VITO – Vlaamse Instelling voor Technologisch Onderzoek, Mol, Belgium; Tampere University of Technology

Company partners

Metso, Ruukki and Omco International, Belgium

Project duration

1.12.2008 – 31.7.2011

Total cost (€)

853 000

Main target

To develp a computational microstructural modlling and simulation based method for optimal wear resistance and coating design of composite thermal spary and laser cladded coatings

Motivation

Wear is a huge cost in industry. Better wear control reduces costs and gives to companies a competitive advance.

Key results and impact

An international breakthrough was made by the new developed software platform VTT ProperTune™ for microstructural wear modelling of composite coatings.

Results of the projects are expected to be in commercial use within how many years?

A trademark VTT ProperTune™ has been applied in Febr. 2013 and actions are on way for larger commersialisation.

Key publications

1) Holmberg K., Laukkanen A., Wear models, In: Hanbook on Lubrication Technology, Vol II Theory and Design, 2nd ed., Chapter 13, CRC press, NewYork, USA, 2012, 13:1-21.
2) Ghabchi A., Rombouts M., Holmberg K., Perons R., Microstructure andf failure modes during scratch testing, Tribology - Materials, Surfaces and Interfaces, in press, 2013.
3) Ghabci A., Wear resistant carbide-based thermal sprayed coatings, PhD thesis, Stony Brook Univ., Long Island, VTT Science 29, 2013.
4) Holmberg K., Laukkanen A., Ghabchi A., Romboutus M., Turunen E., Waudby R., Suhonen T., Valtonen K., Sarlin E..
5) Computational modelling based wear resistance analysis of thick themral spray and laser cladded composite coatings, Surface and Coatings Technologies, Submitted, 2013.

Number of publications

Eight internatioanal publications.

Thirteen internaltional conference presentations of which about more than ten are invited keynote presentations.

Number of Doctoral Thesis

1) Arash Ghabchi, Stony Brook University, Long Island, USA, dissertation in September 2011.

Project Full Name (acronym)

Characterization and modelling for functional sensor materials (FUNKIS)

Organisation

Aalto University, Department of Micro and Nanosciences, Electron Physics Group

Contact Person

Dr. Hele Savin

Other research organisations in the project consortium

VTT Technical Research Centre of Finland

Company partners
Okmetic, Endeas, Semilab, VTI Technologies, Rados, Detection technology, Oxford instruments

International partners (country, organisation)
Hungary, Semilab
Germany, Fraunhofer Institute for Solar Energy

Project duration
1.1.2008 – 31.12.2011

Total cost (€)
1 125 000

Main target
- to find the possible means to produce high-efficiency silicon solar cells that are yet cost-effective by means of controlling the impurities in silicon
- to functionalize the fabrication process for and on the new proprietary material platform G-SOI
- to find out the root causes of the imperfections of the basic radiation detector devices made of FZ silicon

Motivation
To gain the adequate understanding on the material properties and processes, in order to functionalize the fabrication flows for the end products at hand.

Key results and impact
Establishment of a solar cell line at Aalto University, including both implantation and diffusion as well as copper contacts. 15% power increase demonstrated with no extra cost in "dirty Si" by novel defect engineering approach.New physical mechanism found for PDG. To be utilized in further PV research both inside and outside Aalto.

Novel method developed for sensitive characterization of metal impurities in thin SOI layers, utilized in Semilab and Okmetic. Leakage current minimization by optimized gettering treatments. Utilized by the detector companies.
Impact:
- Finnish semiconductor industry
- Scientific community, several groups use our models
- Instrument manufacturers
- Aalto and VTT Technical Research Centre of Finland research groups
- Lot of new collaboration partners and contacts worldwide
- Publications and academic theses
- Patents, invention notices
- Finnish society
- Trained persons who have moved to industry
- In the long run also the environmental impacts

Results of the projects are expected to be in commercial use within how many years?
This varies a lot depending on the result. Some of them are already in commercial use while for the others it can take up to 10 years.

Key publications

1) H. Talvitie, V. Vähänissi, A. Haarahiltunen, M. Yli-Koski, and H. Savin, Phosphorus and boron diffusion gettering of iron in monocrystalline silicon, Journal of Applied Physics 109, 093505 (2011).
2) V. Vähänissi, A. Haarahiltunen, H. Talvitie, M. Yli-Koski, J. Lindroos, and H. Savin, Physical mechanisms of boron diffusion gettering of iron in silicon, Phys. Status Solidi RRL 4, 136 (2010).
3) P. Gundel, M. Schubert, W. Kwapil, J. Schon, M. Reiche, H. Savin, M. Yli-Koski, J. A. Sans, G. Martinez-Criado, W. Seifert, W. Warta, and E. R. Weber, Micro-photoluminesence spectroscopy on metal precipitates in silicon, Phys. Status Solidi RRL 3, 230 (2009).
4) H. Savin, M. Yli-Koski, and A. Haarahiltunen, Role of copper in light induced minority-carrier lifetime degradation of silicon, Applied Physics Letters 95, 152111 (2009).
5) A. Haarahiltunen, H. Savin, M. Yli-Koski, H. Talvitie, and J. Sinkkonen, Modeling phosphorus diffusion gettering of iron in single crystal silicon, Journal of Applied Physics 105, 023510 (2009).
6) A. Haarahiltunen, H. Talvitie, H. Savin, M. Yli-Koski, M. I. Asghar, and J. Sinkkonen, Modeling boron diffusion gettering of iron in silicon solar cells, Applied Physics Letters 92, 021902 (2008).

Number of publications
23

Number of patents and patent applications
1+1

Number of M.Sc.Thesis
2

Number of Doctoral Thesis
1

Project Full Name (acronym)
Novel Electrode Materials for Li-ion Batery (NoMaLi)

Organisation
Aalto University Department of Chemistry

Contact Person
Acad. Prof. Maarit Karppinen

Other research organisations in the project consortium
University of Eastern Finland

Company partners
Sachtleben Pigments Oy, Europan Batteries Oy, Walki Oy, Sun Chemicals Oy, Akkuser, Outotec Reesearch Oy

International partners (country, organisation)
Czech J. Heyrovsky Institute of Physical Chemistry, China Huazhong University of Science and Technology

Project duration
1.2.2009 – 31.8.2012

Total cost (€)
1 051 667

Main target
To develop safer and more efficient electrode materials for Li-ion batteries for applications requiering hign power dnsities, such as hybrid vehicles. Another ditinct goal is to increase battery know-how in Finnish universities to support long-term success of Finnish companies woring on the field.

Motivation
Several Fiinnish companies have bussiness related to producing mainging products, high-tech materials or components for Li-ion batteries. The world wide competition is hard and therefore these companies need to strongly invest in reaserch and development to be able to compete even in these carefully selected special fields.

Key results and impact
- Development of a new binder for fabrication of electrodes from aqeous solutions have gained international attention. Adipting this new new binder material for electrod processing would decrease costs and environmental burden of the Li ion battery fabrication process.
- Fabrication of LiFePO4 materials doped with manganese. LiFePO4 is a safe material commercially used as an active material for positive electrodes of Li-ion battereis. However, it suffers for low potential and sensitivity towards water (humidity from air). These doped materials show higher power and appear to be less sensitive to water.
- Conductivity of negative electrode material Li4Ti5O12 has been increased by doping with Ag and Cu enabeling fabrication of Li ion battery electodes showing smaller losses.

Results of the projects are expected to be in commercial use within how many years?
A new two-year NoFaLi project funded by Tekes has begun 1.9.2012 aiming at commersialization of the results obtained during the NoMaLi project.

Key publications

1) Räsänen, S., Lehtimäki, M., Aho, T., Vuorilehto, K., Karppinen, M., In-situ investigation of the water absorption/desorption behavior of LiFePO4, Solid State Ionics 211 (2012) 65-68.
2) Räsänen, S., Karppinen, M., Thermogravimetric study of of water-based LiFePO4 composite electrode powder, Thermochim. Acta 547 (2012) 126-129.
3) Pohjalainen, E., Räsänen, S., Jokinen, M., Yliniemi, K., Worsley, D.A., Kuusivaara, J., Juurikivi, J., Ekqvist, R., Kallio, T., Karppinen, M., Water soluble binder for fabrication of Li4Ti5O12 electrodes, Journal of Power Sources 226 (2013) 134-139.
4) Räsänen, S., Studies on stability and oxygen and water absorption characteristics of YBaCo4O7+ and LiFePO4, doctoral thesis, Aalto University, Helsinki 2012, 46p.

5) Vara, V., Fabrication of Li4Ti5O12 negative electrode using water-based binders, Master's thesis, Aalto University, Espoo 2010, 58 p.

Number of publications
5 bachelor's theses, 1 master's thesis, 1 doctoral thesis, 3 publications in peer-reviewed scientific publications

Number of patents and patent applications
1

Number of M.Sc.Thesis
1

Number of Doctoral Thesis
1

Project Full Name (acronym)
Oxygen Carriers and Their Inductial Applications (Happirahti)

Organisation
VTT Technical Research Centre of Finland

Contact Person
Dr. Pertti Kauranen, tel. +358407467602,
pertti.kauranen@vtt.fi

Other research organisations in the project consortium
Lappeenranta University of Technology

Company partners
Foster Wheeler Energia Oy, Fortum Oyj

International partners (country, organisation)
Sweden, Chalmers University of Technology
Sweden, Stockholm University
Japan, AIST

Project duration
1.4.2008 – 30.4. 2011

Total cost (€)
1 842 545

Main target
Development of oxygen enrichment membranes and chemical looping combustion process (CLC)

Motivation
Oxyfuel combustion processes facilitate carbon capture and storage (CCS) for mitigation of global warming

Key results and impact
Thermodynamic limits for polymer membrane oxygen enrichment processes were found. Practical membranes are only feasible for oxygen enrichement to 50 %.

State-of-the-art oxygen carriers were synthesized and characterized for the chemical looping combustion process and the total combustion process was modelled. Based on the results, CLC reactor design was initiated.

Results of the projects are expected to be in commercial use within how many years?
The CLC process has been further developed in follow up projects. The commercial use is dependent on emission reduction targets and CCS legistlation and will take over 10 years.

Key publications

1) Seppälä, A., Irreversibility in a gas separation medium, Chemical Physics 367 (2010) 99–109
2) Meriläinen, A., Seppälä, A., Kauranen, P., Minimizing specific energy consumption of oxygen enrichment in polymeric hollow fiber membrane modules, Applied Energy 94 (2012) 285–294
3) Vuorinen, T., Puhakka E., Kauranen, P., Karhu, M., Wikström, L., Häkkinen, S., Wilhelmson, A., Wahlström, R. and Pitkänen, P., Oxygen enrichment by "artificial lungs", International Congress on Membranes and Membrane Processes (ICOM 2011), Amsterdam, July 23 – 29, 2011
4) Moilanen, A., Pikkarainen, T., Lagerbom, J.,Kauranen, P., Koskinen, P., and Saastamoinen, J., Characteristics of various new oxygen carriers for CLC, 1st International Conference on Chemical Looping, Lyon, 17 – 19 March 2010

Number of publications
4

Number of M.Sc.Thesis
2

Project Full Name (acronym)
Valujen sula-lujiterajapintojen ymmärtäminen ja hallittujen FG-rakenteiden kehittäminen (SULATAJU)

Organisation
VTT Technical Research Centre of Finland

Contact Person
Pertti Lintunen

Other research organisations in the project consortium
Aalto University, Tampere University of Technology

Company partners
Elematic Oy, Metso Minerals Oy, Metso Materials Technology; Metso Minerals Oy, Lokomo Steel Foundry, Metso Paper, Valkeakoski Oy; Metso Power Oy; Peiron Oy, Sulzer Pumps Finland Oy, Wärtsilä Finland Oy

Project duration
1.4.2008 – 30.9.2010

Total cost (€)
1 465 349

Main target
Project target was to develop locally reinforced, functional graded materials for wear resistant cast components utilizing reactive inserts or pastes.

Motivation
Increasing material wear and corrosion resistance locally will save material costs and weight for the whole component.

Key results and impact
Reactive cast bonding for small areas improved wear resistance compared to Duplex steel. Traditional cast bonding gave good results and possible product for end-user was developed.

Results of the projects are expected to be in commercial use within how many years?
Within 2-4 years material developed by cast bonding techique is foreseen to be in markets.

Key publications
1) Tiusanen J., Rissa K., Ritvonen T., Lagerbom J.,Keskiaho K., and Lepistö T., Estonian Journal of Engineering, Selected papers of the 18th International Baltic Conference on Engineering Materials and Tribology, BALTMATTRIB 2009; p. 24. Vol. 15 (2009) No: 4, 293-300.
2) Lagerbom J.,Cingi C., Ritvonen T., Lintunen P.,Keskiaho K.,Tiusanen J., Rauta V., Microstructure and properties of TiC metal matrix composite coatings by cast bonding, , PM2010 Powder metalurgy word congress, Firenze, 10.14.10, 2010.
3) Ritvonen T., Tailored properties for cast surface by using exothermic reaction, oral presentation Functional Materials Scientific Day by TEKES, 1.4.2009.

Two (2) diploma work

Number of publications
All together 6: 2 papers, 2 diploma work, 1 oral presentation, 1 public final report

Number of M.Sc.Thesis
2

Project Full Name (acronym)
Life Cycle Assessment Framework and Tools for Finnish Companies (FINLCA)

Organisation
Finnish Environment Institute (SYKE)

Contact Person
Riina Antikainen

Other research organisations in the project consortium

Åbo Academi University, VTT Technical Research Centre of Finland, University of Oulu, Helsinki University of Technology

Company partners

Finnish Forest Industries, The Finnish Plastics Recycling Ltd., Scandinavian Copper Development Association, Outotec Oyj, Metallinjalostajat ry. (Metals Industry), Neste Oil Oyj, The Federation of Finnish Technology Industries, Tikkurila Oyj

International partners (country, organisation)

Nordic association: The Nordic Life Cycle Association, NorLCA;
Austria, University of Leoben and University of Graz
United Kingdom, University College London (Presentations in several international conferences and journals)

Project duration

1.5.2009 – 31.12.2011

Total cost (€)

1 368 099

Main target

The aim of the FINLCA project was to identify problems and obstacles in the use of life cycle methods, especially from the corporate perspective, and develope knowledge and know-how on LCA and related methods. A network of research institutes and companies was established to create a national roadmap on how life cycle methods can be promoted in Finnish industries.

Motivation

The study provides an overview of how life cycle methods can be used to support long term work and environmental competiveness of the Finnish companies, i.e. determining strategy and supporting operative activities. In order to apply life cycle management in the every day situations of society, the life cycle methods should be considered support tools for eco-design and strategic decisions in companies.

Key results and impact

The use of life cycle methods was illustrated with the help of practical examples from different situations. The examples included new metal materials; utilization of waste and by-products from the viewpoint of industrial ecology; land use impacts of biomaterials; the life cycle management of construction; and the challenges of the paint industry.

Finally, several recommendations on how to apply life cycle methods and take different aspects into account in their application were presented in order to improve know-how for conducting life cycle thinking in Finnish society. The main message is that LCA should be used as a basic tool for the environmental assessment of products and services. Improvement in the use of LCA in society needs new networks and co-operation in which shared research programs and pilots play a key role.

Key publications

1) Antikainen, R. & Seppälä, J. (toim.) (2012). Grönroos, J., Korhonen, M.-R., Koskela, S., Manninen, K., Mattila, T., Schultz, E., Tuominen, M., Gustafsson, M., Baumgartner, R., Korhonen, J., Tsvetkova, A., Helin, T., Häkkinen, T., Ovaskainen, M., Pingoud, K., Soimakallio, S., Sokka, L., Tonteri, H., Vares, S., Wessman, H., Angerman, M., Heino, J., Suopajärvi, H., Dahl, O., Husgafvel, R. Elinkaarimenetelmät yrityksen päätöksenteon tukena. FINLCA -hankkeen loppuraportti. Suomen ympäristö 10/2012, Suomen ympäristökeskus, Helsinki.
2) Tsvetkova, A., Gustafsson, M. (2012) Business models for industrial ecosystems: a modular approach. Journal of Cleaner Production, Vol. 29-30, pp. 246-254
3) Mattila, T., Leskinen, P., Soimakallio, S. & Sironen, S. 2012. Uncertainty in environmentally conscious decision making: beer or wine? Int. J Life Cycle Assess 17: 696-705.
4) Mattila, T., Helin, T. & Antikainen, R. 2011. Land use indicators in life cycle assessment—a case study on beer production. The International Journal of Life Cycle Assessment, DOI: 10.1007/s11367-011-0353-z

Number of publications

27

Number of M.Sc.Thesis

1

Number of Doctoral Thesis

1

Project Full Name (acronym)
Printable biosensor surface (BioFace)

Organisation
VTT Technical Reseach Centre of Finland

Contact Person
Liisa Kivimäki

Other research organisations in the project consortium
University of Tampere, Institute of Biomedical Technology; University of Oulu, Department of Chemistry

Company partners
Orion Diagnostica Oy, Ciba Specialty Chemicals Oy, Next Biomed Technologies NBT, Oy Medix Biochemica Ab.
International partners (country, organisation)
Canada, McMaster University, Department of Chemistry (Prof. JD Brennan)

Project duration
1.1.2008 – 31.12.2010

Total cost (€)
1 038 572

Main target
The project focused on development of biosensing surfaces by using printing technologies. The aim of the project was to develop methodology for preparation of avidinylated surfaces, which could be then further functionalized by using biotinylated molecules, such as antibodies, nucleic acids and aptamers. Various immobilization methods were evaluated, including passive coating, covalent linking or doping in the developed materials with the goal of at least one year stability for the immobilized biomolecules.

Motivation
In the field of poin-of-care diagnostics the use of mass production methods enables the generation of low-cost, disposable biosensor platforms. New generic, versatile solutions for tailored sensing surface combined with easily processable substrate materials are beneficial for further development of lab-on-chip devices.

Key results and impact
The BioFace project focused on development of novel manufacturing methods for biosensing surfaces based on printing technologies. Chemically and thermally stabilized chimeric avidin was chosen as generic capture molecule for biosensors prepared on plastic surfaces using inkjet printing. Chimeric avidin has an extraordinarily high binding affinity towards biotin and can therefore function as a universal receptor for biotinylated molecules. The developed generic binding surfaces could be applicable for immunoassay-type diagnostic sensors. Chimeric avidin withstood the processing conditions well, retaining its binding capacity for extended time period. The evaluated immobilization methods for chimeric avidin included passive adsorptive binding on the plastic substrate, chemical bonding via covalent linkage, and doping in the developed sol-gel intermediate materials. The developed sol-gel was also successfully used as an adhesive layer between the plastic substrate and bio-ink. A novel manufacturing method was development for preparation of porous materials by printing technique. The developed porous film effectively increased the binding capacity of physisorbed chimeric avidin layer. The developed printed bioactive surfaces are suitable platforms for biosensing, drug screening and environmental analytical systems.

Key publications

1) Heikkinen, J.J., Kivimäki, L., Hytönen, V.P., Kulomaa, M.S., Hormi, O.E.O, Printable and flexible macroporous organosilica film with high protein adsorption capacity, Thin Solid Films, 520(2012)1934-1937.
2) Heikkinen, J.J., Kivimäki, L., Määttä, J.A.E., Mäkelä, I., Hakalahti, L., Kulomaa, M.S., Hytönen, V.P., Hormi, O.E.O, Versatile bioink for covalent immobilization of chimeric avidin on sol-gel substrates, Colloids and Surfaces B: Biointerfaces, 87(2011)409-414.
3) Heikkinen, J.J., Riihimäki, T.A., Määttä, J.A.E., Suomela, S.E., Kantomaa, J., Kulomaa, M.S., Hytönen, V.P., Hormi, O.E.O, Covalent biofunctionalization of cellulose acetate with thermostable chimeric avidin. ACS Applied Material& Interfaces, 3(2011)2240-2245.
4) Määttä, J.A.E., Eisenberg-Domovich, Y., Nordlund, H.R., Hayouka, R., Kulomaa, M.S., Livnah, O., Hytönen, V.P., Chimeric avidin shows stability against harsh chemical conditions - biochemical analysis and 3D structure, Biotechnol. Bioeng. 108(2011)481-490.

5) Heikkinen, J.J., Telkki, V-V, Hormi, O.E.O, New interconnected macroporous oxide materials by phase separation of bis(trimethoxysilyl)hexane with poly(acrylic acid). PMSE Preprints, 103(2010),5.

Number of publications
5

Number of patents and patent applications
2

Number of M.Sc.Thesis
2

Number of Doctoral Thesis
2

Project Full Name (acronym)
Degrading effects of ultraviolet radiation on materials 2 [UV-säteilyn materiaalivaikutukset 2] (UVEMA 2)

Organisation
Finnish Meteorological Institute

Contact Person
Jarkko Koskinen

Other research organisations in the project consortium
Tampere University of Technolyg, Aalto University

Company partners
Elastopoli Oy, Exel Oyj, Nokian Renkaat Oyj, Oy All-Plast Ab

International partners (country, organisation)
Meteorogical Observatory Lindenberg, German Weather Service; Lindenberg, Germany; Laboratory of Atmospheric Physics, Aristotle University of Thessaloniki; Thessaloniki, Greece; El Arenosillo Sounding Station, National Institute for Aerospace Technology; Huelva, Spain; Observatorio Atmosphérico de Izaña, Instituto Nacional de Meteorología; Tenerife, Spain

Project duration
14.9.2007 – 13.3.2010

Total cost (€)
461 000

Main target
Discovery and development of novel methods applicable in studies of endurance of outdoor materials against UV radiation exposure and other weathering agents.

Motivation
Current methods used for service life time estiations of materials lack knowledge on and empirical methods for investigating wavelength dependencies of UV radiation induced degradation and correlations between the conditions prevailing in weathering tests in laboratories and in real service environments.

Key results and impact
A novel facility for ageing materials with spectrally resolved UV radiation and elevated temperatures simultaneously was designed and constructed. A new methodology for life time estimation was developed, using knowledge on the wavelength dependence of material vulnerability, characterized radiation conditions prevailing in equipment used for accelerated ageing and exposure measured under the Sun.

Results of the projects are expected to be in commercial use within how many years?
Part of the results already used by industrial partners and their customers.

Key publications
1) Heikkilä, A., Tanskanen, A., Kärhä, P. and Hanhi, K., Adjusting timing of weathering test to account for seasonal variations in UV exposure, Polymer Degradation and Stability, 92 (2007) 675-683
2) Lindfors, A., Heikkilä, A., Kaurola, J., Koskela, T. and Lakkala, K. , Reconstruction of Solar Spectral Surface UV Irradiances Using Radiative Transfer Simulations, Photochemistry and photobiology, 85 (2009) 1233-1239
3) Bijl, P., Heikkilä, A., Syrjälä, S., Aarva, A. and Poikonen, A., Modelling of sample surface temperature in an outdoor weathering test, Polymer Testing, 30 (2011) 485-492

4) Kärhä, P., Heikkilä, A., Ruokolainen, K. and Kaunismaa, M., A novel facility for ageing materials with narrow-band ultraviolet radiation exposure, Review of Scientific Instruments, 82 (2011) 023107-1 - 023107-6

Number of publications
11

Number of M.Sc.Thesis
2

Project Full Name (acronym)
Light and wear resistant hydrid materials (K3MAT)

Organisation
Tampere University of Technology, Department of Materials Science/Materials Characterization Group

Contact Person
Prof. Toivo Lepistö and Dr. Minnamari Vippola

Other research organisations in the project consortium
Tampere University of Technology, Department of Materials science, Laboratory of Plastics and Elastomer Technology (Prof. Vuorinen)
Aalto Univeristy, School of Engineering, Department of Applied Mechanics, Aeronautical Engineering (Prof. Saarela)
Aalto University, School of Science and Technology, Department of Applied Physics, COMP (Prof. Nieminen)

Company partners
Fibrocom Oy, FY-Composites Oy, Etteplan Oyj, Metso Minerals Oy, Muovityö Hiltunen Oy, Rautaruukki Oyj, Sako Limited, Teknologiakeskus Hermia Oy

International partners (country, organisation)
Delft University of Technology, Netherlands (researcher visit from Aalto Univeristy, Department of Applied Mechanics)
Max-Planck Institut fur Polymerforschung, Germany (Aalto Univeristy, COMP)

Project duration
1.4.2008 – 31.7.2011

Total cost (€)
1 101 450 (800 000Tekes, 72 000 companies, 229 450 Aalto institutes own funding)

Main target
The main aim of K3MAt project was to understand properties of novel light and wear resistant hybrids and composites and thus control their use when simulating and tailoring novel multiform material solutions in variable load situations for new highperformance applications.

Motivation
Motivation for the K3MAT project was to enable the utilization of the best material properties of different material grades by hybrid structures.

Key results and impact
The research project K3MAT "Light and wear resistant hybrid materials" was implemented together with Tampere University of Technology and Aalto University. The main goal of the K3MAT research project was to give the engineers the needed property data and design information of novel light hybrid materials. This was achieved through fundamental characterization, modeling and simulation. The profound understanding of hybrid materials can generate material models, which can be used to tailor multiform material solutions for the applications of e.g., mechanical and metal industry, machine construction, electronics as well as transportation industry.

Key publications
1) Blomqvist, J., Salo, P.,Adsorption of benzene, phenol, propane and carbonic acid molecules on oxidized Al(111) and alpha- Al2O3(0001) surfaces: A first-principles study, Journal of Physics: Condensed Matter 21, 225001 (2009)
2) Honkanen, M., Hoikkanen, M., Vippola, M., Lepistö, T., and Vuorinen, J., Metal-Plastic Adhesion in Injection-Molded Hybrids Journal of Adhesion Science and Technology 23 (2009) 1747-1761
3) Honkanen, M., Hoikkanen, M., Vippola, M., Vuorinen, J., Lepistö, T., Jussila, P., Ali-Löytty, H., Lampimäki, M., Valden, M., Characterization of Silane Layer in Stainless Steel-TPU Hybrids, Applied Surface Science, VOL 257, 2011, 9335-9346.
4) Hoikkanen, M., Honkanen, M., Vippola, M., Lepistö, T., and Vuorinen, J., Effect of silane treatment parameters on the

silane layer formation and bonding to thermoplastic urethane, Progress in Organic Coatings, Vol 72(4), 2011, 716-723.
5) Kanerva, M., Saarela, O. Near Interface Residual and Surface Stress Measurements in Steel-Epoxy Hybrids Abstract, paper and presentation in International Conference on Composite Structures (ICCS16), Porto, Portugal, June 2011

Number of publications
International refereed journal papers: 7
Other international publications: 21

Number of M.Sc.Thesis
2

Project Full Name (acronym)
Regenerative Active Matrix (RAM)

Organisation
Helsinki University Institute of Biomedicine, Pharmacology

Contact Person
Doc. Esko Kankuri

Other research organisations in the project consortium
Funding for Regea - Institute of Regenerative Medicine, University of Tampere integrated in the project budget as independent entity.
Hospital District of Helsinki and Uusimaa (HUS) and the Satakunta Hospital District (SATSHP)

Company partners
Vivoxid Oy, Fibrogen Europe Oy, WL-Medical Oy, Baxter Suomi Oy, and Surgimed Oy

International partners (country, organisation)
Professor Yoshiki Sawa, Osaka Graduate School of Medicine (Osaka, Japan)
DSc Jozef Bizik, Slovak Academy of Sciences (Bratislava, Slovakia)
In addition several international collaborators.

Project duration
1.1.2008 – 31.3.2012

Total cost (€)
817 500 (University of Helsinki: 551.500 (RAM) + 129 199 (JST-TEKES) = 680 699 and Regea, University of Tampere: 266 000)
Total costs: 946.699

Main target
1) To produce a product for cell culture application and for laboratory/diagnostic use,
2) To develop an active wound healing matrix, and 3) to use the matrix for safety and efficacy testing.

Motivation
Compromised wound healing, such as seen in chronic wounds and large burn wounds, exerts an increasing snowballing effect on national health care costs. The effects of compromised healing and scarring for an individual range from debilitating to fatal, but usually require lengthy hospitalizations and constant wound care. Wound healing mechanisms and scarring are important therapeutic targets not only in the skin but also in other tissues, such as the heart and in heart disease.

Key results and impact
The key targets of the project were achieved. Laboratory-use products were finalized, and a clinically applicable protocol was established.

Results of the projects are expected to be in commercial use within how many years?
Some results have been commercialized to date. Further results of the project will be commercialized within 3 to 5 years.

Key publications
1) Peura, M., Kaartinen I., Suomela S., Hukkanen M., Bizik J., Harjula A., Kankuri E., and Vuola J., Improved skin wound epithelialization by topical delivery of soluble factors from fibroblast aggregates, Burns, 38 (2012) 541-550
2) Peura, M., Siltanen A., Saarinen I., Soots A., Bizik J., Vuola J., Harjula A., and Kankuri E., Paracrine factors from fibroblast aggregates in a fibrin-matrix carrier enhance keratinocyte viability and migration, J Biomed Mater Res A, 95 (2010) 658-664

3) Peura, M., Bizik J., Salmenperä P., Noro A., Korhonen M., Pätilä T., Vento A., Vaheri A., Alitalo R., Vuola J., Harjula A., and Kankuri E., Bone marrow mesenchymal stem cells undergo nemosis and induce keratinocyte wound healing utilizing the HGF/c-Met/PI3K pathway, Wound Repair Regen 17(2009) 569-577
4) Kitabayashi, K., Siltanen A., Pätilä T., Mahar M.A., Tikkanen I., Koponen J., Ono M., Sawa Y., Kankuri E., and Harjula A., Bcl-2 expression enhances myoblast sheet transplantation therapy for acute myocardial infarction, Cell Transplant 19 (2010) 573-588
5) Siltanen, A., Kitabayashi K., Lakkisto P., Mäkelä J., Pätilä T., Ono M., Tikkanen I., Sawa Y., Kankuri E., and Harjula A., hHGF overexpression in myoblast sheets enhances their angiogenic potential in rat chronic heart failure, PLoS One 6 (2011) e19161

Number of publications
12

Number of patents and patent applications
5

Number of Doctoral Thesis
2

Project Full Name (acronym)
Bioaktiivinen pehmytkudosimplantti

Organisation
University of Tampere

Contact Person
Prof. Timo Ylikomi

Project duration
1.1.2011 – 30.11.2013

Total cost (€)
220 320

Main target
Development of a bioactive (angiogenic and adsipogenic) substance as an off the shelf medical product.

Motivation
Soft tissue correction and would healing are important medical problems. No optimal tretaments and products exist.

Key results and impact
GMP-production of the substance established; shelf life studied, shown that the produc is safe and biocompatible; patenting process continued

Results of the projects are expected to be in commercial use within how many years?
3-4 years

Key publications
1) Sarkanen JR, Kaila V, Mannerström B, Räty S, Kuokkanen H, Miettinen S, Ylikomi T.: Human adipose tissue extract induces angiogenesis and adipogenesis in vitro. Tissue Eng Part A. 2012 Jan;18(1-2):17-25.
2) Sarkanen JR, Ruusuvuori P, Kuokkanen H, Paavonen T, Ylikomi T, : Bioactive acellular implant induces angiogenesis and adipogenesis and sustained soft tissue restoration in vivo.. Tissue Eng Part A. 2012 Dec; 18(23-24): 2568-80.

Number of publications
4

Number of patents and patent applications
1

Number of M.Sc.Thesis
1

Number of Doctoral Thesis
1

Project Full Name (acronym)
Novel Responsive Surfaces based on Active Hybrid Coatings Utilizing Encapsulation Technologies (RESCOAT)

Organisation
VTT Technical Research Centre of Finland

Contact Person
Juha Nikkola

Other research organisations in the project consortium
Aalto University, Finnish Institute of Occupational Health

Company partners
Ruukki Metals, Fortum Power and Heat, Tikkurila, Tekno-forest, Taitotekniikka

International partners (country, organisation)
Portugal, IST, Technical University of Lisboa

Project duration
1.2.2011 – 31.1.2014

Total cost (€)
806 000

Main target
The main objective of the VTT Technical Research Centre of Finland , Aalto Univeristy and the Finnish Institute of Occupational Health joint project is to develop new multifunctional and responsive hybrid coating surfaces exploiting encapsulated active components.

Motivation
Project provides solutions for the applications where the well-known thermal, mechanical, or chemical solutions can not be used, or when the value of the products can be increased with the functional and active surface, and its competitiveness improved caused by decrease of maintenance costs.

Key results and impact
Proof-of-concept: capsule materials and encapsulation concept with controlled capsule size and release performance.

Results of the projects are expected to be in commercial use within how many years?
Within 2-5 years, depending on the application.

Key publications
1) Pelto J., Virtanen S., Munter T., Larismaa J.,Jämsä S., Nikkola, J., Encapsulation of 3-iodo-2-propynyl N-butylcarbamate (IPBC) in polystyrene-polycaprolactone (PS/PCL) blends, accepted to Journal of Microencapsulation.

Number of publications
3 conference publications.

Number of M.Sc.Thesis
1 on-going

Number of Doctoral Thesis
2 on-going

Project Full Name (acronym)
Printable pharmaceuticals for drug delivery (pPOD)

Organisation
Åbo Akademi University

Contact Person
Niklas Sandler

Other research organisations in the project consortium
Aalto University, University of Helsinki

Company partners
Bayer Oy, Specim Oy, Sappi Oy, Hormos Medical Oy
International partners (country, organisation)
Denmark, University of Copenhagen

Project duration
1.3.2011 – 28.2.2014

Total cost (€)
1 089 092

Main target
To develop a drug manufacturing platform based on printing technologies.To study and optimize pharmaceutical printing formulations for a wide range of drug substances. Investigate printing substrates to be used as drug-delivery systems.

Motivation
Totally new processing solution enables precise and automated 3-dimensional manufacturing of pharmaceuticals. The procedure provides potential to produce on-demand personalized and tailor-made medicines in a flexible manner.

Key results and impact
The project "pPOD- Printable Pharmaceutials for Drug Delivery" has developed a drug manufacturing platform based on various of printing technologies. The project has generated extensive know-how on fabrication and quality control of printed therapeutic systems. A variety of printable formulations for a wide range of drug substances have been developed and tested. We have also investigated and developed drug carrier substrates to be used as drug-delivery systems. The results of the project provides a solutions to produce on-demand medicines and allow meeting the demands of personalized dosing and flexible manufacturing of pharmaceutical products of the future.

Results of the projects are expected to be in commercial use within how many years?
Approximately 3-5 years.

Key publications

1) Kolakovic, R. Ihalainen, P. Viitala, T. Genina, N,.Peltonen, J., Sandler N. Printing technologies in fabrication of drug delivery systems – review (in Press).
2) Raijada, D., Genina, N., Fors, D., Wisaeus, E., Peltonen, J.Rantanen, J. Sandler N. A Step Toward Development of Printable Dosage Forms for Poorly Soluble Drugs J. Pharm. Sci. 2013 (in Press).
3) Genina, H. Fors, D., Palo, M., Peltonen, J., N. Sandler. Behavior of printable formulations of loperamide and caffeine on different substrates – Effect of print density in inkjet printing. Int. J. Pharm. 2013 (in Press).
4) M. Takala, H. Helkiö, J. Sundholm, N. Genina, P. Kiviluoma, T. Widmaier, N. Sandler, N., P. Kuosmanen, Ink-jet printing of pharmaceuticals, Full paper. In: 8th International DAAM Baltic Conference 'Industrial Engineering', Tallinn, Estonia, April 19-21, 2012.
5) Genina, N., Fors, D., Vakili, H., Ihalainen, P., Pohjala, L., Ehlers, H., Kassamakov, I., Haeggstrom, E., Vuorela, P., Peltonen, J., Sandler, N. Tailoring controlled-release oral dosage forms by combining inkjet and flexographic printing techniques, Eur. J. of Pharm. Sci. 2012, 3,(9) 615–623.

Number of publications
5 refereed articles, 10 poster presentations.

Number of patents and patent applications
2 patent application to be submitted

Number of M.Sc.Thesis
2 M.Sc theses

Number of Doctoral Thesis
2 PhD theses

Project Full Name (acronym)
Printed supercapacitors (PRISU)

Organisation
VTT Technical Research Centre of Finland

Contact Person

Jari Keskinen, tel. +358 20 722 3703, jari.keskinen@vtt.fi

Other research organisations in the project consortium
Åbo Akademi Univeristy, Aalto University

Company partners
Confidex Oy, Kabus Oy, Kemet Electronics Oy, Kone Oyj, Stora Enso Oyj, Walki Oy

International partners (country, organisation)
European Energy Research Alliance, EERA connection
Sweden, Researcher exchange with University of Uppsala
Germany, Material comparison with Fraunhofer Institute IKTS

Project duration
1.4.2012 – 31.3.2014

Total cost (€)
1 100 000

Main target
Very low supercapacitor manufacturing costs facilitated by printing techniques.
Inexpensive and environmentally benign raw materials.
Easily scalable structure.

Motivation
The low costs and non-toxic materials make it possible to find new application areas for supercapacitors.

Key results and impact
Successful pilot scale roll-to-roll printing.
Cycle life of minimum 50000 cycles proved.
Demonstration on hybrid system consisting of printed supercapacitor and printed photovoltaic cell.

Results of the projects are expected to be in commercial use within how many years?
3 years

Key publications

1) Keskinen, J. Sivonen, E., Jussila, S., Bergellin, M., Johansson, M., Vaari, A., Smolander, M. Printed supercapacitors on paperboard substrate, Electrochimica Acta, 85, 2012, 302–306..
2) Keskinen, J., Sivonen, E., Bergelin, M., Eriksson, J.-E., Smolander, M., Vaari, A., Boer, H., Maaninen, T., Tuurala, S., Supercapacitors with Aqueous Electrolyte Made by Printing on Paperboard, Supercapacitors Europe 2013, Apr. 17, 2013, Berlin, www.idtechex.com/printed-electronics-europe/downloads.asp

Number of publications
4 until now, 3 more planned on the basis of the project results

Number of patents and patent applications
1 patent application, at least 1 more planned to be done

Number of Doctoral Thesis
None based on this project alone, partial impact on 2 theses

Project Full Name (acronym)
Disconnecting microbes from food and beverage process surfaces (DISCONNECTING)

Organisation
VTT Technical Research Centre of Finland

Contact Person
Erna Storgårds

Other research organisations in the project consortium
Technical University of Tampere

Company partners
Panimolaboratorio (Brewing Laboratory PBL), Millidyne
International partners (country, organisation)
UK, Manchester Metropolitan University (MMU)
UK, Teer Coatings Limited (Miba)
UK, Cristal Global

Project duration
1.6.2010 – 30.11.2013

Total cost (€)
720 700

Main target
The main target was to develop material solutions capable of reducing microbial attachment on the surfaces of the food and beverage industry. Another target was to investigate ways to disturb quorum sensing signalling of microbes in biofilm formation.

Motivation
To be able to fulfil all the hygienic, economic and environmental demands, novel means for managing microbes on process surfaces are needed.

Key results and impact
Of the hydrophobic, photocatalytic and/or antimicrobial coatings developed, the antimicrobial coatings had the best potential for reducing microbial attachment. The functionality and mechanical durability of the coatings are a challenge in process conditions.

Four plant extracts were shown to inhibit bacterial acyl homoserine lactone -mediated quorum sensing. The expected impact is to provide environmentally friendly means to improve process hygiene in food and beverage industry.

Results of the projects are expected to be in commercial use within how many years?
It is estimated to take 5-10 years before the results can be commercially exploited.

Key publications
1) Priha et al., Production of quorum sensing signalling molecules and biofilm formation of bacteria isolated from brewery processes, and inhibition of AHL signalling by plant extracts (manuscript)
2) Heinonen et al., Bacterial growth on a superhydrophobic surface containing silver nanoparticles (manuscript).

Other publications pending (situation 1.8.2013)

Number of publications
6 publications expected.

Number of M.Sc.Thesis
1 (Saara Heinonen, TUT)

Number of Doctoral Thesis
1 (Soheyla Ostovarpour, MMU)

Project Full Name (acronym)
Smart Active Materials (SAM)

Organisation
University of Eastern Finland, Department of Chemistry

Contact Person
Mika Suvanto

Other research organisations in the project consortium
University of Eastern Finland, SIB Labs

Company partners
Metso Paper Oy, Ecocat Oy, Joptek Oy Composites, Nokian Tyres Oyj

Project duration
1.12.2011 – 31.12.2014

Total cost (€)
680 000

Main target
The focus of the project has been on:
1) Composite joints involving metal and polymer materials – the main goal of the research has been development of adhesion between the joint components based on physical and chemical modifications.
2) Emission control catalyst technology – the aim of a work package has been to study effect of morphology and composition of exhaust cleaning catalysts on their activity under sulphur containing reaction conditions. Adhesion properties of the catalyst wash coat on a structurally and chemically modified metal foil will be studied, as well.

Motivation
Almost all technical devices contain different kinds of joints. Structurally durable joints are typically shear joints which are most often based on adhesion or mechanical interlocking. Under similar test conditions it has been noticed that strength of the adhesive joints is higher than that of the mechanical ones. The high strength together with the ease of production have resulted with the adhesive joints in replacement of the conventional mechanical and welding joints in many applications. Due to an increasing use of the adhesive joint geometry it is of particular importance to further develop and optimize mechanical strength of joints based on the interaction between adhesives and adherends.

Liquid fuels may include small amount of sulphur compounds, although the modern oil refining removes these efficiently. Sulphur residues in the fuel may act as a catalyst poison and one clear and well known disadvantage is a formation of toxic H2S having a bad smell. Of considerable environmental importance in the catalyst technology is an understanding of the structure – property relationship. There is a clear requirement for studying and providing more sulphur tolerant catalyst compositions which will inhibit the

formation of undesirable side products, as well. Improvement of the adhesion of a catalytically active wash coat in metal constructions may offer a new solution to enhance mechanical strength and thus life time of the exhaust cleaning catalyst system.

Key results and impact

Adhesive joints In this project, several approaches for improving the adhesion in different material-pair systems have been studied. Surface properties of the metal and resin substrates have been modified physically with a controlled micro-scale patterning and chemically with silane coupling agents or plasma treatments. Three different material pair systems have been evaluated: aluminum substrate/polyepoxy resin (A), aluminum substrate/ polyester resin (B) and polyepoxy resin substrate/polyurethane resin (C). For these systems we have employed a single lap joint geometry.

With system A the 3-glycidyloxypropyl trimethoxysilane (γ-GPS) has been used as an adhesion promoter. It has been noticed, that with a proper hydrolysis time, 1 w-% of water in the alcohol/silane solution is enough to fully hydrolyze the γ-GPS. The pH of the silane solution has been observed to have a significant influence on binding of silane to aluminum surface. In comparison to the unmodified system, the γ-GPS treatment with proper parameters has more than doubled the shear strength of the aluminum - polyepoxy resin adhesive joint.

For systems B and C the physical modification of substrate surfaces with the controlled micro-scale patterning was the main target. The micro-scale patterning was performed with a micro mesh printing technique with different mesh sizes from 30 µm to 400 µm.

The micro patterning provides an easy and low cost method to introduce mechanical locking points and to increase the surface area of the substrate and therefore increase the shear and tensile properties of the specimen. Our preliminary results have demonstrated that in aluminum-resin and resin-resin systems, the micro patterning improved adhesion of the test specimens more than 100%.

With both systems the oxygen plasma treatment was tentatively studied. Preliminary results show that compared to untreated systems, the oxygen plasma treatment improved clearly the shear strength of both systems.

The knowledge will be applied for developing new coating and protection techniques and to improve adhesion properties of composite surfaces.

Emission control catalysts

A set of catalysts for exhaust treatment was prepared and tested in CO and C_3H_6 oxidation processes. The main aim of the work is to prepare catalysts with a high activity and resistance to sulfur poisoning. Palladium was used as an active metal and alumina oxide as active metal support. Two palladium precursors (Pd(acac)2 and $Pd(NO_3)_2$) and two support materials (γ-Al_2O_3 and γ- Al_2O_3-La_2O_3) were used for catalyst preparation. It was tested whether a choice of starting materials can influence on the catalyst performance in oxidation reactions. Part of the catalysts were co-impregnated with Ni precursor with different Pd:Ni ratios. Ni promoter is expected to improve sulfur resistance of catalysts by providing additional binding sites for the adsorption of sulfur molecules. Based on the results of catalytic activity tests, it was concluded that the addition of nickel decreases activity of fresh catalysts. However, the activity of aged catalysts was not affected by the presence of nickel.

Various characterization techniques (TEM/EDS, SEM, XRD, BET, TPD) were employed to investigate the state of Ni dopant on the catalyst: whether it (i) forms agglomerates with noble metal, (ii) encapsulates noble metal, (iii) forms separate particles or (iv) interacts with the support. The next step of the research is to determine the role of Ni for adsorption and removal of SOx and H_2S.

Results of the projects are expected to be in commercial use within how many years?

Within 2-5- years

Number of M.Sc.Thesis

2

Project Full Name (acronym)

Graphene for mobile applications: Nanolaminates & Biosensing (GraNBis)

Organisation

VTT Technical Research Centre of Finland

Contact Person
Sanna Arpiainen
Other research organisations in the project consortium
Aalto University, Department of Micro- and Nanosciences

Company partners
Okmetic Oyj, Oxford Instruments Analytical Oy, Picosun Oy
International partners (country, organisation)
China, Tsinghua University, Institute of Microelectronics
Italy, University of Perugia, Department of Physics
Spain, Catalan Institute of Nanotechnology

Project duration
1.3.2011 – 28.2.2014

Total cost (€)
1 660 000

Main target
Project aims to the development of graphene technology enablers and novel responsive films and devices based on CVD graphene. The target applications range from electronics, OLED's and biosensors to strong hermetic films and foils.

Motivation
Graphene is one of the most promising new materials with high technological and commercial prospects, which was also emphasized by the selection graphene as other of the EU Flagships in future research. From the domestic point of view, it is important to develop graphene based technology to the level where it can be easily prototyped and commercialized.

Key results and impact
Development of photo-thermal chemical vapor deposition method for the fast and scalable growth of high quality graphene is an important step towards industrialization. One essential building block for graphene electronics is a current inverter based on the ambipolarity of graphene, which was demonstrated by Aalto University in collaboration with Nokia. In biosensing , tailorable functionalization of graphene with genetically engineered hydrophobins paves the way for programmable on-chip biorecognition on a reusable platform.

Results of the projects are expected to be in commercial use within how many years?
5 to 10 years

Key publications

1) Riikonen J., Kim W., Li C., Svensk O., Arpiainen S., Kainlauri M., Lipsanen H., Photo-thermal chemical vapor deposition of graphene on copper, Carbon, 62 (2013) 43 – 50.
2) Kim W., Riikonen J., Li C., Chen Y., Lipsanen H., Highly Tunable Local Gate Controlled Complementary Graphene Device Performing as Inverter and Voltage Controlled Resistor, Nanotechnology, accepted.
3) Kainlauri M., Kurppa K., Soikkeli M., Arpiainen S., Gunnarsson D., Laaksonen P., Prunnila M., Linder M., Ahopelto J., Surface Functionalization of Graphene Biosensors with Tailored Hydrophobins, to be published.
4) Kim W., Riikonen J., Pasanen P., Lipsanen H., Nonlinear behavior of three terminal graphene junctions, Nanotechnology, 23 (2012) 115201.
5) Naumenko D., Snitka V., Snopok B., Arpiainen S., Lipsanen H., Graphene-enhanced Raman imaging of TiO_2 nanoparticles, Nanotechnology, 23 (2012), 465703.

Number of publications
7

Number of M.Sc.Thesis
3

Project Full Name (acronym)
Improved energy efficiency by modifying the surface properties of materials (EFFIMAT)

Organisation
VTT Technical Research Centre of Finland

Contact Person
Eini Puhakka

Other research organisations in the project consortium
University of Oulu, Centre de Recherche Public Gabriel Lippmann

Company partners
Andritz Oy, Oerlikon Balzers Sandvik Coating Oy, OMYA GmbH, Outokumpu Stainless AB, Suomen Karbonaatti Oy

Project duration
20.9.2010 – 31.8.2013

Total cost (€)
1 725 559

Main target
The main targets of the project were to increase energy efficiency of heat transfer by developing surface materials, which restrain crystallization fouling and precipitation of sub-micron particles onto the surfaces of process equipment, to develop a comprehensive computational fluid dynamics (CFD) fouling model in order to predict crystallization and a particle deposition processes in industrial processes, to find out a new way to improve surface properties in order to mitigate fouling both in the short and long term, and to achieve a good combination of non-fouling properties and corrosion resistance for stainless steel using environmentally sustainable methods.

Motivation
Fouling causes economic losses and has a marked effect on carbon dioxide releases and thus on climate change. It has been estimated that fouling costs are about 0.2% of the countries' Gross National Product.

Key results and impact
Based on the experiments and molecular modelling, it was developed functionalized silicon oxide coatings which are promising materials for mitigation of fouling caused by calcium carbonate. Further, the comprehensive CFD fouling model was developed and validated in order to simulate deposition rates in heat exchangers. In the model, the crystallization and particulate fouling models were combined in order to model fouling of both the clean and fouled surfaces.

Results of the projects are expected to be in commercial use within how many years?
Over five years.

Key publications

1) Puhakka, E., Riihimäki, M., and Keiski, R.L., The effect of magnesium on the formation of CaCO3 depositions, Proceedings of International Conference on Heat Exchanger Fouling and Cleaning - 2011 (Peer-reviewed), June 05 - 10, 2011, Crete Island, Greece, Editors M.R. Malayeri, H. Müller-Steinhagen and A.P. Watkinson, Crete Island, Greese, June 05 - 10, 2011 (2012), 243-250.
2) Ojaniemi, U., Riihimäki, M., Manninen, M., and Pättikangas, T., Wall function model for particulate fouling applying XDLVO theory, Chem. Eng. Sci., 84 (2012) 57–69.
3) Pääkkönen, T.M., Riihimäki, M., Simonson, C.J., Muurinen, E., and Keiski, R.L., Crystallization fouling of CaCO3 – Analysis of experimental thermal resistance and its uncertainty, International Journal of Heat and Mass Transfer, 55 (2012) 6927-6937.
4) Ojaniemi, U., Manninen, M., Pättikangas, T., and Riihimäki, M., Effects of turbulence and thermophoresis on particulate fouling in heat exchangers modelled with CFD, Heat Exchanger Fouling and Cleaning – 2013, June 09-14, 2013, Budapest, Hungary.
5) Puhakka, E., and Lecoq, E., Organo silicon and titanium oxide coatings for mitigation of CaCO3 depositions, Heat Exchanger Fouling and Cleaning – 2013, June 09-14, 2013, Budapest, Hungary.

Number of publications
7 scientific articles, 5 oral presentations, 6 poster presentations

Project Full Name (acronym)
Commercialization of green, bio-based galvanic skin treatment patch for personal well-being markets (COSPAD)

Organisation
VTT Technical Research Centre of Finland

Contact Person
Anu Vaari

Other research organisations in the project consortium
Åbo Akademi University
Tampere University of Technology

Company partners
Lumene Oy, Joutsen paino Oy, Stora Enso Oyj, Tervakoski Oy, AB Enzymes (company partners only in advisor board, not finace parties)

Project duration
1.4.2012 – 30.9.2013

Total cost (€)
349 760

Main target
The main target is providing solutions for commercialization of skin treatment pad for cosmetic applications. In project the feasibility of the new type of product is validated in technical, market and business point of view.

Motivation
The motivation for this project is that we have both interesting new type of product / product idea and market demand. In our product concept we are pooling together different know-how on printed intelligence and enzymatic power source. And in cosmetics there seems to be a big market potential for enhanced single-use, disposable skin care products.

Key results and impact
The project will give valuable information for the future steps in commercialization process designed patch. Alternatives for suitable business model for example. We will get proof of relevance not only for design product, but also for the whole research theme from the perspective of commercialisation. The reviews of competitors and competing solutions, will give useful information also for new/other product in cosmetic business.

Results of the projects are expected to be in commercial use within how many years?
In the best case, if the results of forthcoming commercialization projects are positive, the product might be in commercial use in 3 – 4 years.

Number of patents and patent applications
Patent proses on going, one new invention disclosures have been sending.

Project Full Name (acronym)
Robust dye solar cells printed on metal (KesMPV)

Organisation
Aalto University

Contact Person
Janne Halme, tel. +358 50 3441695, janne.halme@aalto.fi

Other research organisations in the project consortium
Åbo Akademi University, VTT Technical Research Centre of Finland

Company partners
Rautaruukki Oyj, Volatec Oy, Finnseri Oy, Beneq Oy

Project duration
1.4.2011 – 31.3.2014

Total cost (€)
613 808

Main target
The goal of the project is to find material and process solutions for pre-industrial manufacturing of durable but low-cost flexible metal based dye-sensitized solar cells (DSC). The aim is to reduce manufacturing costs by replacing conducting titanium foil and indium tin oxide (ITO) coated plastic, used in present commercial DSCs, with cheaper metals and conductors protected against iodine induced corrosion.

Motivation
Commercial flexible DSCs suffer from high material costs due to titanium metal and indium-tin-oxide (ITO) plastic foils used

as current collecting substrates. Alternative low cost metallic conductors and new solar cell structures that make their application possible would bring the DSC technology closer to commercialization provided that the high efficiency and durability of the conventional DSCs can be maintained with the new materials.

Key results and impact

Divided to several work packages the project has made progress in many fronts important for the practical realization of low cost fully metal based DSCs. The following achievements can be highlighted:

- A roll-to-roll compatible method for producing porous conductive metal films was developed that decreases the manufacturing time of the solar cells.
- The role of surface properties of metal substrates on the stability of DSCs was clarified and improved stability was obtained by carefully selecting the metal and it surface treatment. This together with new understanding obtained on the electrochemical corrosion reactions with SEM analysis helps further development of stable metal based DSCs.
- New experimental methodology based on mass spectroscopy for characterization of the stability of ruthenium based metalloorganic dyes in complete DSCs was developed. The method helps obtaining more detailed picture of the chemical interactions taking place in the cell due to long term exposure to sunlight and elevated temperatures.
- New screen printable ink formulations for most of the porous metal, metal oxide and catalyst layers of the cell were developed by solving problems related for example to compatibility with the substrate material and printability. The final goal is to realize most of the components of the complete solar cell structure by fast screen printing and curing processes.
- The baseline energy conversion efficiency with standard DSC materials was increased from 5 % to 7 % by application of surface treatment and light scattering techniques, meeting one of the quantitative objectives of the project. The final goal is to reach 3 - 4 % in fully metal based DSC prototype module, as a proof of concept of the applicability and scalability of the cheaper metal materials, and reach stable operation in accelerated aging test corresponding to 1000 hours of continuous full sunlight illumination with a metal based DSC.

Results of the projects are expected to be in commercial use within how many years?

9

Key publications

1) Vahlman, H., Halme, J., Korhonen, J.T., Aitola, K., and Patakangas, J., On the Mass Transport in Apparently Iodine-Free Ionic Liquid Polyaniline-Coated Carbon Black Composite Electrolytes in Dye-Sensitized Solar Cells, The Journal of Physical Chemistry C 117, pp. 11920-11929 (2013).

2) Miettunen, K., Saukkonen, T., Li, X., Law, C.H., Sheng, Y.K., Halme, J., Tiihonen, A., Barnes, P.R.F., Ghaddar, T., Asghar, I., Lund, P., and O Regan, B.C., Do Counter Electrodes on Metal Substrates Work with Cobalt Complex Based Electrolyte in Dye Sensitized Solar Cells?, Journal of the Electrochemical Society 160, pp. H132-H137 (2013).

3) Hashmi, S.G., Miettunen, K., Ruuskanen, A., Asghar, M.I., Halme, J., and Lund P., Process steps towards a flexible dye solar cell module, Proceedings of the 27th European Photovoltaic Solar Energy Conference 27, pp. 2922-2924 (2012).

4) Miettunen,K., Jouttijärvi, S., Jiang, R., Saukkonen , T., Romu, J., O'Regan, B.C., Low cost ferritic stainless steel substrate in dye sensitized solar cells with cobalt complex electrolyte, To be submitted (2013)

5) Rendon, S.M.K., Mavrynsky, D., Meierjohann, A., Tiihonen, A., Miettunen, K., Halme, J., Kronberg, L., Leino, R., A method for analyzing dye degradation products and assessing the dye purity in dye-sensitized solar cells, manuscript in preparation.

Number of publications

3 published, 6 - 10 expected in total

Number of Doctoral Thesis

1 (Henri Vahlman, Aalto Univeristy, 2014 expected)

Project Full Name (acronym)
Continuous Atomic Layer Process

Organisation
Tampere University of Technology, Paper Converting and Packaging

Contact Person
Researcher Petri Johnasson and Prof. Jurkka Kuusipalo

Other research organisations in the project consortium
Lappeenranta Uviversity of Technology (ASTRAL Mikkeli), VTT Technical Research Centre of Finland

Company partners
Saarioinen, Stora Enso, UPM, Bemis
International partners (country, organisation)
UK, Innovia Films

Project duration
1.8.2010 – 30.11.2013

Total cost (€)
350 000

Main target
Development of barrier and other products with Roll-to-Roll ALD equipment.

Motivation
Sustainable ultrathin coatings can be utilized in multiple areas instead of thicker coating materials.

Key results and impact
It is possible to gain homogeneous coatings having e.g., good barrier properties with this technique, but further process and product development is necessary.

Results of the projects are expected to be in commercial use within how many years?
Depending on products, some in few years but primarily in 5-10 years.

Key publications

1) Lahtinen, Kimmo; Maydannik, Philipp; Seppänen, Tarja; Cameron, David; Johansson, Petri; Kotkamo, Sami; Kuusipalo, Jurkka 2013. Protecting BOPP film from UV degradation with an atomic layer deposited titanium oxide surface coating.
2) Lahtinen, Kimmo; Johansson, Petri; Kääriäinen, Tommi; Maydannik, Philipp; Cameron, David; Kuusipalo, Jurkka 2012. Toward more controlled, nanoscale barrier layers in packaging . Plastics Research Online num. 17th August, 1-3. http://dx.doi.org/10.2417/spepro.004237 Applid Surface Science 282 (2013) 506-511 506-511.
3) Lahtinen, Kimmo; Maydannik, Philipp; Johansson, Petri; Kääriäinen, Tommi; Cameron, David C.; Kuusipalo, Jurkka 2011. Utilisation of continuous atomic layer deposition process for barrier enhancement of extrusion-coated paper.
4) Surface and Coatings Technology vol. 205, num. 15, 3916-3922. http://dx.doi.org/10.1016/j.surfcoat.2011.02.009
5) Lahtinen, Kimmo; Johansson, Petri; Kääriäinen, Tommi; Cameron, David, C. 2012. Adhesion of Extrusion-Coated Polymer Sealing Layers to a Fiber-Based Packaging Material with an Atomic Layer Deposited Aluminum Oxide Surface Coating . Polymer Engineering and Science vol. 52, num. 9, 1985-1990. http://dx.doi.org/10.1002/pen.23148

Number of publications
4

Project Full Name (acronym)
Clean steels and fatigue survival with material imperfections (FATE-DEFEX)

Organisation
VTT Technical Research Centre of Finland

Contact Person
Jussi Solin

Other research organisations in the project consortium
Aalto University (TKK), Tampere University of Technolgy

Company partners
Wärtsilä Finland, Metso Paper, Ovako Bar
International partners (country, organisation)
Japan, Kyushu University (separate budget)

Project duration
1.3.2008 – 30.6.2011

Total cost (€)
1 077 014

Main target
The main goal was to enhance safe use of ultra clean high strength steels in fatigue loaded machinery by improving mechanismbased and probabilistic models for assessment of fatigue and reliability.

Motivation
Acceptable fatigue fracture rate in engine crankshafts, paper machine rolls and many other components is very small, but zero cannot be reached. Quantitative analysis is required.

Key results and impact
Understanding of mechanisms and experimental capability were developed to international state of the art. Developed models were implemented by participating industries in a way bringing at least Wärtsilä beyond the current industrial state of art.

Results of the projects are expected to be in commercial use within how many years?
During the project.

Key publications

1) Lind M., Holappa L., Transformation of alumina inclusions by calcium treatment. Metallurgical and Materials Transactions 41B (2010), 359-366.
2) Mikkola E., Marquis G., Solin J., Mesoscale modelling of crack nucleation from defects in steel. International Journal of Fatigue, 41 (2012) 64-71.
3) Roiko A., Hänninen H., Vuorikari H., Anisotropic distribution of non-metallic inclusions in a forged steel roll and its influence on fatigue limit. International Journal of Fatigue, 41 (2012) 158-167.
4) Roiko A., Murakami Y., A design approach for components in ultralong fatigue life with step loading. International Journal of Fatigue, 41 (2012) 140-149.
5) Wallin K., Statistical aspects of fatigue life and endurance limit. Fatigue & Fracture of Engineering Materials & Structures, 33 (2010) 333–344

Number of publications
15 scientific review papers
5 Conference presentations
5 Masters thesis
3 reports

Number of M.Sc.Thesis
5

Project Full Name (acronym)
Ferroelectric and Conductor Materials for Printed Electronics Applications (Fercon)

Organisation
VTT Technical Research Centre of Finland

Contact Person
Jaakko Leppäniemi, jaakko.leppaniemi@vtt.fi

Other research organisations in the project consortium
Japan, National Institute of Advanced Industrial Science and Technology (AIST)

Company partners
No companies
International partners (country, organisation)
Japan, National Institute of Advanced Industrial Science and Technology (AIST)

Project duration
1.5.2011 – 30.4.2014
Total cost (€)
416 250

Main target
Main targets include developing novel ferroelectric and conductor printing inks, their deposition and functionalizarion methods and their applications. Establish collaboration between VTT and AIST.

Motivation
To enable ubiquitous printed electronics, advances are required in materials that can be utilized in memory devices.

Key results and impact
Development of new low-voltage and low-current writable write-once-read-many memory with the combination of VTT and AIST technologies.

Results of the projects are expected to be in commercial use within how many years?
3-5

Number of publications
(1 submitted)

Number of Doctoral Thesis
(1 under research phase)

Project Full Name (acronym)
Scaffolds for Tissue Engineering (SCATE)

Organisation
University of Oulu, Department of Anatomy and Cell Biology

Contact Person
Prof. Juha Tuukkanen

Other research organisations in the project consortium
University of Helsinki, Derpartment of Inorganic Chemistry

Company partners
Finnish Red Cross Blood Srervice, Scaffdex Inc

International partners (country, organisation)
Sweden: University of Borås, Italy: Nobil Bio Ricerche s.r.l, Saati s.p.a., National Research Council ITM-CNR

Project duration
1.1.2011 – 31.4.2014

Total cost (€)
884 187

Main target
The aim of this project is to make resorbable composite scaffold materials for tissue engineering, which stimulate cell differentiation instead of the adverse foreign body reaction. The industrial manufacturing of such scaffolds needs specific development in medical grade textile technology.

Motivation
By stimulating endogenous tissue reactions to support healing we can avoid using exogenous molecules

Key results and impact
Hydroxyapatite can be compunded to resorbable scaffolds, it can be electrospinned to make hydroxyapatite fibrous scaffolds and it can nanocoat titanium implants. All these approaches are highly biocompatible and can be used in manufacturing

Results of the projects are expected to be in commercial use within how many years?
5

Key publications
1) Persson, M., Cho, S-W., Skrifvars, M. The effect of process variables on the properties of melt-spun poly(lactic acid) fibres for potential use as scaffold matrix materials Mater Sci 48 (2013) 3055–3066.
2) Persson, M., Lorite, G.S., Cho,S-W., Tuukkanen, J., Skrifvars, M., Melt Spinning of Poly(lactic acid) and Hydroxyapatite Composite Fibers: Influence of the Filler Content on the Fiber Properties, ACS Appl. Mater. Interfaces 5 (2013) 6864–6872.

Number of publications
2

Project Full Name (acronym)
Internal Mineral Surfaces (SIPI)

Organisation
VTT Technical Research Centre of Finland

Contact Person
Anna Kronlöf

Other research organisations in the project consortium
Aalto University, Åbo Akademi University

Company partners
Cementa Ab, Nordalk Oyj Abp, Tikkurila Oy

International partners (country, organisation)
Russia, Moscow University (Prof. Karen Scrivener EPFL and Dr.Ilya Anoshkin)

Project duration
1.1.2011 – 30.11.2011

Total cost (€)
1 350 000

Main target
Target of the project was to tailor structures in porous and highly heterogeneous material by utilizing particles under µm size scale and modified surfaces.

Motivation
The chemical and mechanical behaviour of mineral vastes and/or low cost materials can be modified for valuable applications.

Key results and impact
Thermodynamic principles of nucleation and crystal growth in cement hydration was understood. A method to modify particle surfaces for more favourable for hydration process was developed.

Exploitation potential: Acceleration of cement hydration. Increased utilization of supplementary cementitious materials and inorganic waste materials. Surface modification can also improve adhesion between nanocellullose and paper pigment. Modification can also immobilise ultrafine titania.

Results of the projects are expected to be in commercial use within how many years?
2 years

Key publications
The key papers have not bee published yet due to patenting process and the ongoing doctoral studies on Tapio Vehmas with his newly appointed professor A. Cwitrzen (Aalto University).

Number of publications
5 -7

Number of patents and patent applications
2

Number of Doctoral Thesis
0.5

Project Full Name (acronym)
Novel Electrode Fabrication Methods for Lithium Ion Battery (NoFaLi)

Organisation
Aalto University

Contact Person
Prof. Maarit Karppinen

Other research organisations in the project consortium
University of Oulu

Company partners
Sachtleben, Sun Chemical, Walki, European Batteries, Cargotec, Akkuser, Keliber

Project duration
1.9.2012 – 31.8.2014

Total cost (€)
349 100

Main target
To develop and commercialize new environmentally friendly and economical chemicals and methods for manufacturing lithium ion battery electrodes.

Motivation
Lithium ion battery markets are rapidly expanding. Currently organic solvents are commonly employed in electrode fabrication processes. This is environmentally risky and expensive. The water-based processes aimed here are therefore highly demanded.

Key results and impact
We have successfully optimized the precise composition and structure of electrodes fabricated using the new lithium titanate product of Sachtleben, and demonstrated the possibility to scale-up the new water-based electrode manufacturing process developed within the project in collaboration with Sachtleben, Walki and Sun Chemical.

The results obtained so far have brought competitive advantage for the companies involved in the project.

Results of the projects are expected to be in commercial use within how many years?
2

Key publications

1) Pohjalainen, E., Räsänen, S., Jokinen, M., Yliniemi, K., Worsley, D.A., Kuusivaara, J., Juurikivi, J., Ekqvist, R., Kallio, T., and Karppinen, M., Water Soluble Binder for Fabrications of Li-4Ti5O12 Electrodes, Journal of Power Sources, 226 (2013) 134-139.
2) Räsänen, S., Lehtimäki, M., Aho, T., Vuorilehto, K., and Karppinen, M., In-situ Investigation of the Water Absorption/Desorption Behavior of LiFePO4, Solid State Ionics 211 (2012) 65-68.
3) Räsänen, S., and Karppinen, M., Thermogravimetric Study of Water-Based LiFePO4 Composite Electrode Powders, Thermochimica Acta 547 (2012) 126-129.

Number of publications
3 articles in international peer-reviewed scientific journals

Number of M.Sc.Thesis
1

Number of Doctoral Thesis
1

Project Full Name (acronym)
Active Nanocomposite Materials

Organisation
University of Eastern Finland

Contact Person
Prof. Jorma Jokiniemi

Other research organisations in the project consortium
VTT Technical Research Centre of Finland, Åbo Akademi University

Company partners
OMG Kokkola Chemicals Ltd, Nokia Ltd

International partners (country, organisation)
France, SAFT

Project duration
1.1.2008 – 31.21.2010

Total cost (€)
1 136 665

Main target
The aim of this project was to develop tailored functional silicon based materials and Si-metal nanocomposites for Li-ion cells and other industrial applications.

Motivation
The project tried to solve the issues related to the current anode technology of Li-ion cells that hinder the development for long life industrial battery application such as HEV or standby (for sustainable energy device).

Key results and impact
Industrially viable production methods for the tailored functional nanocomposites were developed. The produced nanocomposites included micron- and nano-sized silicon particles, silicon monoxide and composites. In addition coated and/or functionalized Si (e.g., Si/PAA, Si/POSS, Si/metals) were produced for Li-ion battery applications.

Key publications

1) Lähde, A., Kokkonen, N., Karttunen, A., Jääskeläinen, S., Tapper, U., Pakkanen, T.A., Jokiniemi, J. Preparation of copper-silicon dioxide nanoparticles with chemical vapor synthesis. J Nanopart Res 13(9) (2011) 3591-3598.
2) Miettinen, M., Johansson, M., Suvanto, S., Riikonen, J., Tapper, U., Pakkanen, T.T., Lehto, V.-P., Jokiniemi, J., Lähde, A. Atmospheric pressure chemical vapour synthesis of silicon-carbon nanoceramics from hexamethyldisilane in high temperature aerosol reactor. J Nanopart Res. 13 (2011) 4631-4645.

Number of publications
3

Number of patents and patent applications
3

Number of M.Sc.Thesis
2

Project Full Name (acronym)
Novel inorganic inks for hybrid printed electronic demonstrators (INNOINKS)

Organisation
University of Oulu

Contact Person
Prof. Heli Jantunen

Other research organisations in the project consortium
Slovenia, Jozef Stefan Institute
Poland, Institute of Electronic Materials Technology

Company partners
Sachtleben Pigments Oy, Finland, Pulse Finland Oy, Finland, NOF Corporation, Japan

International partners (country, organisation)
Slovenia, Jozef Stefan Institute
Poland, Institute of Electronic Materials Technology
Japan, NOF Corporation

Project duration
1.1.2011 – 31.12.2013

Total cost (€)
1 226 000

Main target
The main objectives of the project are firstly to develop nano inorganic oxide particles (piezoelectric, ferroelectrics, dielectric and ferromagnetic) in 1-D (needles) and 2-D (flakes) shape and secondly use them as filler materials in functional inks (piezoelectric, magnetic, and dielectric).

Motivation
Development of Printed Electronics (PE) beyond current state-of-the-art requires highly tailorable, high performance and multifunctional ink materials for different industrial printing processes. This is especially true when highly integrated passive components on flexible substrate, miniaturised antennas, energy harvesters, thin and flat sensor topologies, etc. are expected to enable new market opportunities with low production costs.

Key results and impact
The research results can widely advance printable electronics and ubiquitous information technology and related industry fields like chemical, electronics, ICT, security and telecommunication industries. Already 2 prototype level applications are fabricated and tested in small scale production by the industrial partners.

Results of the projects are expected to be in commercial use within how many years?
1-5

Key publications

1) S. Rajesh, K. Sonoda, A. Uusimäki, K. H. Yang, H. Y. Lu, H. Jantunen: Effective dielectric response of polymer composites with ceramic coated silver flakes, Journal of Materials Science: Materials in Electronics 24(1)191-195, 2013.
2) M. Nelo, AK.Sowpati, VK.Palukuru, J. Juuti, H. Jantunen, Utilization of screen printed low curing temperature cobalt nanoparticle ink for miniaturization of patch antennas, Progress in Electromagnetics Research –PIER 127, 427-444, 2012.
3) Myllymaki, S., Teirikangas, M., Nelo, M., Tulppo, J., Sobocinski, M., Juuti, J.; . Jakubowska, M. (2013). Radio frequency characteristics of printed meander inductors and interdigital capacitors. Japanese Journal of Applied Physics, 52 (5 PART 2).
4) Nelo, M., Sloma, M., Kelloniemi, J., Puustinen, J., Saikkonen, T., Juuti, J., Jantunen, H. (2013). Inkjet-printed memristor: Printing process development. Japanese Journal of Applied Physics, 52(5 PART 2).

Number of publications
6

Number of patents and patent applications
Not by research partners

Number of M.Sc.Thesis
1

Number of Doctoral Thesis
2 to be completed in 1-2 years.

Project Full Name (acronym)
Printed Activity and Movement Sensors (PAMS)

Organisation
University of Oulu

Contact Person
Tapio Fabritius

Other research organisations in the project consortium
Tampere University of Technology

Company partners
Metso, Polar Electro

Project duration
1.3.2012 – 28.2.2014

Total cost (€)
450 000

Main target
Implementation of printable autonomously working activity sensor based piezo component with memory element.

Motivation
Inexpensive and autonomously working sensors enable the implementation of new kind of sensor applications. Can be applied for example, in human activity monitoring, smart packaging, machine vibration stability analysis, Cattle activity monitoring.

Key results and impact
Results:
1) Suitable piezo materials for printing based manufacturing.
2) Printed piezoelectric component suitable for application specified by the industrial partners of the project.
3) Fully inkjet printed memristor element. Can be used as a memory element in activity sensors
4) Liquid processable component structure for super capacitor. Alternative for memristor based memory element.

Results of the projects are expected to be in commercial use within how many years?
Some parts of the developed technology (piezo electric component) are possible commercialized within next 2-3 years. Super capacitor and memristor technology requires more research and development.

Key publications

1) Nelo M. et al., Inkjet-printed memristor – printing process development, ICFPE 2012 –conference, Tokyo, Japan. (Student poster award for outstanding presentation).

2) Lehtimäki et al. A printable super capacitor as strong unit in an RF energy harvester, International Journal of Electrical Power and Energy Systems. (Submitted).
3) Nelo M. et al., Inkjet-printed memristor – printing process development, Japanese Journal of Applied Physics (Submitted).

Number of publications
1 conference paper,
2 journal articles (submitted)

Number of M.Sc.Thesis
1 M. Sc. Thesis

Project Full Name (acronym)
New nano-sized additives to control fouling, corrosion and emissions in mixed fuel combustion (NanoPoltto)

Organisation
University of Eastern Finland

Contact Person
Olli Sippula

Company partners
MW Biopower, Vapo, Savon voima

International partners (country, organisation)
Austria, Graz University of Technology
Switzerland, Swiss Federal Institute of Technology

Project duration
1.1.2009 – 30.6.2012

Total cost (€)
500 000

Main target
To develop effective nano-sized additives for solving ash-related problems in biomass and mixed fuel combustion.

Motivation
Many biomasses contain a large fraction of volatile ash compounds (e.g., alkali metals, chlorine) that are vaporized during combustion. This causes fouling and corrosion of heat exchangers, and fine particle emissions. Many biomass firing boilers are hampered by these ash related problems. Additives can be used to convert corrosive and harmful ash species to another form or prevent their release. However, many of the currently known additives are not effective.

Key results and impact
A fully logic controlled biomass combustion reactor applicable for various biomasses was built and operated in the project. A method for in-situ generation of nanoparticles in a biomass combustion process was developed. The method was tested with various precursors and it resulted in particles with a high concentration, high surface area, narrow size distribution and predictable chemical composition. Combustion experiment with wood and wood-straw were carried out with and without nano-sized additives.

Combustion generated nanoparticles have wide applications. First, the generation method can be used in biomass-fired boilers to decrease fouling and corrosion by changing chemical reactions taking place in the furnace and by altering chemical composition of particulate matter. Second, the method is also applicable for large-scale production of various nanomaterials with wideapplications.

Results of the projects are expected to be in commercial use within how many years?
In 2 to 4 years. A commercialization project is currently going on.

Key publications
1) Nuutinen, I., Sippula, O., Tissari, J., Jokiniemi, J. (2010) Fine particle and gas emissions of a pellet burner based on gasification combustion. Proceedings from the International Aerosol Conference 2010, August 29 – September 3, 2010 Helsinki.
2) Kettunen, T., Kortelainen, M., Sippula, O., Nuutinen, I., Lamberg, H., Jokiniemi, J., Novel laboratory-scale biomass combustion reactor for studies on emission formation and ash behaviour. Proceedings in the European aerosol conference Manchester, United Kingdom, 4-9 September 2011 (2011).

3) Kortelainen, M., Nuutinen, I., Lamberg, H., Torvela, T., Kaivosoja, T., Karhunen, T., Tissari, J., Jokiniemi, J., Sippula, O., Ash Behavior and Emission Formation in a 40 kW Step-grate Combustion Reactor Operated with Wood Chips, Reed Canary Grass and Straw, Manuscript in preparation.

Number of publications
4

Number of M.Sc.Thesis
2

Project Full Name (acronym)
Intefaces in wood-based materials (INTERWOOD)

Organisation
Aalto University, Department of Forest Products Technology

Contact Person
Mark Hughes

Other research organisations in the project consortium
None

Company partners
Stora Enso Oyj, UPM Kymmene-Wood Oy, Tikkurila Oyj, Dynea Chemicals Oy

International partners (country, organisation)
USA, Forest Products Laboratory, Madison

Project duration
1.1.2009 – 31.12.2012 (extended by 1 year)

Total cost (€)
994 735

Main target
Develop detailed knowledge about the surface of wood and the interface formed between wood and other materials
Understand how the surface is influenced by raw material characteristics
Determine how the surface and interface can be manipulated through process control and modification

Motivation
In the future we will have to rely more and more on renewable resources of which wood is the most important. New composite materials and products will be demanded and so understanding better how we can create better interfaces, will help enhance the performance and propertries of these materials

Key results and impact
Significant effects of the felling season on the chemistry and physiochemical properties of birch (and also on the resulting adhesion properties).
XPS has shown that the surface (4-10 nm) dependent upon the media (water/acetone) and presence of extractable materials

Concentrations of saccharides and flavonoid in the material may be changed by high temperature soaking

Veneer surface properties can be modified by a chemical treatment with bleaching agent

Soaking temperature significantly affects the colour of wood. This indicates chemical changes. Colour is correlated with wetting behaviour, which in turn is correlated with bond strength (ABES)

It appears that resin is only able to penetrate broken cells or other fissures in the wood, limiting the penetration depth to a "few" cells

Raw material and processing affects the bonding not only between wood and PF resin, but also with low environmental impact soy-based adhesives

Results of the projects are expected to be in commercial use within how many years?
Some results may be implemented immediately, others is 2-5 years

Key publications
1) Rohumaa, A., Hunt, C., Hughes, M., Frihart, C and Logren, J. Deep lathe checks degrade shear strength in phenol formaldehyde bonded birch plywood (Holzforschung: DOI 10.1515/hf-2012-0161).
2) Yamamoto, Akio, Rohumaa, Anti, Kontturi, Eero, Hughes, Mark, Saranpää, Pekka and Vuorinen, Tapani. Colorimet-

ric behaviour and seasonal characteristic of xylem sap obtained by mechanical compression from Silver birch (Betula pendula) - (Accepted for publication in ACS Sustainable Chemistry & Engineering).

3). Rohumaa, Anti, Hunt, Chris, Hughes, Mark, Frihart, Chuck and Ohlmeyer, Martin. Soaking temperature and felling season impact veneer wettability and bond strengths (submitted).

Number of M.Sc.Thesis

1

Number of Doctoral Thesis

2 expected

Project Full Name (acronym)

Novel methods to formulate polymer nanocomposites and tailor their dielectric properties (NANOCOM)

Organisation

Tampere University of Technology, Department of Electrical Engineering

Contact Person

Adjunct Prof. Kari Lahti, Research Manager, kari.lahti@tut.fi

Other research organisations in the project consortium

VTT Technical Research Centre of Finland, Advanced Materials; University of Jyväskylä, Nanoscience Center , Department of Chemistry; Tampere University of Technology, Department of Physics

Company partners

Reka Kaapeli Oy, Borealis Polymers N.V., Kemira Pigments Oy, Nokian Capacitors Oy, Evox Rifa Group Oyj, Ab Rani Tervakoski Oy, FP-Pigments Oy

International partners (country, organisation)

Sweden, Chalmers University of Technology
Japan, Kitami Institute of Technology

Project duration

1.1.2008 – 30.4.2011

Total cost (€)

1 051 600

Main target

The main target was to create and characterize novel electrically insulating polymer nanocompounds where the electrical, mechanical and thermal properties are highly tailored to achieve more cost-effective, energy-effective and hence environmentally better materials for the electrical and electronics insulation technology. Additionally, one target was to explain the measured materials properties using molecular modeling and electronic structure calculation methods.
Motivation

The saving of space and various raw materials in manufacturing of electrical components, such as power capacitors used widely in electric power applications from high voltage grid installations to individual power devices, causes also the energy consumption and waste burden to be lower.

Key results and impact

The best results were achieved with 4.5 wt-% silica-polypropylene nanocomposite: the AC and DC breakdown strength were increased by 20 % and 50 %, respectively, whereas corona type partial discharge resistance times were up to 900% compared to the reference. These achievements gave promising possibilities to develop and test AC and DC power capacitors with high energy density.

Results of the projects are expected to be in commercial use within how many years?

5 (continuation project: NANOPOWER)

Key publications

1) Takala M., Ranta H., Nevalainen P., Pakonen P., Pelto J., Karttunen M., Virtanen S., Koivu V., Pettersson M., Sonerud B. And Kannus K., Dielectric Properties and Partial Discharge Endurance of Polypropylene-Silica Nanocomposite, IEEE Transactions on Dielectrics and Electrical Insulation, Vol.17, No.4 (2010) 1259-1267.

2) Ruuska H., Arola E., Kortelainen T., Rantala T.T., Kannus K., and Valkealahti S., A density functional study on dielectric

properties of acrylic acid grafted polypropylene, Journal of Chemical Physics 134, (2011), 134904.
3) Takala M., Sonerud B., Ranta H., Pelto J., Ahonen S., Pettersson M. and Kannus K., Effect of Low Amount of Nanosilica on Dielectric Properties of Polypropylene, Proceedings of IEEE International Conference on Solid Dielectrics (ICSD2010), Potsdam, Germany, July 4-9 (2010), 187-191.

Number of publications
5

Number of M.Sc.Thesis
1

Number of Doctoral Thesis
1

Project Full Name (acronym)
Novel polymer nanocomposites for power capacitors (NANOPOWER)

Organisation
Tampere University of Technology, Department of Electrical Engineering

Contact Person
Adjunct Prof. Kari Lahti Research Manager, kari.lahti@tut.fi
Other research organisations in the project consortium
VTT Technical Research Centre of Finland, Advanced Materials; University of Jyväskylä, Nanoscience Center, Department of Chemistry; Tampere University of Technology, Optoelectronics Research Centre

Company partners
Terichem Tervakoski Oy, KEMET Electronics Oy, Borealis Polymers N.V., ALSTOM Grid Oy, Sachtleben Pigments Oy, Extron Engineering Oy

International partners (country, organisation)
United States, Rensselaer Polytechnic Institute (researcher exchange from University of Jyväskylä)

Project duration
1.2.2011 – 31.12.2013

Total cost (€)
1 385 715

Main target
The main target was to further develop (see previous project NANOCOM) and achieve more cost-effective, energy-effective and hence environmentally better polymer nanocomposite materials for electrical and electronics insulation technology, specifically concentrating on power capacitor applications. This included optimizing and transferring the production of developed polypropylene nanocomposites up to industrial scale, as well as deepening our understanding on nanocomposites in general and developing the testing methods involved.

Motivation
The saving of space and various raw materials in manufacturing of electrical components, such as power capacitors used widely in electric power applications from high voltage grid installations to individual power devices, causes also the energy consumption and waste burden to be lower.
Key results and impact

The optimized manufacturing process of previously promising (see project NANOCOM), electrically improved polypropylenesilica nanocomposites was successfully transferred into industrial pilot scale. This achievement makes possible manufacturing and testing actual pilot products based on the new material. Additionally, the developed interdisciplinary knowledge among the research parties gives good knowhow and competence for further research and deeper understanding of nanocomposite insulating materials.

Results of the projects are expected to be in commercial use within how many years?
2

Key publications
1) Rytöluoto I. and Lahti K., New Approach to Evaluate Area-dependent Breakdown Characteristics of Dielectric Polymer Films, IEEE Transactions on Dielectrics and Electrical Insulation, Vol.20, No.3 (2013) 937-946.

2) Virtanen S., Ranta H, Ahonen S., Karttunen M., Pelto J., Kannus K. and Pettersson M., Structure and Dielectric Breakdown Strength of Nano Calcium Carbonate/Polypropylene Composites, Journal of Applied Polymer Science, Early View – published online July 8 2013 (2013), DOI: 10.1002/app.39504.
3) Ranta H. and Kannus K., Effects of Electrical-Thermal Aging on Short-Term Dielectric Strength of Biaxially Oriented Polypropylene-Silica Nanocomposite Films, Proceedings of the 22nd Nordic Insulation Symposium 2011, Tampere, Finland, June 13-15 (2011), 7-12.
4) Ranta H. and Kannus K., Permittivity and Loss Factor Measurements of Biaxially Oriented Polypropylene-Silica Nanocomposite Films During Electrical-Thermal Aging, Proceedings of the 22nd Nordic Insulation Symposium 2011, Tampere, Finland, June 13-15 (2011), 7-12.
5) Ranta H., Rytöluoto I. and Lahti K., Thickness Dependency in Dielectric Breakdown Strength of Biaxially Oriented Polypropylene-Silica Nanocomposite Films, Proceedings of the 23rd Nordic Insulation Symposium 2013, Trondheim, Norway, June 9-12 (2013), 179-182.

Number of publications
5

Number of M.Sc.Thesis
2

Project Full Name (acronym)
Functional nano- and microporous carbon based coatings for tools and components (CARBONBON)

Organisation
Aalto University, School of Chemical Technology

Contact Person
Prof. Jari Koskinen

Other research organisations in the project consortium
VTT Technical Research Centre of Finland

Company partners
DIARC Technolgy Oy, Wärtsilä, Metso Automation Oy

International partners (country, organisation)
Italy, IMAMOTER, Institute of Agriculture and Earthmoving Machines
Italy, Wolframcarb (company)
Italy, UFS (company)

Project duration
20.9.2010 – 31.10.2013

Total cost (€)
1 694 000 (Finland: 1 074 000)

Main target
Develop carbon based physical vapour deposition (PVD) coatings combined with laser processing in order to provide enhanced lubricating properties. The innovation is to develop a hybrid function of controlled microporosity and self-lubrication to higher performance tools and components.

Motivation
The industrial need for lubrication solutions for harsh conditions at elevated temperature where lubricants may not be used.

Key results and impact
A hybrid surface treatment which combines laser texturing, hard diamond-like coating and solid lubricant (WS2) has been demonstrated to lower the coefficient of friction below 0.1 and extend the wear life of the surface by about 100% has been demonstrated in laboratory tribological tests at 250°C temperature.

Results of the projects are expected to be in commercial use within how many years?
The results will are currently in filed test evaluation in industry. Possible new products are expected in 2 – 3 years after this project.

Key publications
1) Jussi Oksanen, Timo J. Hakala, Sanna Tervakangas, Petri Laakso, Lauri Kilpi, Helena Ronkainen, Jari Koskinen, Tribological properties of laser-textured and ta-C coated surfac-

es with burnished WS2 at elevated temperatures, Tribology International, accepted for publication (2013); Extended abstract: PSE2012; World Tibology conference, extended abstract.

Number of publications
3

Project Full Name (acronym)
3D technology

Organisation
University of Tampere, the Finnish Centre for Alternative Methods (FICAM)

Contact Person
Prof. Tuula Heinonen

Other research organisations in the project consortium
University of Helsinki, Department of Biopharmacy; VTT Technical Research Centre of Finland

Company partners
OrionPharma, Scafdex

Project duration
1.6.2011 – 30.6.2013

Total cost (€)
149 520

Main target
Cellular tests and the laboratory automation for safety testing of chemicals and efficacy testing of pharmaceuticals.

Motivation
Animal tests are not relevant to mimic effects in man. Threfore, the need and global market for cellular tests are growing strongly. The partners had a long research experience and viable test methods which could productize and commercialize.

Key results and impact
The technology survey revealed need for new instrumentation and automation. Customers want miniatyrised, rapid, highthroughput, intelligent systems. We also identified need for human cell based tests for toxicity and mechanistic testing and for disease models. The evaluated users found 3D-tests FICAM is developing very useful for their purposes. FICAM is developing test methods industry, regulators and contract research organizations needed. In the experimental part automation of the FICAM´s developed angiogenesis test was simulated against the technologies noted in the technology survey. The whole test procedure could be primarily performed automatically. Under this project we automated the microscopic analysis of tubule structures which is the most time consuming and analyst sensitive. The correlation between the results from the developed analysis programme and the used manual method was excellent. Automation and miniaturization of the whole testing procedure continues. In optimization of the hepatic model developed by the university of Helsinki the performance of the critical functional parameters in nanomaterials of Extracell and GrowDex were compared to each other. The projects created new knowledge and directed test model and techniques development among partners to the direction customer need is largest. The results from the technology survey were utilized in addition to partners by the industry members in the steering group, too. The project increased knowledge and concrete co-operation among University and industry.

Results of the projects are expected to be in commercial use within how many years?
angiogenesis test - withing 3 years
hepatic model - withing 5 years

Key publications
The results of this project are utilised in 3 publications which are under writing

Number of publications
The results of this project are utilised in 3 publications which are under writing

Project Full Name (acronym)
New concepts for high- temperature low-friction materials (NEWCON-HTLF)

Organisation
Aalto University, School of Chemical Technology, Department of Materials Science and Engineering

Contact Person
Prof. Simo-Pekka Hannula

Other research organisations in the project consortium
VTT Technical Research Centre of Finland

Company partners
Wärtsilä Finland Oy, Metso Minerals Oy, Metso Automation Oy, OMG Kokkola Chemicals Oy, Luvata Pori Oy, Outotec Oy

International partners (country, organisation)
Korea, Sun Moon University

Project duration
1.1. 2008 – 31.10.2011

Total cost (€)
285 714 (Aalto University, VTT Technical Research Centre of Finland)
$ 200 000 (Korea, Sun Moon University)

Main target
The aim of the project was to create a strong scientific and technical basis for the later processing and techno-economical development of nanocomposite high-temperature low friction materials.

Motivation
Inspite of large technical and economical need there are no satisfactory solutions for self-lubricating materials for temperature above 400˚C.

Key results and impact
Strong scientific and technical basis for the processing and techno-economical development of nanocomposite high-temperature low friction materials was developed based on pulsed electric current sintering and thermal sparying. Idnetification. New type of selflubricating materials concept as well as powder processing technologies were developed. The material concept is under patenting procedure. In addition, results of the research were published widely in scientic forums.

Results of the projects are expected to be in commercial use within how many years?
Between 2014-2016.

Key publications

1) R. Ritasalo, M.E. Cura, X.W. Liu, Y. Ge, T. Kosonen, U. Kanerva, O. Söderberg, S-P. Hannula, Microstructural and mechanical characteristics of Cu–Cu2O composites compacted with pulsed electric current sintering and hot isostatic pressing, Composites: Part A 45 (2013) 61–69.
2) M.E. Cura, S-H. Kim, T. Muukkonen, A. Vaajoki, O. Söderberg, T. Suhonen, U. Kanerva, S.W. Lee, S-P. Hannula, Microstructural and friction properties of pulsed electric current sintered alumina – 15 wt% zirconia nanocomposites with different solid lubricants at room temperature, Ceramics International, 39 (2013) 2093–2105.
3) R. Ritasalo, M.E. Cura, X.W. Liu, O. Söderberg, A. Keski-Honkala, V. Pitkänen, and S.-P. Hannula, The microstructural effects on the mechanical and thermal properties of pulsed electric current sintered Cu-Al2O3 composites, Procedia Engineering 10 (2011) 124-129.
4) R. Ritasalo, M.E. Cura, X.W. Liu, O. Söderberg, T. Ritvonen, and S-P. Hannula, Spark plasma sintering of submicron-sized Cupowder – influence of processing parameters and powder oxidation on the nanomechanical properties, Materials Science and Engineering A 527 (2010) 2733–2737.
5) S.H. Kim, S-P. Hannula, Lee, S.W., Effects of the sliding conditions on the tribological behavior of atmospheric plasma sprayed Al2O3-15 wt.% ZrO2-CaF2 composite coating, Surface and Coatings Technology, 210 (2012) 127–134.
6) M.E. Cura, O. Söderberg, S-P. Hannula, Self-Lubricating Nano- and Microcomposites for Room and Elevated Temperatures, Chapter 8 in Engineered Metal Matrix Composites: Forming Methods, Material Properties and Industrial Applications, pp. 193-242. Ed. Luca Magagnin, Nova Publishers, 2012, ISBN: 978-1-62081-719-3.

Number of publications
20+

Number of patents and patent applications
1

Number of M.Sc.Thesis
2

Number of Doctoral Thesis
Publications will be part of three doctoral thesis. Two of those will be completed in 2013-14.

Project Full Name (acronym)
Composites for Tissue Regeneration (KURKO)

Organisation
Tampere University of Technology

Contact Person
Prof. Minna Kellomäki

Other research organisations in the project consortium
Aalto University, University of Tampere

Company partners
Scaffdex Oy, BBS - Bioactive Bone Substitute Oy
International partners (country, organisation)
The Netherlands, University of Twente,
The Netherlands, Purac Biomaterials bv,
Switzerland, ETHZ
Brazil, University of Sao Paulo
Mexico, CICY Research Center

Project duration
1.3.2011 – 28.2.2014

Total cost (€)
928 571

Main target
Main targets are to develop key production technology to manufacture biodegradable polymer and composite scaffolds with high interconnected porosity and to show their functionality with adipose stem cells towards bone tissue.

Motivation
Technology will enable commercialization of new type of scaffolds for bone tissue engineering.

Key results and impact
The processing method has been developed for repeatable pilot-size production process and scaffolds have been shown functional in the intended application area.

Results of the projects are expected to be in commercial use within how many years?
We expect to have results partially commercialized in 3-5 years for laboratory use and later for clinical use.

Key publications

1) Paakinaho, K., Ahola, N., Aydogan, B., Toropainen, S., Hyttinen, J., Kellomäki, M., New Advanced Osteopromotive Scaffolds for Bone Tissue Engineering Applications: Supercritical Fluid Processing and Cellular Response with Human Adipose Stem Cells, 9th World Biomaterials Congress. 1.-5.6.2012, Chengdu, China.
2) Ahola, N. Paakinaho, K., Toropainen, S., Kellomäki, M., Osteopromotive scaffolds for bone tissue engineering: a solvent-free manufacturing process based on extrusion and supercritical fluid processing, Journal of Tissue Engineering and Regenerative Medicine 3rd TERMIS World Congress 2012, 5-8 September 2012, Vienna, Austria.
3) Huttunen, S., Kyllönen, L., Paakinaho, K., Ahola, N., Kellomäki, M., Miettinen, S., Haimi, S.. Adipose Stem Cells and Supercritical Fluid Processed Porous Scaffolds in Regeneration of Vascularized Bone. 25th European Conference on Biomaterials, Madrid, Espanja.(8.9.-12.9.3013).
4) Paakinaho, K., Ahola, N., Hannula, M., Power, L., Hyttinen, J., Kellomäki, M., Progress in Scaffold Technology for Bone Tissue Engineering; Osteopromotive Composite Scaffolds by Supercritical Fluid Processing and Cellular Response with Human Adipose Stem Cells, BioMediTech Research Day, 18.12.2012, Finn-Medi 5, Tampere.
5) Ahola, N., Paakinaho, K., Hannula, M., Toropainen, S., Hyttinen, J., Kellomäki, M., Advanced Osteopromotive Scaffolds for Bone Tissue Engineering; Supercritical Fluid Processing and Cellular Response with Human Adipose Stem Cells,

Tekes Functional Materials, Functional Materials Summer Festival 2012, Annual Seminar of the Tekes Functional Materials Programme, 29. - 30.5.2012, Helsinki, Finlandia Hall.

Number of publications
5

Number of M.Sc.Thesis
3

Number of Bachelor Thesis
3

Project Full Name (acronym)
Nanocellulose film for high performance applications (NCFilm)

Organisation
VTT Technical Research Centre of Finland

Contact Person
Tekla Tammelin

Other research organisations in the project consortium
-

Project duration
1.9.2012 – 31.5.2014

Total cost (€)
500 000

Main target
To create high value nanocellulose based products to support the renewal of Finnish forest based industry.

Motivation
There is a market need for sustainable, high performance films which repalece oil-based films and less viable existing biobased films.

Key results and impact
Nanocellulose film which can be manufactured in pilot scale (R2R) is benchmarked against commercially exiting plastic films. Its advantageous features as well as its weaknesses have been clarified and thus the potential application areas can be identified.

Results of the projects are expected to be in commercial use within how many years?
10

Project Full Name (acronym)
High Performance Lithium Ion Battery Anodes based on Novel Nanocarbons (LIBACAM)

Organisation
Aalto University, School of Science

Contact Person
Prof. Esko I. Kauppinen

Other research organisations in the project consortium
Tokyo A&T University, Tokyo, Japan

Company partners
Fortum (Finland), Toyota Central R&D Labs., Inc. (Japan)

International partners (country, organisation)
Japan, Tokyo A&T University,
Japan, Toyota Central R&D Labs., Inc.

Project duration
1.5.2010 – 30.4.2013

Total cost (€)
464 000

Main target
- Improve lithium ion battery (LiB) performance with nanocarbons
- improve LiB graphite electrode conductivity by nanocarbons.

Motivation
LiB performance is limited by the electron conductivity of the electrodes.

Key results and impact
CVD growth of carbon nanotubes and nanofibers directly onto the surface of graphite powder particles which were demonstrated to have better conductivity as LiB electrodes.

Results of the projects are expected to be in commercial use within how many years?
5 years

Key publications

1) Nomura Y., Anoshkin I.V., Okuda C., Iijima M., Nasibulin A.G., Ukyo Y., Kamiya H. and Kauppinen E.I., Carbon nanotube/nanofibers and graphite hybrids for Li-ion battery application, Carbon (submitted).
2) Anoshkin I.V., Nasibulin A.G., Mudimela P.R., He M., Ermolov V. and Kauppinen E.I., Single-Walled Car-bon Nanotube Networks for Ethanol Vapor Sensing Application, Nano Research 6 (2), 77-86 (2012).
3) Anoshkin I.V., Nasibulin A.G., Mudimela P.R., Raula J., Ermolov V., Kauppinen E.I., Selective Chemical Functionalization of Carbon Nanobuds, Carbon 50 (11), 4171–4174 (2012).
4) Nasibulin, A.G., Koltsova, T., Nasibulina, L.I., Anoshkin, I.V., Semencha, A., Tolochko, O.V., Kauppinen, E.I., A Novel Approach for Nanocarbon Composite Preparation, MRS Proceedings, 1454, 279-286 (2012).
5) Koltsova, T.S., Nasibulina, L.I., Anoshkin, I.V., Mishin, V.V., Kauppinen, E.I., Tolochko, O.V., Nasibulin A.G., New hybrid copper composite materials based on carbon nanostructures, Journal of Materials Sci-ence and Engineering B, 2, 240-246 (2012).
6) Talyzin A.V., Luzan S.M., Anoshkin I.V., Nasibulin A.G., Jiang H., Kauppinen E.I., Hydrogen driven col-lapse of C60 inside of SWNTs, Angewandte Chemie International Edition, 124, 4411-4415 (2012).
7) Nasibulina L.I., Anoshkin I.V., Nasibulin A.G., Cwirzen A., Penttala V. Kauppinen E.I., Effect of carbon nanotube aqueous dispersion quality on mechanical properties of cement composite, Journal of Nanomaterials, 169262 (2012).
8) Nasibulina L.I., Anoshkin I.V., Semencha A.V., Tolochko O.V., Malm J.E.M., Karppinen M.J., Nasibulin A.G., Kauppinen E.I., Carbon nanofiber/clinker hybrid material as a highly efficient modificator of mor-tar mechanical properties, Materials Physics and Mechanics, 1, 77-84 (2012).
9) Talyzin A., Anoshkin I.V., Nasibulin A.G., Krasheninnikov A., Nieminen R., Jiang H., Kauppinen E.I., Synthe-sis of graphene nanoribbons encapsulated in single-walled carbon nanotubes , Nano Letters, 11, 4352-4356 (2011).
10) Nasibulina L.I., Anoshkin I.V., Shandakov S.D., Nasibulin A.G., Cwirzen A., Mudimela P.R., Habermehl-Cwirzen K., Malm J.E.M., Koltsova T.S., Tian Y., Vasilieva E.S., Penttala V., Tolochko O.V., Karppinen M.J., Kauppinen E.I., Direct Synthesis of Carbon Nanofibers on Cement Particles, Transportation Research, Rec. 2, 96-101 (2010).

Number of publications
10

Number of Doctoral Thesis
1 (to be finished 2014)

Project Full Name (acronym)
Novel technology platform for mass produced inexpensive transistors on flexible substrates enabling sensing applications (Flex- Sens)

Organisation
Åbo Akademi University, Laboratory of Physical Chemistry

Contact Person
Professor Jouko Peltonen

Other research organisations in the project consortium
University of Turku, Tampere University of Technology, University of Oulu

Company partners
BASF, Stora Enso - Forest Pilot Center, Panipol, Perlos, Labmaster

International partners (country, organisation)
China, Hefei University of Technology (Prof. Liu Hewen), Germany, Ulm University, Inorganic Chemistry II (Prof. Mika Lindén),

Japan, Kyoto University, Institute of Advanced Energy (Prof. Yukio Ogata)

Project duration
1.1.2009 – 31.3.2012

Total cost (€)
1 800 000

Main target
The main objective of the project was to create a universal technology platform for inexpensive mass produced ion-modulated transistors which accelerates the development of novel practical device applications. The transistor technology will be used in plastic or fiber based flexible packages, and in technical plastics for switching and sensing purposes.

Motivation
Market analyses and research reports estimate printed and organic electronics to become a huge, several hundred billion dollar business in the future. However, currently printed and especially inexpensive mass produced electronics is still in its infancy and only the very first products are entering the market.

Key results and impact
The main objective of the project Flex-Sens was to create a universal technology platform for inexpensive mass produced ionmodulated transistors which accelerates the development of novel practical device applications. The work was carried out in 4 work packages dealing with substrate (paper and synthetic membrane) and component (transistor, display, memory, different sensors) development as well as life cycle analysis (LCA). Finally the components were collected to a joint demonstrator.

The design of the actual printing pattern for the demonstrator was based on the model circuit schematics, including (1) paper as a print substrate, (2) printed Ag conductive tracks and electrode structures, (3) printed or coated active sensor material (humidity or H_2S gas), (4) HIFET transistor, (5) printed PEDOT:PSS resistor line, (6) printed PEDOT:PSS electrodes with electrolyte gel, (7) protective barrier coating (optional) and (8) a power source (1.5 V).

Results of the projects are expected to be in commercial use within how many years?
3-6 years

Key publications

1) A. Määttänen, D. Fors, S. Wang, D. Valtakari, P. Ihalainen, and J. Peltonen: Paper-based planar reaction arrays for printed diagnostics. Sensors and Actuators B, 160 (2011) 1404-1412.
2) N. Kaihovirta, C.-J. Wikman, T. Mäkelä C.-E. Wilén and R. Österbacka: Self-supported ion conductive membrane based transistors. Advanced Materials, 21 (2009) 2520-2523.
3) N. Kaihovirta, T. Mäkelä, X. He,C.-J. Wikman,C.-E. Wilen and R. Österbacka: Printed all-polymer electrochemical transistors on patterned ion conducting membranes. Organic Electronics, 11 (2010) 1207-1211.
4) A. Määttänen, P. Ihalainen, P. Pulkkinen, S. Wang, H. Tenhu and J. Peltonen: Inkjet-printed gold electrodes on paper – characterisation and functionalisation. Applied Materials and Interfaces, 4 (2012) 955-964.
5) J. Sarfraz, A. Määttänen, P. Ihalainen, M. Keppeler, M. Lindén, J. Peltonen: Printed copper acetate based H_2S sensor on paper substrate. Sensors and Actuators B, 173 (2012), 868-873.

Number of publications
21

Number of patents and patent applications
3

Number of M.Sc.Thesis
1

Number of Doctoral Thesis
2

Project Full Name (acronym)
Advanced dilute nitride technology for high brightness lasers (Brightlase)

Organisation
Tampere University of Technology, Optoelectronics Research Centre

Contact Person
Prof. Mircea Guina; mircea.guina@tut.fi and Dr. Tomi Leinonen; tomi.leinonen@tut.fi

Company partners
No companies. "TUTLI" type of project.

Project duration
1.1.2012 – 31.12.2013

Total cost (€)
349 228

Main target
Develop novel high power laser sources with emission at yellow-orange wavelength range. Advance the relevant technology to a level that would enable commercialization for volume applications and take the first steps towards commercialization of the technology.

Motivation
Current laser technologies do not meet the applications demands in respect with cost, power, wavelengths functionality, compactness. There is a high demand in biophotonic applications for lasers with emission at wavelength targeted by the project.

Possible applications include treatment of cutaneous vascular disorders, controlling coagulating processes, or photodynamic therapy. Additional applications could be found in laser projection or spectroscopy.

Key results and impact
Development of a technology platform for yellow-orange lasers.
Development of a laser prototype to be used in applications.
Establishing a market perspective concerning the commercialization path.

Results of the projects are expected to be in commercial use within how many years?
2 years

Key publications

1) T. Leinonen, E. Kantola, S. Ranta, M. Tavast, V.-M. Korpijärvi, M. Guina,High Power 1100 -1200 nm Semiconductor Disk Lasers, Invited Paper at Conference on Lasers and Electro-Optics Pacific Rim 2013. Kyoto, Japan, June 30-July 4, 2013.
2) W.J. Alford, G.J. Fetzer, R.J. Epstein, A. Sandalphon, N. Van Lieu, S.Ranta, M. Tavast, T. Leinonen, M. Guina, Optically Pumped Semiconductor Lasers for Precision Spectroscopic Applications, EEE Journal of Quantum Electronics, 49, Issue 8, pp. 719-727 (2013).
3) E. Kantola, T. Leinonen, S. Ranta, M. Tavast, M. Guina, High-efficiency yellow VECSEL with an output power of about 12 W, CLEO-Europe 2013, 21th International Congress on Photonics in Europe, 12 -16 May, 2013, Münich, Germany, Oral CB-10.2 THU.
4) T. Leinonen, S. Ranta, M. Tavast, R. Epstein, G. Fetzer, A. Sandalphon, N. Van Liu, M. Guina, High Power (23W) Vertical External-Cavity Surface-Emitting Laser emitting at 1180 nm,SPIE Photonic West 2013-LASE: Lasers and Sources, Feb 2 - 7, 2013, San Fransisco, CA, U.S.A. Oral presentation [8606-3] p, 1-6 (2013).
5) S. Ranta, M. Tavast, T. Leinonen, R. Epstein, M. Guina, Narrow linewidth 1118/559 nm VECSEL based on strain compensated GaInAs/GaAs quantum-wells for laser cooling of Mg-ions Optical Materials Express, 2, pp. 1011-1019 (2012).

Number of publications
> 10 including 3 journal papers, a book chapter, and two invited talks.

Number of M.Sc.Thesis
Two MsC thesis to be completed in 2014.

Number of Doctoral Thesis
Results are relevant for two theses. One to be completed in 2014 and another one in 2015.

Project Full Name (acronym)
Technology up-scaling for next generation multi-junction solar cells (NextSolar)

Organisation
Tampere University of Technology, Optoelectronics Research Centre

Contact Person
Prof. Mircea Guina; mircea.guina@tut.fi

Company partners
Fortum Oyj, EpiCrystals Oy, DCA Instruments Oy

Project duration
1.7.2012 – 31.12.2013 (We are applying for a three months extension for the project)

Total cost (€)
270 000

Main target
NextSolar develops methods to fabricate III-V dilute nitride semiconductor materials combined with III-V antimonide materials for next generation multijunction concentrator solar cells. In particular it concentrates on methods to scale up fabrication process of 4" multijunction solar cells made of dilute nitrides and antimonides towards commercial production using molecular beam epitaxy.

Motivation
Utilization of solar energy becomes ever more important when the energy production is gradually shifted towards the renewable energy sources. Multi-junction solar cells are the prime choice for efficient solar energy harvesting as they provide the highest direct light-to-electricity conversion efficiency of all methods in the field.

Key results and impact
- MBE growth process parameters optimized for III-V dilute nitride and antimonide materials on 4" GaAs wafers
- Implementation of moth-eye pattern-based antireflection coatings on triple-junction GaInP/GaAs/GaInNAs solar cells.

Results of the projects are expected to be in commercial use within how many years?
3-6

Key publications
1) Aho A., Tukiainen A., Polojärvi V., Salmi J., and Guina M., High current generation in dilute nitride solar cells grown by molecular beam epitaxy, Proc. SPIE 8620, Physics, Simulation, and Photonic Engineering of Photovoltaic Devices II, 86201I (March 25, 2013). doi:10.1117/12.2002972

Number of publications
1

Number of M.Sc.Thesis
1 M.Sc. thesis will be ready by the end of 2013

Number of Doctoral Thesis
2 Doctoral Theses partially connected to NextSolar will be finalized in 2014.

Project Full Name (acronym)
Enhancing cell sheet technology

Organisation
University of Helsinki, Institute of Biomedicine

Contact Person
Doc. Esko Kankuri

Other research organisations in the project consortium
Helsinki University Central Hospital, Heart and Lung Center

Company partners
Finnish Red Cross Blood Service, Bionectra Ltd, Cellseed Inc

International partners (country, organisation)
Japan, Osaka University Graduate School of Medicine, Cardiovascular Surgery
Japan, Tokyo Women's Medical University, Institute of Advanced Biomedical Engineering and Science

Project duration
1.5.2011 – 31.3.2014

Total cost (€)
416 678

Main target
Already for more than a decade, cell therapies have been developed to enhance treatment of heart failure.

The efficacy of these therapies, unfortunately, has not been optimal.

Motivation
Previous studies have demonstrated that transplantation of patient's own cells e.g., during bypass surgery is a viable therapeutic option. The major issues remain with isolation, selection and optimal administration of cells.

Key results and impact
The eSEED collaboration project between Finland and Japan utilized the strong clinical expertise of the participating teams to help solve these issues. As a result, a novel cell therapy option for heart failure patients was developed. Clinical evaluation of this therapy for more widespread use is conducted at the Helsinki Academic Medical Center.

Results of the projects are expected to be in commercial use within how many years?
1

Number of publications
Approx. 2-3, in progress

Number of Doctoral Thesis
1 (MD Hisazumi Uenaka)

Project Full Name (acronym)
Integrated functionality through novel manufacturing and materials (FUNC-MAMA)

Organisation
VTT Technical Research Centre of Finland

Contact Person
Dr. Helena Ronkainen

Other research organisations in the project consortium
University of Oulu, Lappeenranta University of Technology

Company partners
Nokia, Sandvik Mining and Construction, Rahapaja Oy, Telatek Oy, Millidyne Oy, Kemin Digipolis

International partners (country, organisation)
USA, Mesoscribe Technology Inc.
UK, Imperial College

Project duration
1.1.2009 – 30.4.2012

Total cost (€)
1 112 607

Main target
The main objective of the project was to open the technological bottle necks to direct manufacturing of oxide free metallic wiring combined with dense, dielectric matrix to facilitate the fabrication of multi-material structures, manufactured directly within complex components or on component surfaces.

Motivation
Global competition in technology-driven companies is forcing them to create more sophisticated products in smaller and lighter packages. In addition to miniaturization, multifunctional structures are increasingly needed for process monitoring, diagnostics and control. By integrating sensors and intelligent components within or onto the surface of components, a multi-functional structure can be formed which is capable of self-knowledge and control.

Key results and impact
With thermal spraying it was possible to fabricate electrical insulating ceramic layers and the prevention of humidity or water penetration through the thermal sprayed ceramic layers could be further improved by using sealants. Different alumina-based coatings were suitable for low frequency appli-

cations (e.g., for sensor applications), where dielectric losses play less significant role. The conductive materials sprayed by DWTS, e.g., special copper powders, provided conductivity values as high as 42–56% of IACS values which can be considered sufficient for many applications.

Results of the projects are expected to be in commercial use within how many years?
About 5 years

Key publications

1) Ronkainen, H., Kanerva, U., Varis, T., Ruusuvuori, K., Trurunen, E., Perätie, J., Putaala, J., Juuti, J., Jantunen, J., Materials for electronics by thermal spraying. The proceedings of The 7th International Conference on Physical and Numerical Simulation of Materials Processing ICPNS2013, Oulu, June 16-19, 2013, 6 p.
2) Putaala, J., Sobocinskia, M., Ruotsalainen, S., Juuti, J., Laakso, P., Characterization of laser sintered thick-film paste on polycarbonate substrate, Optics and Lasers in Engineering.
3) Lehti, A., Taimisto, L., Piili, H., Salminen, A., Kujanpää, V., Evaluation of Different Monitoring Methods of Laser Assisted Additive Manufacturing of Ceramic Materials. Conference proceedings of 13th Conference on Laser Materials Processing in the Nordic Countries NOLAMP, Norway 27.-29.6.2011, 12 p.

Number of publications
7

Number of M.Sc.Thesis
1 M.Sc. Thesis
2 B.Sc. Thesis

Project Full Name (acronym)
Environment-friendly Functional Surface Treatment (ENFUNSURF)

Organisation
VTT Technical Research Centre of Finland

Contact Person
Dr. Helena Ronkainen

Other research organisations in the project consortium
Keio University, Kanagawa Industrial Technology Center and Kanagawa Academy of Science and Technology

International partners (country, organisation)
Japan: Keio University, Kanagawa Industrial Technology Center and Kanagawa Academy of Science and Technology

Project duration
1.4.2009 – 31.3.2012

Total cost (€)
130 000

Main target
In the collaborative project with Keio University, KITC, KAST and VTT the objective was to broaden the understanding of the diamond-like carbon (DLC) coatings by combining the knowledge and the research facilities in collaborating organizations. The experience in DLC coatings and modelling were combined to find new coating solutions.

Motivation
The DLC technology can provide excellent wear resistance and low friction properties both in dry and lubricated conditions and is thus a promising coating for tribological applications to improve energy efficiency and to enhance environmentally friendly solutions.

Key results and impact
The effect of coating properties on the stress and strain propagation was studied. The stresses and strains experienced by the ta-C coating were higher that a-C:H coating due to high hardness and Young´s modulus value. For the ta-C coating an optimum stress level was found for the coating thickness of about 0.5 µm. For the a-C:H coating the stress accumulation increase with thickness.

Results of the projects are expected to be in commercial use within how many years?
3-5 years

Key publications

1) H. Ronkainen, K. Holmberg, A. Laukkanen, T. Andersson, M.Kano, T.Horiuchi, T.Suzuki, The effect of coating properties on the fracture characteristics and tribological performance of a-C:H and ta-C films. Submitted for publication

Number of publications

4

Project Full Name (acronym)

Surface Engineering of Pulp Fibres: New Functionalization Concepts for Smart Fibre Products (SmartFibre)

Organisation

Åbo Akademi University, Department of Chemical Engineering, Laboratory of Fibre and Cellulose Technology

Contact Person

Prof. Dr. Pedro Fardim

Other research organisations in the project consortium

Tampere University of Technology, Department of Automation Science and Engineering (Prof. Pasi Kallio)

Company partners

UPM-Kymmene, Stora Enso, Metsä-Fibre (formerly: Metsä-Botnia)

International partners (country, organisation)

Latvia, Latvian State Institute of Wood Chemistry (Prof. Arnis Treimanis)

Project duration

2.2.2009 – 31.12.2011

Total cost (€)

889 600

Main target

The main target was to develop innovative wood-based fibre materials with high added value and a completely new technological platform for investigation of functional fibres and papers.

Motivation

Tailoring and tuning of smart fibre properties by fibre functionalization is practically unexplored. Especially the reactive and stimuli responsive wood fibre products are completely missing.

Key results and impact

A new method for functionalizing pulp fibres with Layered double hydroxides (LDH) was presented. The surface properties of fibres were changed from hydrophilic to hydrophobic. The modified pulp fibres were tested in composite application where they performed better than native fibres. It was demonstrated that the modification process helped in retaining optical brightening agents without causing severe leaching into effluent while the quantum yield was largely unaffected. In bleaching process the hybrid LDH particles directed chemical reactions to pulp fibre surface enhancing opacity and reducing peroxide consumption at the same brightness level. A unique and totally new type of tool for paper fiber studies was developed using microrobotics allowing new knowledge on the strength of individual paper fiber bonds and the influence of chemicals on the strength and wetting properties

Results of the projects are expected to be in commercial use within how many years?

The concept for functionalizing of pulp fibres was developed to be readily implementable in industrial processes without high capital investments. Microrobotic tool for paper fiber studies: 2015-2016.

Key publications

1) Lange, C., Lundin, T. and Fardim, P., Hydrophobisation of mechanical pulp fibres with with sodium dodecyl sulphate functionalised layered double hydroxide particles, Holzforschung, 66 (2012) 433-441.

2) Lange, C. Touaiti, F., and Fardim, P. Hybrid clay functionalized biofibres for composite applications, Compos. Part B, 47 (2013) 260-266.

3) Lange, C. Touaiti, F., and Fardim, P. Hybrid clay functionalized biofibres for composite applications, Book of Abstracts , ed. Fangueiro, R., 1st International Conference on Natural Fibers, Guimarães, Portugal, 2013, p 233.
4) Saketi, P. and Kallio, P. "Measuring Individual Paper Fiber Bond Strength using Microrobotics", Proceedings of the Progress in Paper Physics Seminar. Graz, Austria, September 2011.
5) Saketi, P., von Essen, M., Mikczinski, M., Heinemann, S., Fatikow, S. and Kallio, P. "A Flexible Microrobotic Platform for Handling Microscale Specimens of Fibrous Materials for Microscopic Studies". Journal of Microscopy, 248, Issue 2 (2012), 163–171.

Number of publications
12

Number of patents and patent applications
1

Number of M.Sc.Thesis
6

Project Full Name (acronym)
Liquid Flame Sprayed Nanocoating for Flexible Roll-to-Roll Web Materials 2 (NANORATA 2)

Organisation
Tampere University of Technology, Department of Physics

Contact Person
Prof. Jyrki Mäkelä, jyrki.makela@tut.fi

Other research organisations in the project consortium
Laboratory of Paper Converting and Packaging Technology, Tampere University of Technology; Laboratory of Paper Coating and Converting, Åbo Akademi University; Research and Innovation Laboratory Unit & Centre for Sustainable Consumption and Production, Finnish Environment Institute (SYKE)

Company partners
UPM Kymmene, Stora Enso, Beneq

International partners (country, organisation)
Sweden, YKI, Institute for Surface Chemistry, Stockholm
Norway, Paper and Fibre Research Institute (PFI), Trondheim
USA, Department of Chemical Engineering, Caltech, CA
Switzerland, Particle Technology Laboratory, ETH, Zürich

Project duration
1.4.2011 – 31.3.2014

Total cost (€)
813 574

Main target
The main target was to control surface properties and functionality of flexible natural fibre-based materials in large scale through nanoparticle deposition by the Liquid Flame Spray –process (LFS). The benefits of such LFS coating are affordability with versatile metal or metal oxide nanoparticle deposition and continuous nature of the process.

Motivation
Full utilization of paper, paperboard and polymer structures, being highly versatile materials with various favorable properties, e.g., biodegradability (biopolymers), renewability, mechanical flexibility and affordability, requires the ability to tailor and control their surface properties. The existing coating methods, usually based on vacuum and low-pressure techniques, are not still feasible enough for cost-effective massive industrial processing. The atmospheric nanoparticle coating method developed in this project will contain robust up-scalable features to be applicable in an industrial scale. Here we have worked on adjustable surface wetting, stimuli responsive surfaces, improved printability , adhesion and release properties, and basis of nanocoatings generally, to develop new functional coatings for flexible substrates.

Key results and impact
Nanoparticle structured surface coatings for flexible web-like materials have been successfully developed with controlled

adjustable wetting properties between superhydrophilicity and superhydrophobicity. In the industrial set up line speeds in the order of 500 m/min have been achieved to create ultra-thin nanocoatings with a mass loading of 10-100 mg/m². The surfaces can now be practically repeatedly tailored, and even tuned, to any adjusted water contact angle based on UV- and heat treatment responsive properties of the surfaces. Additionally, highly omniphobic surfaces have been successfully fabricated on the same flexible substrates by using combination of the LFS-nanocoating and plasma enhanced CVD. Special effort has been put to characterization of the nanocoating and its physico-chemical properties to provide the tunable functionality and to understand the basic mechanisms. Moreover, wear properties, calandering of the coating as well as possible nanoparticle emission from the surface into air and liquid during disposal have been studied. Also, a full Life Cycle Analysis (LCA) was performed for one of our nanocoated products, as a case study.

Results of the projects are expected to be in commercial use within how many years?

2-5 years

Key publications

1) Teisala, H., Tuominen, M., Aromaa, M., Stepien, M., Mäkelä, J.M. , Saarinen, J.J. , Toivakka, M., Kuusipalo, J. (2012) Nanostructures Increase Water Droplet Adhesion on Hierarchically Rough Superhydrophobic Surfaces, Langmuir. DOI: 10.1021/la203155d
2) Aromaa, M., Arffman, A., Suhonen, H., Haapanen, J., Keskinen. J., Honkanen. M., Nikkanen, J.-P., Levänen, E., Messing, M.E. Deppert, K., Teisala, H., Tuominen, M. Kuusipalo, J., Stepien, M., Saarinen J.J., Toivakka. M. and Mäkelä J.M. Atmospheric synthesis of superhydrophobic TiO_2 nanoparticle deposits in a single step using Liquid Flame Spray. J. Aerosol Sci. 52 (2012) 57-68.
3) Stepien, M. Saarinen, J.J., Teisala, H., Tuominen, M., Aromaa, M., Kuusipalo, J., Mäkelä, J.M. Toivakka, M. "Surface chemical analysis of photocatalytic wettability conversion of TiO_2 nanoparticle coating", Surface and Coatings Technology 208 (2012) 73-79.
4) Teisala, H., Tuominen, M., Stepien, M. , Haapanen, J., Mäkelä, J.M. , Saarinen, J.J., Toivakka, M., and Kuusipalo, J. (2013) Wettability conversion on the liquid flame spray generated superhydrophobic TiO_2 nanoparticle coating on paper and board by photocatalytic decomposition of spontaneously accumulated carbonaceous overlayer Cellulose: 20 (2013) 391-408.
5) Stepien M., Saarinen J. J., Teisala H., Tuominen M., Aromaa M., Haapanen J., Kuusipalo J., Mäkelä J. M., Toivakka M., "ToF-SIMS Analysis of UV-Switchable TiO_2 Nanoparticle-Coated Paper Surface", Langmuir 29 (2013) 3780-3790.

Number of publications

12 peer reviewed journal articles, 10 conference articles

Number of patents and patent applications

2

Number of M.Sc.Thesis

1

Number of Doctoral Thesis

3

Project Full Name (acronym)

Advanced III-V semiconductors for multi-junction high efficiency solar cells (SOLAR III-V)

Organisation

Tampere University of Technology, Optoelectronics Research centre

Contact Person

Prof. Pekka Savolainen

Other research organisations in the project consortium

Helsinki University of Technology, Department of Micro and Nanosciences; University of Turku, Department of Physics and Astronomy

Company partners

EpiCrystals Oy, Fortum Oyj, Naps Systems Oy, CimSolar Oy, Canatu Oy

Project duration
1.7.2009 – 30.6.2012

Total cost (€)
1 131 667

Main target
The project aimed at developing multi-junction solar cells with performance exceeding the current state-of-the-art 'triple-junction' solar cells. In particular the aim was to demonstrate that dilute-nitride materials enable laboratory demonstration of solar cells with the high conversion efficiency at AM1.5 under a 100 - 500 sun concentrator.

Motivation
Utilization of solar energy becomes ever more important when the energy production is gradually shifted towards the renewable energy sources. At the moment, multi-junction solar cells are the prime choice for efficient solar energy harvesting as they provide the highest direct light-to-electricity conversion efficiency of all methods in the field.

Key results and impact
- State-of-the art developments concerning MBE of dilute nitride solar cells: high quality single-junction GaInNAs solar cells were demonstrated with high short-circuit current and large open circuit voltage.
- Full chain for fabrication of research solar cells, including epitaxy, simulation, processing, and characterization was established.
- Novel dilute nitride solar cells incorporating nanostructured antireflection coatings were demonstrated with <2% average reflectivity over wavelength range of 400-1800 nm.

Results of the projects are expected to be in commercial use within how many years?
3-5 years

Key publications

1) Tommila J., Aho A., Tukiainen A., Polojärvi V, Salmi J., Niemi T., Guina M., Moth-eye antireflection coatings fabricated by nanoimprint lithography on 1 eV dilute nitride solar cells, Progress in Photovoltaics: Research and Applications, p.1-5 (2012). doi:10.1002/pip.2191
2) Tommila J., Polojärvi V., Aho A., Tukiainen A., Viheriälä J., Salmi J., Schramm A., Kontio J.M., Turtiainen A., Niemi T., and Guina M.,"Nanostructured broadband antireflection coatings on AlInP fabricated by nanoimprint lithography", Solar Energy Materials & Solar Cells, 94, 2010, pp.1845-1848. doi:10.1016/j.solmat.2010.05.053
3) Aho A., Tukiainen A., Polojärvi V., Salmi J., Guina M., "MBE growth of high current GaInNAs-based single and triple junction solar cells", EU-PVSEC Frankfurt, Germany, 24-28 September (2012).
4) Aho A., Tukiainen A., Korpijärvi V.-M., Polojärvi V., Salmi J., Guina M., " Comparison of GaInNAsSb solar cells grown by plasma-assisted molecular beam epitaxy", AIP Conf. Proc. 1477, pp. 49-52; doi:10.1063/1.4753831 (4 pages). 8th International Conference on Concentrating Photovoltaic Systems, CVT-8, April 16 - 18, 2012, Toledo, Spain (2012).
5) Aho A., Tukiainen A., Polojärvi V., Gubanov A., Salmi J., Guina M., "Lattice Matched Dilute Nitride Materials for III-V High-efficiency Multi-Junction Solar Cells: Growth Parameter Optimization in Molecular Beam Epitaxy", 26th EU PVSEC, European Photovoltaics Solar Energy Conference and Exhibition Proceedings (2011) .

Number of publications
9 journal papers
23 conference/workshop contributions

Number of M.Sc.Thesis
2 diploma theses, 1 BSc thesis

Number of Doctoral Thesis
two PhD theses to be completed at ORC in 2014

Tekes

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