Quickfire seminar -version 15.12.2011

Nanotechnology Research in Finland 2011

OSKE
NANOTECHNOLOGY
CLUSTER PROGRAMME

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Welcome to explore nanotechnology research in Finland. The content of this report is based on both "HelsinkiNano – Nanotechnology research in Helsinki Region 2010" -report and a survey on Finnish nanotechnology research groups carried out by Nanotechnology Cluster Programme during 2011. The information includes, for every research group, special know-how of the group, objectives of the research, the recent significant results, the industrial sectors who could utilize the results, and the contact information. The classification on page G makes it as easy for the industrial players to find the research relevant for their business.

This preliminary report is for the 15.12.2011 Quickfire-seminar. The updated version of this report will be available on www.nanobusiness.fi on 15th January 2012. In addition, the all the related data will be uploaded on www.nanoresearch.fi -portal by 15.3.2012.

NANOTECHNOLOGY CLUSTER PROGRAMME

Nanotechnology Cluster Programme (2007–2013) initiated by the Ministry of Employment and Economy promotes nanotechnology based business in Finland. Nanocluster is a nationwide network reaching more than 90 % of all Finnish nano- and microtechnology related activities and stakeholders.

The mission of the Nanocluster is to foster the growth of Nanotechnology based business and to support implementation of nano and microtechnologies and future materials in Finnish companies.

More information: www.nanobusiness.fi

Nanotechnology in Finland

Finland has invested actively in the development of nanotechnology since 1990s. Ministries, Tekes (the Finnish Funding Agency for Technology and Innovation) and Academy of Finland finance the development of nanotechnology in Finland.

Finnish innovation environment combines public and private sector. Over 300 companies work with nanotechnology, 100 of them already having commercial nanotechnology based products. Finnish Nanotechnology business is supported by research conducted in 170 groups both in universities and in research centers.

The turnover of Finnish commercial nanotechnology sector was over 300 million euros in 2008. In 2013 it is estimated to be 1.2 billion euros (source: Finnish Funding Agency for Technology and Innovation). Finnish companies with commercial products are successful according to the EU survey (NanoCom).

THE SPEARHEADS OF FINNISH NANOTECHNOLOGY:

High class research & well established business:

- Nanomaterials
- Nanosurfaces and coatings
- Microtechnology and sensors
- Diagnostics, pharmaceuticals, medical
- Photonics
- Aerosols

High class research, to be commercialized:

- Safety and metrology
- Modelling and characterization
- Nanoelectronics
- Nanocellulose
- Printed Intelligence

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HOW TO USE THE CLASSIFICATION MATRIX

The matrix on the previous page classifies all the research groups according to their expertise (columns) and industry sectors that have the most potential in applying the results of the research of the groups (rows).

Every number in the matrix represents a page number in the document and therefore represents one research group. In the electronic (pdf) version, each number acts also as a link to the corresponding page.

Example:

If you are looking for a research group with expertise in 'Nano-materials' that could best be applied in 'Metal industry', cross-reference the column 'Nano-materials' and row 'Metal industry' and you see on the corresponding cell that the groups on pages '5, 7, 36, 49, 54, 99, 112, 120, 121' are the best matches.

CLASSIFICATION MATRIX

	Surfaces	Nano-materials	Aerosols	Well-being	Built environments	Electronics	Characterization	Fabrication	Theory	Services	Other
Chemical industry	1, 9, 11, 48, 49, 50, 59, 61, 66, 74, 86, 102, 104, 105, 131	1, 9, 11, 27, 48, 49, 50, 54, 59, 61, 66, 74, 83, 86, 102, 104, 105, 106, 131, 137	49, 61, 63, 74, 81, 83	6, 9, 49, 54, 61, 74, 86, 131	27, 59, 61, 86	9, 49, 61, 86, 105, 106, 131	1, 6, 11, 27, 48, 50, 59, 63, 66, 74, 81, 83, 86, 104, 105, 106	6, 9, 27, 48, 59, 61, 66, 74, 81, 83	1, 6, 11, 48, 54, 63, 66, 74, 81, 83, 131		1, 27, 59, 74, 129
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Science	1, 2, 4, 5, 19, 33, 35, 44, 69, 73, 77, 85, 95, 99, 107, 118	1, 2, 4, 5, 28, 30, 35, 38, 56, 60, 69, 70, 77, 99, 107, 117, 118, 128	46, 73, 81, 85, 117, 128	14, 19, 30, 56, 69, 73, 85, 95, 128	44, 107	2, 4, 14, 19, 29, 33, 35, 38, 39, 43, 56, 60, 69, 70, 77, 99, 114, 119, 125, 128	1, 2, 4, 5, 14, 19, 29, 30, 33, 35, 44, 46, 56, 60, 69, 70, 73, 75, 77, 78, 81, 95, 99, 119, 125, 128, 133	4, 5, 14, 19, 29, 38, 41, 60, 69, 70, 77, 81, 95, 99, 119, 125, 128, 133	1, 19, 28, 29, 35, 38, 46, 56, 62, 69, 73, 77, 78, 80, 81, 85, 96, 117, 119, 125, 128, 133	41, 44, 75, 99	1, 5, 44, 45, 46, 71, 107
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AALTO UNIVERSITY

Faculty of Chemistry and Materials Science
Department of Biotechnology and Chemical Technology

Group name

Industrial chemistry

Leader

Prof. Outi Krause

Special know-how of the group:

- Development of catalytic materials, including catalyst synthesis, characterization and activity testing (e.g. preparation of catalysts by atomic layer deposition, in situ characterization of catalysts under reaction conditions).
- Modeling of the catalytic phenomena taking place during reactions and development of new modeling tools, e.g. for the utilization of temperature-programmed methods in transient kinetic modeling.

Objectives of the research:

Our research group concentrates on the phenomena present in the chemical reactor. This includes studies on catalytic nanomaterials and catalytic processes. The objective of the research is to utilize the fundamental knowledge obtained on catalytic phenomena in the development of processes that are environmentally benign and important for the society. Special emphasis is in the production of hydrogen for fuel cells and of chemicals and liquid fuels from biomass.

The recent significant results:

Several papers have been published in high-ranking scientific journals. Fundamental information has been obtained on several catalytic systems. Methods have been developed for extracting information from temperature-programmed experiments

Who could utilize the results?

The results can be utilized by industrial companies in e.g. the development of environmentally benign and more efficient catalytic processes for production of chemicals and fuels. Results are also beneficial for further fundamental research work.

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AALTO UNIVERSITY

Faculty of Chemistry and Materials Science
Department of Biotechnology and Chemical Technology

Group name

Polymer Technology group

Leader

Prof. Jukka Seppälä

Special know-how of the group:

- Polymerization engineering and chemical modification of polymers
- Polymer tailoring, structure/property correlations
- Compatibilization of nanostructural composites; nanoclay, carbon nanotubes and nanocellulose
- Polymerization of biodegradable polymers for controlled release and tissue engineering applications
- New polymerization routes for amphiphilic block polymers
- Rheological and thermomechanical characterization of polymers, polymer composites and dispersions with state of the art equipment

Objectives of the research:

Research is focused on synthesis and characterization of polymers, development of new materials utilizing polymerization techniques and composite technology, structure/property correlation research of nanostructured polymers and composites, and compatibilization of heterophasic systems.

The recent significant results:

Silane functionalized polyolefins via metallocene catalysis; synthesis and use in polyolefin coposites, Preparation of polymeric nanocomposites and their structure-property relationships, Poly(ester-anhydrides) Based on Polylactone Precursors. Also the following awards have been received: **1**) Millennium Distinction Award **2**) New Materials Invention Award **3**) TKK Most Prominent Inventor Award **4**) Several scientific articles and patents/invention claims.

Who could utilize the results?

1) New properties for products of forest industry with amphiphilic block copolymers **2**) Novel composite materials for electronic applications **3**) Novel materials for controlled drug release applications and tissue engineering scaffolds **4**) Nanocellulose; use and composites

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3

AALTO UNIVERSITY

Faculty of Chemistry and Materials Science
Department of Chemistry

Group name

Analytical Chemistry

Leader

Prof. Sakari Kulmala

Special know-how of the group:

Luminescence methods in general.

Objectives of the research:

Electrochemiluminescence, mainly Hot electron-induced Electrohemiluminsescence, and its analytical applications but also applications of some other fields of luminescence.

The recent significant results:

1) Color tunability and electrochemiluminescence of silver nanoclusters 2) Hot Electron-induced Electrogenerated Chemiluminescence 3) Ultrathin tunnel insulator films on silicon for electrochemiluminescence

Who could utilize the results?

Mainly in IVD applications.

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4

AALTO UNIVERSITY

Faculty of Chemistry and Materials Science

Department of Chemistry

Group name

NewMaterial Group

Leader

Acad. prof. Maarit Karppinen

Special know-how of the group:

Systematic new-material design concept, inorganic materials chemistry, functional oxide materials, atomic layer deposition (ALD) technology

Objectives of the research:

Atomic-level layer-by-layer design and synthesis of novel (functional) materials.

The recent significant results:

1) Atomic layer deposition of both hexagonal and orthorhombic $YMnO_3$ thin films **2**) Atomic layer deposition of stable inorganic-organic hybrid thin films **3**) Atomic layer deposition of gas-barrier coatings for fiber-based packaging materials **4**) Conformal ALD coating of nanoscale topographies of with thin ZnO films for photo-controlled wettability switching **5**) Progress in nanoscale area-selective ALD

Who could utilize the results?

Scientific communities in new material research and ALD technology; Future spintronics industry; (Food and pharmaceutical) packaging industry

Contact

Acad. prof. Maarit Karppinen (maarit.karppinen(a)tkk.fi)

In addition to the mentioned leader, the research profile includes the research of:

prof. Matti Putkonen

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AALTO UNIVERSITY

Faculty of Chemistry and Materials Science
Department of Chemistry

Group name

Physical Chemistry and Electrochemistry

Leader

Prof. Kyösti Kontturi

Special know-how of the group:

In general, the laboratory's research focus is on electrochemical applications of nanotechnology such as catalytic materials, antibacterial coatings, memory devices, diagnostics, sensors, etc. Group consists of the following persons: **Prof. Kyösti Kontturi**: transport processes at interfaces, electrochemistry **Dr. Lasse Murtomäki**: drug delivery **Dr. Christoffer Johans**: nanoparticle synthesis and mechanisms of nanoparticle nucleation and growth **Dr. Tanja Kallio**: energy conversion **Dr. Kirsi Yliniemi**: functional nano-interfaces **Dr. Benjamin Wilson**: nanoscale oscillators

Objectives of the research:

1) Functional nanocoatings: how tight attachment of nanoparticles influences on their properties **2**) Scale-up fabrication of nanoparticles: mechanisms of nanoparticle nucleation and growth **3**) New synthetic routes for Co/Fe nanoparticles **4**) Nanoscale electrochemical oscillators for memory applications **5**) Catalytic materials for fuel cell applications

The recent significant results:

1) Fabrication of monodisperse Co nanoparticles (patent pending) **2**) Induced electrochemical oscillations on Pt surface and glucose oxidase enzyme (GOD) coated surface **3**) Nucleation and growth mechanism of metallic nanoparticles **4**) Functional nanocoatings based on polymers and Ag nanoparticles

Who could utilize the results?

To great extent the research in the group is basic research which finds its use in the scientific community. Additionally, some research areas are closely related to industry, for example the fabrication of nanoparticles in large scale as well as functional nanocoatings can be useful for metal industry.

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AALTO UNIVERSITY

Faculty of Chemistry and Materials Science
Department of Chemistry

Group name

Laboratory of Organic chemistry

Leader

Prof. Ari Koskinen

Special know-how of the group:

Synthetic organic chemistry

Objectives of the research:

Synthesis of natural products, development of novel synthetic methods capable of being transferred into industrially applicable synthetic technologies

The recent significant results:

The latests publications are good examples of the latest results: **1**) Highly Chemoselective Copper Catalyzed Conjugate Reduction of Stereochemically Labile α,β-Unsaturated Amino Ketones **2**) indolizidine alkaloids - synthesis of dideoxycastanospermine **3**) Towards the total synthesis of Calyculin C: preparation of the C13-C25 spirocyclic core **4**) Catalytic Activity Dependency on Catalyst Components in Aerobic Copper-TEMPO Oxidation **5**) Chiral 3-(4,5-dihydrooxazol-2-yl)phenyl alkylcarbamates as novel FAAH inhibitors: insight into FAAH enantioselectivity by molecular docking and interaction fields **6**) Synthesis and agonist properties of novel quinoline and isoquinoline derivatives toward the cannabinoid receptor CB2 **7**) The Synthesis and Biological Evaluation of para-Substituted Phenolic N-Alkyl Carbamates as Endocannabinoid Hydrolyzing Enzyme Inhibitors
8) A Simple Organocatalytic Enantioselective Synthesis of Pregabalin **9**) 'Synthesis of DEFG Ring System of Cneorins **10**) Aldol-Tischenko Reaction **11**) Development of Di-(2-picolyl)amine Zinc Chelates for Imidazole Receptors **12**) Stereoselective Total Synthesis of Pachastrissamine (Jaspine B) **13**) A New Application for PyOX-ligands: The Asymmetric Henry Reaction **14**) Mild and Efficient Synthesis of 2-indole-2´-Oxazolines at Room Temperature – a Simple Access to Novel IndOX-ligands

Who could utilize the results?

Pharmaceutical industry can use some of our methodologies

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AALTO UNIVERSITY

Faculty of Chemistry and Materials Science
Department of Materials Science and Engineering

Group name

Active and Functional Materials

Leader

Prof. Simo-Pekka Hannula

Special know-how of the group:

- Synthesis metal nanoparticle modified silica particles
- Spark plasma sintering of bulk nanocrystalline materials
- Sub-Å HR-TEM electron diffraction, EELS, EDX
- Hysitron nanoindenter with the heat stage (max 400°C)

Objectives of the research:

1) Developing metal-nanoparticle modified ceramic powders **2**) Understanding the SPS compaction of the nanocrystalline materials of nanopowders **3**) Structure characterization of nanopowders and nanocrystalline materials and coatings **4**) Application of nanopowders in sol-gel coatings and paints as well as in paper and textiles

The recent significant results:

1) Development of novel nanocrystalline ceramic coatings **2**) Development of antibacterial light coloured nanopowders for coating applications **3**) SPS compacts with the nanocrystalline structures **4**) Characterization of nano-alfa-alumina with novel morphology **5**) Characterization of the nanomechanical properties of nanocomposites

Who could utilize the results?

In antibacterial coatings for building industry. In coatings for demanding conditions in various machinery.

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8

AALTO UNIVERSITY

Faculty of Chemistry and Materials Science
Department of Materials Science and Engineering

Group name

Materials Processing and Powder Metallurgy

Leader

Prof. Michael Gasik

Special know-how of the group:

The research activities of the MVT are recently concentrated in fields of powder metallurgy and advanced materials processing, fuel cells and catalysts, functionally gradated materials (FGM), biomaterials, thermodynamic data bank and modelling, light alloys and intermetallic composites development, processes simulation (CFD, FEM, etc.), environment and recycling, etc. It is for instance internationally recognised for its work on FGM design, processing and evaluation. The group has extensive expertise in combined thermal analysis (dilatometry, thermogravimetry, coupled FTIR, calorimetry, DMA, thermal conductivity), powder processing and characterisation (from 0.6 nm up), materials performance evaluation (aggressive environments) and special processing (such as microwave hybrid treatment). The essential know-how is also in data processing and modelling (mathematical, thermodynamical, CFD and FEM).

Objectives of the research:

The group of materials processing and powder metallurgy (MVT) performs international research in the field of materials processing and powder metallurgy, related physical-chemical phenomena, computer based and experimental modelling, and new materials solutions. The core competence of the group is in the chain 'materials design - processing – structure - properties - testing – applications' research, management and modelling. The research are concentrated on various industrial processes, their modelling and design, materials design, their optimisation and modelling, materials thermodynamics and kinetics, analysis and testing, applied materials processing technology and powder metallurgy, as well as specific contract research.

The recent significant results:

1) New ceramic and coated prostheses made of combined and FGM materials with better wear resistance (5 times) and strength (+75%) were designed, optimised and manufactured, giving also significant increase in strength. Also new algorithm and model for calculation of the non-uniform sintering kinetics and residual stresses in FGM were developed, implemented and applied for several systems. This study was selected to CORDIS technology marketplace and as EU feature article. **2**) New method of fast (50-100 times) manufacturing of carrier-integrated nano-structured MnCo2O4 spinel and doped Raney-type nickel catalysts using focussed microwave radiation-assisted synthesis has been developed (power density was increased by 30-35% vs. traditional catalysts). **3**) For applications with aggressive environments and high temperatures, protective coatings have been developed in cooperation with Japan. An excellent performance of these FGM solutions (life time improved over 100 times, hot corrosion stability over 100-150 times) lead to extensive testing of these coatings in Japanese industry (JIS H 7851 standard was developed). **4**) Development of advanced analyticla FEM models for CFD and multiphysics modeling of materials behaviour, pyro- and hydrometallurgical processes, including the validation of these models.

Who could utilize the results?

Industrial applications (power generation, metallurgy, electronics, corrosion protection, etc.), health care (orthopaedics, dental).

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AALTO UNIVERSITY

Faculty of Chemistry and Materials Science
Department of Materials Science and Engineering

Group name

Microfabrication group

Leader

Prof. Sami Franssila

Special know-how of the group:

- Materials and fabrication methods of micro- and nanodevices
- Surfaces and coatings
- Fluidic devices for chemistry and biology

Objectives of the research:

To develop novel fabrication methods for micro- and nanodevices

The recent significant results:

1) Control of wetting by micro- and nanostructured surfaces 2) New focused ion beam (FIB) nanofabrication method 3) Novel CNT transistor fabrication process 4) Suspended and thermally insulated micro- and nanostructures

Who could utilize the results?

In chemical and biochips for analytical chemistry, protein chemistry, diagnostics

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AALTO UNIVERSITY

Faculty of Chemistry and Materials Science
Department of Materials Science and Engineering

Group name

Physical properties of surfaces and interfaces

Leader

Prof. Jari Koskinen

Special know-how of the group:

Plasma assisted coating methods, PVD, carbon based coatings

Objectives of the research:

To develop thin films with functional properties and to tailor the coating substrate interface.

The recent significant results:

Textured surface of a diamond-like carbon coating allowing the reduction of friciton in lubricated conditions. It should be noted, that the group was found less than one year ago.

Who could utilize the results?

Components and tools

Contact

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AALTO UNIVERSITY

Faculty of Chemistry and Materials Science
Department of Forest Products Technology

Group name

Forest products surface chemistry

Leader

Prof. Janne Laine

Special know-how of the group:

- Surface science of cellulosic materials
- Characterization, utilization and modification of nanocellulose
- Interactions and adsorption at various cellulose surfaces. The cellulose may be cellulose fibre or thin films made from nanocrystalline cellulose, nanofibrillar cellulose or regenerated cellulose
- Surface modification
- Polyelectrolyte multilayers

Objectives of the research:

1) Nanotechnological applications in the forest products sector 2) Surface modification of macroscopic material like paper or wires, surface modification of cellulose fibers and surface modification of nanomaterial.

The recent significant results:

Establishing the Finnish Centre for Nanocellulosic Technologies together with UPM and VTT. The centre aims at creating new applications for cellulose as a raw material, substance and end product.

Who could utilize the results?

The results can be applied in paper making, packaging and in developing new materials from wood. The results may also be applied in material science. Industries benefiting from the results are the paper industry, chemical suppliers, and any company interested in developing new materials from sustainable resources.

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AALTO UNIVERSITY

Faculty of Chemistry and Materials Science
Department of Forest Products Technology

Group name

Paper Converting and Packaging

Leader

Prof. Jouni Paltakari

Special know-how of the group:

- Paper and paperboard converting and coating
- Behaviour of fibre-based packaging materials
- Production of microfirillated and nano-scale lignocellulose material

Objectives of the research:

Development of bio-/fibre based materials and composites including nano-scale fractions for novel paper and paperboard structures for converting and packaging end uses.

The recent significant results:

1) Start-up of a production unit for micro- and nanofibrillated cellulose at TKK 2) Research and investigation of the behaviour of micro- and nanofibrillated cellulose in paper and paper board furnishes, and as a component in coating colours.

Who could utilize the results?

Results are directly applicable in industrial processes within forest products industry and in other relevant application areas.

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AALTO UNIVERSITY

Faculty of Chemistry and Materials Science
Department of Forest Products Technology

Group name

Paper technology

Leader

Prof. Hannu Paulapuro

Special know-how of the group:

- Fiber and paper physics
- Process technology
- Control and diagnostic methods of papermaking processes

Objectives of the research:

1) Improve the properties of fibers and paper 2) Develop new paper manufactoring technology (especially forming technology, reducing the energy consumption of papermaking)

The recent significant results:

1) Use of fibrils (nanomaterial) in papermaking 2) New ways of fiber treatment for improving paper properties
3) Increasing the filler (pigment) content in paper (up to 60 %) without deteriorating paper properties
4) Improving the optical properties of fillers (nanocoated filler particles) 5) Developing the air dynamic forming concept for waterless papermaking 6) Developing the ultra high forming (up to 15 %) concept for paper- and board making.

Who could utilize the results?

The results are partly revolutionary to papermaking. They can be directly applied in paper and board mills. Especially when developing new paper and board products the results with nanomaterials (fibrils, nanocoated fillers) are essential.

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AALTO UNIVERSITY

Faculty of Electronics, Communications and Automation
Department of Automation and Systems Technology

Group name

Micro- and Nanorobotics Group

Leader

Doc. Quan Zhou

Special know-how of the group:

- Microrobotics
- Nanomanipulation inside SEM
- Optical quality control robots for microcomponents, assembly methods for RFIDs, microgrippers and optical actuation methods

Objectives of the research:

1) Develop tools and automation for micro- and nanomanufacturing, including new micro- and nanoassembly methods based on robotics and/or self-assembly, new handling strategies for micro- and nanocomponents, new actuation principles and quality control in micro- and nanomanufacturing 2) Use the aforementioned methods for manufacturing autonomous and mobile micro- and nanorobots

The recent significant results:

1) Nanomanipulator inside a SEM 2) New microhandling strategy combining robotics and self-assembly based on droplet self-alignment 3) swallowable wireless biotelemetry device ("intelligent pill") for the analysis of gastrointestinal tract

Who could utilize the results?

Researchers who need precise handling of nanoscopic samples, RFID or heterogeneous IC companies, biomedical device manufacturers

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AALTO UNIVERSITY

Faculty of Electronics, Communications and Automation

Department of Micro and Nanosciences

Group name

Nanotechnology Group

Leader

Prof. Harri Lipsanen

Special know-how of the group:

- Nanofabrication, advanced materials, functional surfaces, materials characterization
- Nanofabrication methods including electron beam lithography, focused ion beam lithography, nanoimprint lithography, atomic layer deposition (ALD), metalorganic vapour phase epitaxy (MOVPE) and other advanced deposition and dry etching processes combined with standard microfabrication techniques
- Semiconductor nanostructures such as quantum dots and nanowires are also processed by self-assembly
- Fabrication methods for graphene are developed
- Novel nanomaterials are developed from structures based on nanolaminates, plasmonic structures, functional nanostructures and bioinspired structures
- Nanocharacterisation methods covers techniques such as scanning probe microscopy, SEM, TEM, advanced X-ray diffraction, Raman spectroscopy, photoluminescence and various electrical methods.

Objectives of the research:

1) World-class research on nanostructures, nanomaterials and nanocharacterization **2**) Application of nanotechnology in advanced devices and materials for nanoelectronics, nanophotonics and sensors.

The recent significant results:

1) Ballistic graphene devices **2**) New gallium nitride nanostructures for LEDs **3**) New plasma-ALD processes **4**) Semiconductor nanowire structures **5**) ALD nanolayers for surface passivation **6**) Novel genetic fitting algorithms and statistical error analysis methods for x-ray reflectivity analysis **7**) Photonic crystal waveguides for silicon integrated optics

Who could utilize the results?

The results can be applied in the development of new devices and functional surfaces. The expertise in nanofabrication and characterization has a wide field of applications.

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AALTO UNIVERSITY

Faculty of Electronics, Communications and Automation
Department of Micro and Nanosciences

Group name

The electron physics group

Leader

Prof. Pekka Kuivalainen

Special know-how of the group:

- Fabrication of Mn-doped InAs magnetic quantum dots on a GaAs substrates using molecular beam epitaxy
- Fabrication of SETs using e-beam lithography **3**) Modelling of the spintronic devices

Objectives of the research:

We are carrying out basic research in the field of semiconductor spintronics, studing especially the magnetic semiconductor single electron transistors (SETs) made of ferromagnetic semiconductor quantum dots. The objective is to show, by fabricating and modelling the SETs, that the electrical and magnetic properties of these transistors can be controlled simultaneously by the gate voltage. This provides, e.g. new highly miniaturized non-volatile memory elements.

The recent significant results:

1) The modelling results predicting many novel features for magnetic SETs **2**) Fabrication of the ferromagnetic InAs quantum dots on a GaAs substrate, where the dots had Curie temperatures higher than the room temperature

Who could utilize the results?

The above mentioned results may be useful in novel non-volatile memories or in solid state quantum computers, but of course these applications are far in the future.

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AALTO UNIVERSITY

Faculty of Electronics, Communications and Automation
Department of Micro and Nanosciences

Group name

Micro and Quantum Systems Group

Leader

Prof. Ilkka Tittonen

Special know-how of the group:

- Theoretical skills in quantum optics
- Micro- and nanofabrication
- Clean room use
- Numerical modelling of microsystems

Objectives of the research:

1) International status in the fields of micromechanical applications, optically active biomolecules and micro- and nanofabrication 2) Development of thermoelectric materials and systems

The recent significant results:

1) New fabrication method using focused ion beam and deep reactive ion etch 2) Development of new lasers 3) Development of photoacoustic sensors 4) Coupled micromechanical resonators

Who could utilize the results?

Photoacoustic sensors are already in commercial use, thermoelectric materials will benefit almost any company who wants to convert heat back to electricity, FEM modelling of microsystems will benefit many sensor companies, new fabrication methods make prototyping of some microsystems orders of magnitude faster

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AALTO UNIVERSITY

Faculty of Electronics, Communications and Automation
Department of Micro and Nanosciences

Group name

Fiber Optics Group

Leader

Doc. Hanne Ludvigsen

Special know-how of the group:

The Fiber Optics Group has extensive expertise in optical measurement techniques, spectroscopy, and photonic device construction. The group has made extensive studies of supercontinuum generation in microstructured fibers and is currently developing novel device and sensor applications that are based on the new possibilities offered by these fibers.

The group is located in Micronova, the largest micro- and nanotechnology center in Finland, which provides state-of-the-art fabrication and characterization facilities for modern material science.

Objectives of the research:

1) To develop novel sensor concept based on microstructured optical fibers 2) To design and construct new supercontinuum sources and find new applications for these broadband light sources.

The recent significant results:

1) We proposed a novel surface-plasmon resonance concept based on a microstructured optical fiber coated with a gold layer on the inner surface of the holes.

2) We demonstrated the use of a supercontinuum source in a scanning white-light interferometer to perform 3D profile measurements of a MEMS component.

3) We demonstrated that a hollow microstructured optical fiber filled with a highly nonlinear liquid can support single-mode guiding at wavelengths longer than 600 nm in a 4-µm-diameter liquid core.

Who could utilize the results?

High quality control of MEMS devices
Microelectronics
Biology
Medicine (OCT)

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AALTO UNIVERSITY

Faculty of Electronics, Communications and Automation

Department of Micro and Nanosciences

Group name

Optoelectronics Group

Leader

Prof. Markku Sopanen

Special know-how of the group:

- Epitaxy (growth) of III-V semiconductor layers, device strutures and nanostructures
- Fabrication of optoelectronic components (LEDs, diode lasers, detectors, solar cells, etc.)
- Growth of quantum dot, quantum wire and quantum well structures
- Optical spectroscopy, atomic force microscopy and X-ray diffraction.

Objectives of the research:

1) To improve optoelectronic devices by utilizing new materials and nanostructures 2) To design devices and systems intended for applying optoelectronic devices in biological, chemical and physical measurements.

The recent significant results:

1) Enhancement of visible LED efficiency 2) UV LED matrices for DNA studies

Who could utilize the results?

Companies involved in our TEKES projects. Spin-off companies. Our graduatees.

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AALTO UNIVERSITY

Faculty of Electronics, Communications and Automation
Department of Micro and Nanosciences

Group name

Photonics Group

Leader

Prof. Seppo Honkanen

Special know-how of the group:

- 1) Investigation of the photodarkening effect in Yb-doped fibers
- Integration of Atomic Layer Deposition (ALD) with Si-nanophotonics and studies of Ag nanoparticles embedded in glass
- In general, strong expertise on guided-wave nanophotonics

Objectives of the research:

World-class research on nanophotonics with applications on telecommunications, fiber lasers and guided-wave sensors.

The recent significant results:

1) Photodarkening studies of Yb-doped fibers **2**) Demonstration of Surface Enhanced Raman Scattering (SERS) with Ag nanoparticles partially embedded in glass with an ion exchange process **3**) Integration of ALD-deposited materials with Si-nanoslot waveguides

Who could utilize the results?

The results can be applied in the development of improved fibers for fiber lasers, in novel biosensors and in all-optical devices for telecommunication.

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AALTO UNIVERSITY

Faculty of Electronics, Communications and Automation
Department of Radio Science and Technology

Group name

Artificial electromagnetic materials and applications

Leader

Prof. Sergei Tretyakov

Special know-how of the group:

World-class expertise in the electromagnetic theory, analytical modelling of artificial electromagnetic materials and surfaces including metamaterials and metasurfaces, electromagnetic computations in both radio and optical frequency ranges, microwave, millimeter and submillimeter electromagnetic characterization of natural and artificial material samples, waveguides, antennas and components of wireless techniques. The key personnel of the team is internationally well-known for the books and papers referring to the applied electromagnetics and artificial materials. E.g. "Analytical modelling in applied electro-magnetics" (2003) was the first known monograph where the properties of metamaterials were studied and explained. The leaders of metamaterial research at Aalto University School of Science and Technology are professors Sergei Tretyakov, Constantin Simovski and Dr Igor Nefedov.

Objectives of the research:

Design, realization, and investigations of artificial electromagnetic materials (metamaterials), posessing exotic and useful properties, not available in natural materials. The focus is on metamaterials formed by inclusions on the nanoscale, which could result in innovative collective responses at optical and THz frequencies.

The recent significant results:

New approaches to cloaking of objects from electromagnetic fields, new principles of the design of artificial materials for transformational electromagnetics and optics, compact antennas utilizing artificial magnetic counductors and magnetic nanocomposites, non-reflecting microwave lenses, new principles and devices for sub-wavelength imaging at microwaves, in the THz and optical ranges, new theory of electromagnetic characterization of micro- and nano-structured materials taking in account the resonant properties of constituents, new metamaterials for nanosensing, metamaterial tips for near-field microscopes enabling the field-enhanced Raman scattering and fluorescence.

Who could utilize the results?

Main applications are in the field of nanophotonics, including optical nanoimaging and nanosensing. Medicine, biology, security, space optics and prospective telecommunications systems can benefit from new devices designed in our group and based on metamaterial components.

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AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Biomedical Engineering and Computational

Group name

Engineered nanosystems, BECS

Leader

Prof. Jukka Tulkki

Special know-how of the group:

- Semiconductor optics
- Modeling of electronic structure carrier dynamics in nanostructures
- Device level multiphysics modeling in optoelectronics

Objectives of the research:

To develop generic multiphysics modelling tools for nanometerscale crystals and related optoelectronic and thermophotonic devices.

The recent significant results:

1) Introduction of a new device concept the thermophotonic heat pump 2) Research of drooping in high efficiency LEDs 3) research of quantum trajectory model of photon fields

Who could utilize the results?

Optoelectronics, thermophotonics

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AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Applied Physics

Group name

NanoMaterials Group, NMG

Leader

Prof. Esko I. Kauppinen

Special know-how of the group:

- SWCNT (Single wall carbon nanotube), CNT (Carbon nanotube) and CNB (Carbon nanobud) synthesis
- Optical characterisation (Raman, absorption): 1 Å resolution HRTEM, electron diffraction, EELS; EDS
- Aerosol flow reactors
- Nanoparticle synthesis and measurement
- Manufacturing and characterisation of TFT-FET and transparent electrodes 6) Inhalation drug delivery materials and technologies

Objectives of the research:

1) Develop new carbon nanomaterials (SWCNTs, CNB) -synthesis, structure characterisation and transparent, flexible electronics applications (transparent conductors, TFT-FETs, field emission sources) **2**) Develop novel drug delivery technologies (inhalation, injection) based on nanoparticles as well as on nanostructured microparticles

The recent significant results:

1) World record conductivity transparent flexible electrode based on SWCNTs: sheet resistance 40 ohms/sq when transparency 80 % (compare to best graphene which has 10 times lower conductivity with similar transparency) i.e. better than ITO on polymer **2**) Flexible, transparent TFT-FETs with both electron and hole mobilities better than those of best organic thin film TFTs and which are much more stable **3**) Lithograhy free manufacturing of SWCNT TFT-FETs **4**) Method to manufacture free standing SWCNT films which are transparent and highly conductive, can be used e.g. as loadspeaker and are excellent nanoparticle filters **5**) Method to produce N-doped SWCNTs - SWCNTs with extremely high crystallinity as verified by STM and HRTEM **6**) Electron diffraction method to determine chirality of SW, DW, and TWCNTs **7**) Peptide coated, easily flowable microparticles for inhalation delibvery of drugs & related manufacturing method **8**) Novel, simple method to grow metal oxide nanowires **9**) Novel CNT-cement hybride material for the production of super-strong, electrically conductive concrete **10**) Temperature dependent Raman studies of SWCNT and CNBs **11**) Simulataneous HRTEM, ED and Raman studies of an individual carbon nanobud (CNB)

Who could utilize the results?

Transparent electrodes and transistors have billion eur + markets in e.g. e-paper, flexible displays, touchscreens, haptic user interfaces, solar cells etc. TKK spin-off Canatu is commercialising these technologies Peptide coated drug particles have billion level end markets in the fields of both local (asthma, COPD) as well as systemic (e.g. insulin, pain killers) drug delivery systems. TKK spun off Teicos Pharma Oy to commercialise the technology developed at NMG.

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AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Applied Physics

Group name

Multiscale Statistical Physics Group

Leader

Prof. Tapio Ala-Nissilä

Special know-how of the group:

Theoretical and computational multi-scale and coarse-graining methodologies; various simulation methods on all scales from nano to macro.

Objectives of the research:

Theoretical and computational multi-scale modeling of micro- and nanosystems, and their application in thin films, surface coatings, microfluidistics, and controlling microstructure of materials (metals and polymers).

The recent significant results:

1) Development of a new method to model multiphase flows in microchannels 2) Construction of a computationally efficient model for water molecules 3) Construction of a computationally efficient model for the study of microstructures in metals 4) Unraveling the influence of various physical parameters (such as polymer-pore interactions) on the translocation dynamics of DNA through nanopores

Who could utilize the results?

Coating industries, lab-on-a-chip technology, microcircuit cooling

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AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Applied Physics

Group name

Nanomagnetism and Spintronics

Leader

Prof. Sebastiaan van Dijken

Special know-how of the group:

The NanoSpin Group has an extensive expertise in thin film and multilayer growth, nanoscale device fabrication, and structural, magnetic, and ferroelectric characterization. The experimental infrastructure consists of a pulsed-laser deposition system for high-quality multilayer oxide growth, a multi-target magnetron sputtering system with in-situ patterning capability, and several dedicated setups for magnetic, ferroelectric, and magnetotransport analysis. Besides, the group utilizes state-of-the-art equipment at the Micronova cleanroom (lithography) and the recently established Nanomicroscopy Centre.

Objectives of the research:

The Nanomagnetism and Spintronics (NanoSpin) Group focuses on the experimental investigation and utilization of magnetic phenomena and spin transport in new functional materials and hybrid nanoscale structures. Current projects include studies on magnetoelectric coupling in ferromagnetic/ferroelectric thin film composites, tunnel junctions with active tunnel barriers, current-induced spin-torque switching in MgO-based magnetic tunnel junctions, and high-speed domain wall dynamics.

The recent significant results:

1) Strong magnetoelectric coupling in hybrid BaTiO3/thin magnetic film structures **2**) Fabrication of all-oxide tunnel junctions with magnetic and ferroelectric functionality **3**) Current-induced magnetic switching in nanopillar tunnel junctions with ultrathin MgO barriers **4**) Development of a new method based on magneto-optics for studying dynamic domain wall motion in thin magnetic films

Who could utilize the results?

The application areas of our research include magnetic sensors, magnetic and ferroelectric storage, and tunable microwave device technology.

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AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Applied Physics

Group name

Quantum Dynamics

Leader

Prof. Päivi Törmä

Special know-how of the group:

- Nanoelectronics and nanofabrication
- Plasmonics
- Many-body quantum physics, analytical and numerical methods

Objectives of the research:

1) Nano- and molecular electronics 2) Programmable materials, especially DNA self-assembly 3) Plasmonics and nanophotonics 4) Theory research on many-body quantum physics

The recent significant results:

The titles of the latest articles are good examples of the latest results: 1) Field induced nanolithography for high-throughput pattern transfer 2) Fermi Condensates for Dynamic Imaging of Electromagnetic Fields 3) Hopping modulation in a one-dimensional Fermi-Hubbard Hamiltonian 4) High speed memory from carbon nanotube field-effect transistors with high-K gate dielectric 5) Vacuum Rabi splitting and strong coupling dynamics for surface plasmon polaritons and Rhodamine 6G molecules 6) Induced interactions for ultra-cold Fermi gases in optical lattices 7) DNA origami as a nanoscale template for protein assembly 8) Spectral signatures of the Fulde-Ferrell-Larkin-Ovchinnikov order parameter in one-dimensional optical lattices 9) Dielectrophoretic Trapping of DNA Origami

Who could utilize the results?

In nanodevices using carbon nanotubes (the carbon nanotube memory), in assembly of nanodevices (the work on DNA origami), and in coherent plasmonics (the work on Rabi splitting).

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AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Applied Physics

Group name

New Energy Technologies

Leader

Prof. Peter Lund

Special know-how of the group:

- Material, characterization and device know-how on solar cells and fuel cells
- Nanomaterial integration into energy deviced

Objectives of the research:

1) Nanoscience and nanotechnology integration into energy applications **2**) Future energy technologies such as fuel cells and solar energy

The recent significant results:

1) Nanosolar cells on flexible substrates (dye sensitized nanostructured TiO_2 cell) **2**) Scaling up of laboratory solar cells into a technology scale **3**) Nanotechnology enhanced thin solar cells

Who could utilize the results?

Small scale energy applications, mobile and portable power production Solar energy applications, built

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AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Applied Physics

Group name

Computational Soft Matter Research Group

Leader

Academy Research Fellow Emppu Salonen

Special know-how of the group:

The group's expertise lies in molecular modeling of carbon-based nanomaterials (fullerenes and carbon nanotubes; both pristine and functinalized) and biological systems. The methods used range from ab initio quantum chemistry calculations to classical atomistic and coarse-grained molecular dynamics simulations.

Objectives of the research:

1) Provide insight on the basic interactions between carbon-based nanomaterials and biological macromolecules, such as proteins/peptides, nucleic acids, lipids, and carbohydrates. 2) Assess the solubilization, transport, and uptake mechanisms of nanomaterials in laboratory conditions as well as in the environment (especially natural water sources). 3) Develop novel methods for simulations of nanomaterial-biomaterial interactions.

The recent significant results:

Together with our experimental colleagues at Clemson University (SC, USA), we characterized the solubilization of fullerenes C_{70} by gallic acid (GA), a phenolic acid that is commonly found in plants. This was followed by exposing live human tumor cells to the GA-solubilized fullerene clusters, resulting in rapid cell death. Another study with the same experimental collaborators demonstrated the inhibition of DNA polymerase reaction by the water-soluble fullerene derivative $C_{60}(OH)_{20}$. This was concluded to result from the direct interaction of $C_{60}(OH)_{20}$ with the polymerase enzyme. A detailed investigation to uncover the mechanism of enzyme inhibition at the atomic scale is now in progress. In addition to applications, the group has worked on the development of state-of-the-art models of fullerenes and fullerene derivatives to be used in classical molecular dynamics simulations.

Who could utilize the results?

The group's focus is on basic research related to nanomaterial-biomaterial interactions. The aim is to provide complementing insight on systems and processes studied in experiments, and to motivate further experimental work on topics that have been first investigated in modeling studies.

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AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Applied Physics

Group name

Quantum Computing and Devices

Leader

Dr. Mikko Möttönen

Special know-how of the group:

- Theory of quantum systems
- Nanoelectronic devices
- Josephson devices
- Experimental low-temperature physics

Objectives of the research:

We study fundamental quantum mechanical phenomena in nanoscale systems and aim to use them in practical applications such as quantum bits, current sources, and microwave detectors.

The recent significant results:

1) Demonstration of a single-electron turnstile for quantum metrology 2) Experimental determination of the Berry phase in a superconducting charge pump 3) Suggestion for experimental realization of Dirac monopoles 4) Demonstration of a single-atom transistor.

Who could utilize the results?

Redefinition of the international system of units (SI), fundamental knowledge of Nature, and emerging computational devices.

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AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Applied Physics

Group name

Molecular materials/Ruokolainen

Leader

Prof. Janne Ruokolainen

Special know-how of the group:

- High resolution microscopy for soft materials
- Self assembly materials

Objectives of the research:

1) Develop new functional materials and smart materials. Currently the main focus is in responsive materials such as hydrogels and vesicular structures e.g. for drug delivery applications We use polymers, liquid crystals, polypeptides, electrospun nanofibers, aerosol polymer nanoparticles as structural units in supramolecular assemblies. 2) Second objective is to set up experimental facilities for high resolution microscopy characterization and especially cryo electron microscopy for materials science applications.

The recent significant results:

Development of new self-assembly materials based on dendron and dendrimer supramolecular liquid crystals

Who could utilize the results?

Scientific community

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AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Applied Physics

Group name

Optics and molecular materials

Leader

Acad. Prof. Olli Ikkala

Special know-how of the group:

Learn from biological material to obtain new extraordinary materials properties

Objectives of the research:

Biomimetic and functional materials based on self-assemblies

The recent significant results:

1) Steel-strong nanostructured materials based on biological concepts 2) New biological concepts for self-propulsion of miniaturized devices 3) New self-cleaning surfaces 4) Functional material based on nanocellulose 5) Metal nanoclusters for sensing and diagnostics

Who could utilize the results?

Lightweight but strong construction for telecommunication and other constructs, coating industry

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AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Applied Physics

Group name

Biological Physics group

Leader

Prof. Ilpo Vattulainen

Special know-how of the group:

Multi-scale modeling of biological matter, including quantum-mechanical, atomistic classical and coarse-grained modeling of biological systems.

Objectives of the research:

The group focuses on the theory and modeling of biologically relevant soft and condensed matter systems. The research includes the development of theoretical and computational techniques for coarse graining and multiscale modeling, the development of force fields for atomistic simulations of biological matter, and applications of these methods to study physicochemical properties of biological systems over a multitude of scales in time and space. The area of research covers lipid membranes (as well as interactions of these systems with e.g. drugs, alcohols, and sterols), drug delivery, nanomaterials, structure and dynamics of protein-membrane complexes, lipoproteins, glycosystems, and nanocellulose.

The recent significant results:

1) Structure of lipid rafts **2**) Structure of lipoproteins **3**) Atomistic models for nanocellulose **4**) Determination of activation mechanisms for membrane proteins **5**) Determination of nanomaterial induced cell death.

Who could utilize the results?

Understanding of the mechanisms of nanomaterial-induced cell death allows better design of safer nanomaterials. Development of functionalized nanocellulose paves way for novel nanomaterials with user-tuned properties. Understanding of ways to govern protein activation and functionality allows the design of biological nanoengines, for example, as biosensors. Determination of lipoprotein structures and their functions allows one to better understand why and how cardiovascular diseases emerge, and to find means to treat these diseases.

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AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Applied Physics

Group name

Surface Science Group

Leader

Doc. Jouko Lahtinen

Special know-how of the group:

Structural and chemical characterization of solid surfaces using ultra high vacuum techiques like XPS, LEED and STM

Objectives of the research:

1) To understand adsorption on atomic level on some catalytic processes 2) To understand and model adhesion processes 3) To build up a model for light emission in Si nanocrystals

The recent significant results:

Showing how an increase in the surface roughness decreases adhesion in general and especially on medically used salbutamol sulfate particles

Who could utilize the results?

Our results will be useful for researchers who work closer to the industrial applications.

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AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Applied Physics

Group name

Electronic properties of Materials / COMP

Leader

Prof. Martti Puska

Special know-how of the group:

First-principles electronic structure calculations on the atomistic scale. Longer length and time scales are modeled by methods such as the lattice kinetic Monte Carlo.

Objectives of the research:

Modeling of materials and nanostructures on the basis of first-principles electronic-structure calculations. The modeling includes properties and phenomena. Electronic (including e.g. those of defects in semiconductors and electron transport through nanostructures), mechanical and optical properties are considered. Time-dependent (non-adiabatic) phenomena in nanostructures are modeled.

The recent significant results:

1) Modeling of electronic properties of defects and interfaces in semiconductor materials including Si, GaAs, GaN, InGaN, ferroelectric materials, and transparent conducting oxides 2) Modeling of novel carbon materials: nanotubes, graphene etc. 3) Development and implementation of first-principles electronic-structure methods: Time-dependent density-functional theory, van der Waals density functional, application of the finite element method in electronic-structure calculations

Who could utilize the results?

Design of materials and systems for nanoelectronics

Contact

Prof. Martti Puska (martti.puska(a)tkk.fi)
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In addition to the mentioned leader, the research profile includes the research of:

prof. Antti-Pekka Jauho

AALTO UNIVERSITY

Faculty of Information and Natural Sciences
Department of Applied Physics

Group name

COMP

Leader

Prof. Risto Nieminen

Special know-how of the group:

Theory, modelling and simulation of nanomaterials, processes and devices

Objectives of the research:

Center of Excellence in Computational Nanoscience consists of 7 research groups: - Electronic Properties of Materials (**Prof. Puska**) - Surfaces and Interfaces at the Nanoscale (**Prof. Foster**) - Quantum Many-Body Physics (**Dr. Harju**) - Multiscale Statistical Physics (**Prof. Ala-Nissilä**) - Complex Materials and Systems (**Prof. Alava**) - Biological Physics (**Prof. Vattulainen**) - Quantum Computing and Devices (**Dr. Möttönen**)

The recent significant results:

1) Basic-research publication activity, method development, researcher training, visitor program, workshop program **2**) Nanostructured carbon materials and devices, nanoscale ferroelectricity, oxide materials
3) Interpretation of scanning-probe microscopies **4**) Membrane biophysics **5**) Physical realisations for quantum computing

Who could utilize the results?

Applications in functional materials for sensors and other devices -Interpretation of various nanoscale characterisations -Switching and memory elements in nanoelectronics

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AALTO UNIVERSITY

Faculty of Engineering and Architecture
Department of Engineering Design and Production

Group name

Engineering materials

Leader

Prof. Hannu Hänninen

Special know-how of the group:

- Synthesis of metal and oxide nanocomposites of CNTs and CNFs (Carbon nanofibers) using electroless methods
- Mechanical testing of engineering materials and strain localization studies using in-situ loading equipment in FEG-SEM
- Optical strain measurement
- Modelling of load transfer and strain accomodation at the interfaces
- Anelasticity of nanocomposites.

Objectives of the research:

CNT- (Carbon Nanotube) metal and CNT-oxide nanocomposites: synthesis, characterisation and modelling

Who could utilize the results?

Machine construction

Contact

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AALTO UNIVERSITY

Faculty of Engineering and Architecture

Department of Structural Engineering and Building Technology

Group name

Nanomaterials in building technology

Leader

Prof. Vesa Penttala

Special know-how of the group:

Production of carbon nanotube concrete composites.

Objectives of the research:

To improve the properties of building materials by modifying their microstructure by carbon nanofibers or by carbon nanotubes.

The recent significant results:

The compressive strength of the carbon nanotube concretes was improved to nearly double value in comparison with the reference concrete. The electrical resistivity was lowered by on order of magnitude classifying this material as a semiconductor.

Who could utilize the results?

If the mass production of these new carbon nanotube modified cements can be innovated, it benefits the whole concrete industry.

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AALTO UNIVERSITY

Independent Institutions
Low Temperature Laboratory

Group name

NANO-group

Leader

Prof. Pertti Hakonen

Special know-how of the group:

Microwave measurements at millikelvin temperatures

Objectives of the research:

The research work of the NANO group is focused on three areas: **1**) Mesoscopic quantum amplifiers and qubits, **2**) Quantum transport in carbon nanotubes and graphene, and **3**) Current fluctuations and fast dynamics in quantum circuits.

The recent significant results:

Noise characterization of ballistic graphene at GHz frequencies

Who could utilize the results?

The scientific community working on graphene devices

Contact

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AALTO UNIVERSITY

Independent Institutions
Low Temperature Laboratory

Group name

PICO-group

Leader

Prof. Jukka Pekola

Special know-how of the group:

- Physics of single-electron tunneling
- Superconducting nanostructures
- Quantum nanoelectronics
- Electron-beam lithography
- Low temperature techniques.

Objectives of the research:

We aim at understanding the physics of quantum nanostructures at low temperatures. In particular we focus on single-electron tunneling and heat transport properties in superconductors, normal metals and in hybrids of them. We are developing quantum metrological standards for electric current and for thermometry based on single-electron tunneling.

The recent significant results:

1) Hybrid single-electron turnstile as a source of quantized electric current 2) Measurement of the quantum of heat conductance

Who could utilize the results?

In metrology and eventually in the system of units. In the work of other scientists in related fields.

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AALTO UNIVERSITY

Department of Marketing and Management
Organization and Management

Group name

Research group on nanotechnology business

Leader

Dr. Nina Granqvist

Special know-how of the group:

The members of the group have a wide understanding on the dynamics of emergence of novel businesses and industries. The research group members have conducted close to 150 interviews with the key stakeholder in the field both in the Nordic Countries and Silicon Valley. Other data includes a major database on news stories on nanotechnology, both publicly and privately accessible reports, and scientific articles on nanotechnology.

Objectives of the research:

The aim of the research conducted in this group is to understand how nanotechnology contributes to the emergence of novel business activities and to the renewal of existing industries. The research ranges from studying the local local emergence of new scientific and commercial activities, to investigating the origins and processes that induce technology hypes, and to understanding executives' decisions to engage with novel technologies.

The recent significant results:

n.a.

Who could utilize the results?

n.a.

Contact

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Group name

Length group - Dimensional nanometrology

Leader

Dr. Antti Lassila

Special know-how of the group:

- Interferometry
- Scanning probe microscopy
- Error sources of SPM measurements
- Laser diffractometry
- Measurement instrument implementation
- Quantitative measurements

Objectives of the research:

1) Establish traceability chain for realization and transfer of the metre for nanometer scale instruments.
2) Develop facilities to provide traceable calibrations of transfer standards useable for calibration of lateral and vertical microscope scales. 3) Study phenomenon e.g. probe-sample interaction which affect to accuracy of microscopic measurements. 4) Study methods for calibration of Scanning probe microscopes (SPM). 5) Study improved techniques for realization of length in sub-nanometer scale by means of refined interferometry and advanced capasitive position sensors.

The recent significant results:

1) Implementation of interferometrically traceable SPM with sub-nanometer accuracy for transfer standard calibrations. 2) Excellent results in international comparison EURAMET # 925 piloted by PTB. 3) Implementation of laser diffractometer for grating pitch calibration with 10 picometer standard uncertainty.

Who could utilize the results?

These result can be applied by using calibration services for transfer artifacts. MIKES is now capable to calibrate flatness standards, step height standards, 1-D and 2-D gratings at best international level. SPM user can guarantee or test measurement capability of his instrument by performing its calibration with traceably calibrated transfer artifacts. All research groups and companies in Finland with nanoscale instruments can benefit from this work by improved quality of the measurements after calibration.

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Group name

Thermal and Mass Quantities

Leader

Dr. Martti Heinonen

Special know-how of the group:

- Measurement standards
- Traceability
- Evaluation of uncertainty
- Flow, temperature and mass measurements
- Design and validation of humid gas generators

Objectives of the research:

1) To establish traceability to number concentration measurements 2) To improve understanding on the limitations of the filter based particle mass measurement methods 3) Advance the understanding on particle/vapour interaction at different ambient conditions to gain progress in mass measurement

The recent significant results:

n.a.

Who could utilize the results?

n.a.

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Group name

Electricity Group

Leader

Dr. Antti Manninen

Special know-how of the group:

- Traceable and accurate electrical measurements both at room temperature and at cryogenic temperatures down to 15 mK 2) Measurement standards including quantum standards

Objectives of the research:

Nanoelectronics: Application of nanoelectronic phenomena in electrical metrology

The recent significant results:

Experimental demonstration of 100 pA quantized current generated by a quantum current standard based on a nanoelectronic superconductor - normal metal hybrid single electron transistor (in collaboration with the Low Temperature Laboratory of TKK).

Who could utilize the results?

New definitions of SI units will be based on fundamental constants of Nature, and after that the traceability of all electrical measurements will be based on quantum standards. Reliable and traceable measurement of very low currents is needed, e.g., in radiation detection and optical measurements.

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Group name

SYKE nanotechnology and environment

Leader

Dr. Markus Sillanpää

Special know-how of the group:

- Aquatic and terrestrial toxicity tests including (but not limited to) luminescent bacteria toxicity test, Daphnia magna acute and chronic toxicity, green algae growth inhibition, Lemna minor growth inhibition, zebra fish egg-larvae test, biochemical methods (EROD activity, vitellogenin induction), seed germination and soil invertebrates
- Development of analytical and characterisation methods such as dynamic light scattering for size and agglomeration characterisation and ICP techniques for the quantification of nanomaterials and elemental impurities
- Regulatory and harmonisation work in relation to nanomaterials (OECD/WPMN, REACH)
- Nanomaterials and environmental governance: innovation management, public engagement, emerging private - public relationships.

Objectives of the research:

Our research focuses on:

- The fate of nanomaterials in natural waters
- Bioaccumulation and effects of nanomaterials in the species of different trophic levels and
- Environmental regulation.

The recent significant results:

The group has recently studied the fate of titanium dioxide and silver nanoparticles in natural fresh and brackish waters. The measurement methods have been developed for the characterization of above-mentioned nanomaterials at the various stages of effect studies. The group has also made a review of the social scientific literature focusing of nanotechnology and nanomaterials.

Who could utilize the results?

There are a number of gaps in basic knowledge on the environmental impacts of nanomaterials. The results can be applied in risk assessment and management of nanomaterials.

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Group name

Nanosafety Research Consortium

Leader

MD, Prof. Kai Savolainen

Special know-how of the group:

Aerosol physics, Engineering, Occupational hygiene, Particle characterization by using both imaging and non-imaging techniques, A large variety of expertise for assessment of work place or exprerimental exposures, genetic toxicology, cell biology, molecular biology, proteomics, genomics, allergy and immunology, immunotoxicology, animal care, cell culture techniques, medicine, risk assessment

Objectives of the research:

1) Characterization of engineered nanomaterials (ENM) commonly occuring in occupational environments **2**) Developement of characterization techniques **3**) Assessment of exposure at workplaces and exposure modelling **4**) Development of exposure models for experimental research **5**) Research on health effects of ENM with a focus on in vivo and in vitro effects of different types of ENM on genotoxicity and immunotoxicity.

The recent significant results:

1) Several peer reviewed papers on dispersion of ENM is aquaeous media (e.g. TiO_2) **2**) Several peer reviewed papers on gentoxicity of ENM (e.g. TiO_2, single and multi walled carbon nanotubes) **3**) Several papers on immunotoxicity and allergies of ENM (TiO_2)

Who could utilize the results?

In risk assessment and governance of these materials - As a basis for recommendations for regulators and companies and workplaces - As a basis for education of the public at large - Scientific community

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Group name

Aerosols and climate

Leader

Doc. Heikki Lihavainen

Special know-how of the group:

- Aerosols and their effect to climate
- Formation of aerosols 3) Thermodynamical properties of compounds and mixtures affecting to homogeneous and heterogeneous nucleation

Objectives of the research:

The objective of the research is to answer following questions:

- What is the direct radiative forcing in our environment?
- How does pollution in the atmosphere affect to the properties of clouds and indirect radiative forcing in northern latitudes?
- What is the ratio between direct and indirect forcing in our environment?
- What is the role of human activities to the radiative forcing by aerosols in our environment?

The recent significant results:

- We showed that with sulfur acid the new particle formation events can be explained.
- We also studied extensively the very basics steps of the first order phase transition from vapor to liquid.

Who could utilize the results?

Results can be applied in formation of particles or aerosol with wanted composition. Results can also be applied in climate studies through new parametrization of atmospheric new particle formation events.

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Group name

Nanowaste

Leader

Project Manager Åke Jåfs

Special know-how of the group:

We are specialised in handling of nanowaste.

Objectives of the research:

The objectives of the project are:

- To clarify what processes are used to recycle or destruct waste containing nanomaterials
- To present solutions in some special cases -to evaluate the feasibility of methods/processes, costs and profitability In some special cases -to clarify the status of the legislation in EU and Finland
- To give information and recommendations for the REACH legislation
- To support recycling and waste handling companies -to inform nanomaterial producing companies about coming directives

The recent significant results:

Our project started 01.01.2011.

Who could utilize the results?

The results can be used by recycling and waste handling companies.

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Project Manager Åke Jåfs (Ake.jafs@ketek.fi)
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Group name

Laboratory of Green Chemistry

Leader

Prof. Mika Sillanpää

Special know-how of the group:

- Development of functionalized adsorbents
- Development and testing of nanostructured adsorbents
- Study of low-cost adsorbents
- Modeling of adsorption isotherms and kinetics
- Synthesis of nano/micro structured semiconductor materials for the photocatalytic water treatment
- Photocatalysis under UV/visible LED-lights
- Electrochemical water treatment
- Development of novel electrode materials for environmental analysis
- IMS research

Objectives of the research:

The objectives of our research are to develop new, effective, and environmentally benign processes for the water treatment as well as water analysis. In the water treatment the one of the aims is to develop novel adsorption (nanosized) materials and photocatalysts for remediation and degradation of water pollutants. In analysis, development of novel electrode materials is of interest.

The recent significant results:

- Arsenic adsorption by Maghemite and Crystal y-Fe2O3 nanoparticles
- LED-lights in degradation of phenols and disinfection
- Development of cellulose nano fibril based thin film electrodes
- Water purification using magnetic assistance
- Greener synthesis of silver and gold nanoparticles
- DNA modified carbon nanofiber electrodes
- Nanostructured CdS and In2S3 microspheres and their photocatalytic activity
- Nanopowders of iron and iron nickel in magnetic assisted water treatment
- Capture of Co from aqueous Co-EDTA complex by functionalized silica gel and chitosan
- Degradation of dyes under visible-LED radiation using CdS based catalysts

Who could utilize the results?

Applications of the research results are in industrial sector as well as in domestic water treatment

Contact

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Group name

ASTRaL

Leader

Prof David Cameron

Special know-how of the group:

- Thin film deposition. mainly atomic layer deposition but also magnetron sputtering.
- In materials: deposition on polymers, barrier layers, photocatalytic materials.

Objectives of the research:

To develop new thin film and nanomaterial technologies

The recent significant results:

Development of a continuous atomic layer deposition process for moving flexible substrates.

Who could utilize the results?

This is the forerunner of a roll-to-roll atomic layer deposition process which is now under development.

Contact

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Group name

Laboratory of Membrane Technology and Technical Polymer Chemistry

Leader

Prof. Mika Mänttäri

Special know-how of the group:

- Separation phenomena in membrane filtration e.g. in nanofiltration
- Fouling in molecular level and know-how in fouling prevention
- Characterisation of surfaces (e.g. surface charge, hydrohilicity)

Objectives of the research:

- To develop fractionation technologies for nanosized molecules
- To improve separation efficiency by utilising nanoparticles with membrane materials
- To use nanoparticles in green chemistry

The recent significant results:

- Improved fractionation efficiency of nanosized molecules in biorefineries and food industry.
- Green cleaning of membranes

Who could utilize the results?

- Generally, companies who are using membranes in their processes can benefit on the improved knowledge related to separation and fouling phenomena.
- Biorefineries benefit on the results when valuable compounds are recovered and purified.

Contact

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Group name

Oulu University of Applied Sciences

Leader

Project Manager Antti Berg

Special know-how of the group:

- Printed electronics
- Biochemistry.

Objectives of the research:

Development of electrochemical biosensors using printed technology

Set up a small scale printed electronics manufacturing laboratory

Create a multi area know-how subcontractor network of research organizations and companies

The recent significant results:

- Participation in developing the Printocent community in Oulu region
- PrinDemo project demonstrators.

Who could utilize the results?

Companies have the opportunity to create demonstrators which can be used to test the readiness of technologies and to evaluate their potential for industrial production.

Contact

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Group name

Micro- and Nanosystems

Leader

Prof. Pasi Kallio

Special know-how of the group:

- Micro- and nanorobotics
- Microfluidics
- Automation in micro- and nanoscale.

Objectives of the research:

To develop automatic and autonomous systems which allow handling and characterization of micro- and nanoscale objects and samples. Currently, our focus is on stem cells, paper fibers and blood drops.

The recent significant results:

- Miniaturised cell cultivation environment for stem cells
- Mechanical stimulation system for cardiac cells
- Automatic microrobotic platform for handling and characterization of individual paper fiber bonds
- Biomolecule compatible lab-on-chip production technologies

Who could utilize the results?

- Miniaturised cell cultivation environment for stem cells
- Mechanical stimulation system for cardiac cells
- Automatic microrobotic platform for handling and characterization of individual paper fiber bonds
- Biomolecule compatible lab-on-chip production technologies

Contact

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Group name

Biological Physics Group

Leader

Prof. Ilpo Vattulainen

Special know-how of the group:

Multi-scale modeling of biological matter, including quantum-mechanical, atomistic classical and coarse-grained modeling of biological systems.

Objectives of the research:

The group focuses on molecular simulations, modeling, and theory of biologically relevant soft and condensed matter systems. The research includes the development of computational and theoretical techniques for coarse graining and multiscale modeling, the development of force fields for atomistic simulations of biological matter, and applications of these methods to study physicochemical properties of biological systems over a multitude of scales in time and space. The area of research covers membrane proteins and receptors, lipid membranes (as well as interactions of these systems with e.g. drugs, alcohols, and sterols), drug delivery, nanomaterials, lipoproteins, glycosystems, and application-driven soft materials such as drugs and nanocellulose.

The recent significant results:

- Structure and dynamics of lipid rafts
- Understanding how lipids control the function of membrane proteins and membrane receptors
- Structure and dynamics of lipoproteins
- Atomistic models for nanocellulose
- Determination of nanomaterial induced effects such as cell death.

Who could utilize the results?

Understanding of the mechanisms of nanomaterial-induced cell death allows better design of safer nanomaterials. Development of functionalized nanocellulose paves way for novel nanomaterials with user-tuned properties. Understanding of ways to govern protein activation and functionality allows the design of biological nanoengines, for example, as biosensors. Determination of lipoprotein structures and their function allows one to better understand why and how cardiovascular diseases emerge, and to find means and drugs to treat these diseases.

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Group name

Materials and Molecule Modeling

Leader

Dr Jaakko Akola

Special know-how of the group:

- Massively-parallel density functional simulations (electronic structure) in combination with molecular dynamics.
- Primary field: Chalcogenide alloys (phase change materials), amorphous structure, physical properties, and re-crystallization processes.

Objectives of the research:

We perform computer simulations and materials/molecule modeling at atomistic level for relevant systems in nanotechnology. The leading principle is to study the atomic structure (+ electronic properties) in order to understand the function of a system. The group has strong international connections with experimentalists (Japan, USA, UK) and national collaborations with the University of Jyväskylä (Nanoscience Center).

The recent significant results:

- CO oxidation and catalytic properties of Au nanoparticles
- Atomic structure of lead silicate glasses
- STM effects on potassium islands on graphite/graphene and STM effects
- GST alloys (phase change materials) used in optical recording and non-volatile computer memory

Who could utilize the results?

Our work is basic research that has a close connection with real applications. Au nanoparticles are studied extensively and they are prepared via chemical synthesis. Our results give insight about the atomic, electronic and catalyticalytical properties of these technologically important systems. The studies on glass structure are important for the glass industry. Our projects involve experimental partners who have close connections to the Japanese glass industry (e.g. Hoya). Alkali-graphite/graphene systems are important for future nanoelectronics and they are currently being used in batteries. Our studies with the experimental partners (STM) provide basic knowledge of the physical and chemical properties of these systems. The GST alloys are being used in DVD-RAM, DVD-RW, and Blu-ray Discs, and they have wider applications in the future non-volatile computer memory. Our collaboration with the Japanese experimentalists and Panasonic has unravelled the atomic structure of the amorphous phases and provided crucial understanding of the remarkable re-crystallization properties of these materials. One has a better understanding of the data storing/erasing process.

Contact

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Group name

Nanophotonics and application, Optoelectronics Research Centre

Leader

Prof. Tapio Niemi

Special know-how of the group:

- Applications of nanoimprint lithography to fabricate semiconductor components.
- Using lasers to modify surfaces and to fabricate nanomaterials.

Objectives of the research:

We carry out applied and theoretical research on nanophotonic structures and develop novel nanofabrication methods. Our research includes the fields of plasmonics, metamaterials, resonant nanostructures and fabrication of nanoparticles.

The recent significant results:

- Further optimization of nanoimprint lithography for various applications.
- Resonant waveguide gratings for nonlinear optics and broadband reflectors.
- Development of nanoparticle production by laser ablation.

Who could utilize the results?

We aim to develop nanoimprint as a production tool for semiconductor devices. For the nanoparticle research we seek actively applications and networking in three sectors:

- Sustainable energy; including possibilities in solar energy conversion, batteries, super-capacitors and fuel cells.
- Biotechnology; including nano-biomarkers and biosensors.
- Environmental monitoring; including nanocrystal photodetectors and lightsources, gas sensing, nanostructure enhanced catalysis and nanoplasmonics.

Contact

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Group name

Optics Laboratory

Leader

Professor Martti Kauranen

Special know-how of the group:

- Martti Kauranen: Nonlinear characterization of surfaces, thin films, nanostructures, and bulk materials
- Goëry Genty: Nonlinear propagation of ultrafast pulses in waveguides and fibers
- Juha Toivonen: Optical spectroscopy and microscopy

Objectives of the research:

- Martti Kauranen: Engineered nanostructures for nonlinear optics. Nonlinear techniqus for nanostructures and imaging
- Goëry Genty: Nano-scale waveguide engineering and metal-glass nano- composites
- Juha Toivonen: Nano-scale optical imaging and lithography

The recent significant results:

- Martti Kauranen: Key understanding of nonlinear properties of metal nanostructures, unambiguous separation of surface and bulk effects to second-order nonlinear response
- Goëry Genty: Carrier-phase dynamics in silica nanowires
- Juha Toivonen: Diffraction unlimited resolution in localization microscopy using quantum dots

Who could utilize the results?

- Martti Kauranen: Basic research, which is expecetd to lead to new materials and optical measurement techniques
- Goëry Genty: Frequency-comb characterization
- Juha Toivonen: Nano-scale resolution in optical imaging

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Group name

Surface Engineering Research Group

Leader

Prof. Petri Vuoristo

Special know-how of the group:

- Process-structure-property-performance relationships of protective and functional coatings and surface treatments.
- Advanced materials processing for coating production, characterisation of the coatings, properties of coatings, and industrial applications.

Objectives of the research:

Research and development on engineering surfaces and coatings based on advanced coating materials and processes. The research is particularly done in the field of thermal coating processes, which includes thermal spray and laser surface treatments. Coating and surface treatments involves mainly protective and functional surfaces. Furthermore, surface engineering research is done in the field of thin film technologies. In this area the research is focused at the moment in solar heat absorber surfaces and their properties.

The recent significant results:

- Novel nanostructured coatings materials and processing these to high-end application purposes by thermal spray (powder and suspension processing)
- Laser surface treatments (novel laser cladding processes with very high power levels).

Who could utilize the results?

Manufacturing industries from very different industrial sectors.

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Group name

Supramolecular Photochemistry

Leader

prof. Helge Lemmetyinen

Special know-how of the group:

- Planning and synthesis of complex organic compounds and structures, with photo- electroactive properties, by synthetic chemistry and creating desired structural complexities by self-assembling and self-organization of smaller units with and without the help of chemical bonds.
- Optical spectroscopy characterization of compounds and nanostructures, including ultrafast time resolved spectroscopy and fluorescence lifetime microscopy.
- Organic photovoltaics, device fabrication and investigation.

Objectives of the research:

The Research and Strategy of the Group is fundamental study of the photochemistry occurring in solutions and in artificial or self-assembled molecular systems. The key issues are the discovery and development of new materials with desired properties. Systems of interest include molecules capable of transmitting energy, charge or electrons, materials exhibiting electrical conductivity, molecules with unusual optical properties, and structures with optical information storage and processing capability. We are developing and investigating of photo- and electroactive organic and hybrid organic-semiconductor nanostructures for applications in optoelectronics and nanophotonics.

The recent significant results:

Design and synthesis of donor-acceptor dyads in particular porphyrin- and phthalocyanine-fullerene dyads with efficient electron transfer properties.

Who could utilize the results?

- Organic photovoltaics
- Molecular sensors.

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Group name

Semiconductor Technology, Optoelectronics Research Centre

Leader

professor Jyrki Vuorinen

Special know-how of the group:

Processing of polymeric nanocomposites by using single screw extrusion, twin screw extrusion, injection molding, high shear mixing and ultrasonication.

Objectives of the research:

To achieve well descriped dispersion of various nanoparticles in mostly polyolefin, polyamides and epoxy matrices.

The recent significant results:

Processing of layered nanocomposites using ALD coated polyamide and polystyrene microgranulates (coated by Beneq) by twin screw extrusion and measuring the propeties of these nanocomposites.

Who could utilize the results?

These results can be used in production of tailored nanocomposites where the nanoparticle range is not restricted by the availability of nanoparticles but the particles can be processed in wide range of chemistry by using ALD.

Contact

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Group name

Semiconductor Technology, Optoelectronics Research Centre

Leader

Prof. Mircea Guina

Special know-how of the group:

- Molecular Beam Epitaxy of III-V compounds
- Characterization of semiconductor nanostructures
- Processing of optoelectronics devices
- Physics of optoelectronics devices

Objectives of the research:

- Develop epitaxial techniques/nanostructures for optoelectronics (with application in quantum optics, lasers, and photovoltaics).
- Combine nanotechnology related processing tools and epitaxial techniques for fabrication of optoelectronics devices.

The recent significant results:

- New epitaxial technique for fabrication of quantum nanostructures on patterned substrates.
- Development of laser diodes using nano-imprint lithography (for telecomm and spectroscopic applications).
- Development of specific III-V compounds for high power lasers (dilute nitride lasers with yellow emission).
- Development and application of nanostructure antireflection coatings for broadband high efficiency solar cells.

Who could utilize the results?

Most of these ideas are basis for future research and applications. The yellow lasers have a high potential for commercialization in medical markets (pre-comercialization research is underway).

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Group name

Aerosol Synthesis Group

Leader

Professor Jyrki M. Mäkelä

Special know-how of the group:

- Controlled metal and metal oxide nanoparticle production by flame and furnace techniques for nanoparticle size range of 2-200 nm. Nanoparticles can be producted at rate in the order of gram per min.
- Process know-how of aerosol behavior and deposition during the coating process.
- Aerosol measurement techniques in the nanoparticle generation with collaborators.

Objectives of the research:

Production of nanostructured materials using aerosol techniques, especially Liquid Flame Spray (LFS), for:

- Test aerosol and nanopowder generation
- Functional coatings
- Surface nanostructures.

The recent significant results:

- Nanostructured coatings on paperboard. A new flame based aerosol method for nanostructured coatings in a continuous roll-to-roll process. Ultimate control over wetting is achieved by reversibly switching between superhydrophilic and superhydrophobic surfaces. The method has potential for scaling up to industrial level (large volumes at high speed).
- Metal nanoparticles for glass coloring using Liquid Flame Spray. Recent development has been directed on industrial up-scaling of the process.

Who could utilize the results?

- Production of nanopowders and test aerosols
- Production of hybrid and composite nanoparticles for novel materials
- Functional nanocoating
- Control of surface energy and wetting properties.

Large scale coating process has a potential in roll-to-roll functional coating of flexible substrates, such as e.g. paper and paperboard materials, with applications in packaging and printing technologies.

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Group name

Electronic Structure Theory

Leader

Prof Tapio Rantala

Special know-how of the group:

- Electronic Structure Theory and Calculations
- Modeling and Simulations
- Many-body Physics of Electrons
- Materials Physics and Chemistry

Objectives of the research:

- Many-body Physics of Electrons
- Quantum dynamics of light-matter interaction
- Development of Quantum Monte Carlo approach
- Development of Density Functional Theory
- Finite Temperature Quantum Statistics Materials Physics and Chemistry
- Compound semiconductors: bulk defects, surfaces, interfaces, nanostructures
- Organic materials, photoabsorption, electron transfer, nanostructures
- Finite Temperature Quantum Chemistry

The recent significant results:

- Finite-temperature electronic structure approach
- Improvements in DFT-functionals
- Metal oxide surface chemistry

Who could utilize the results?

We develop new approaches to the "electronic structure calculations"; community, see e.g. http://www.psi-k.org/
These methods can be used for modeling of nanostructures and evaluation of the properties with improved accuracy.

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Group name

Aerosol Instrumentation and Emissions Group

Leader

prof Jorma Keskinen

Special know-how of the group:

- Instrument development from basic operation principles to industrial production.
- Aerosol sampling and dilution
- Real-time, on-line instrumentation
- CFD based aerosol modeling

Objectives of the research:

- Development of real-time aerosol measurement techniques and instruments.
- Effect of technology development on traffic related nanoparticle emissions.
- Particle properties, formation processes, and real-world emissions.

The recent significant results:

- Particle physical phase characterization method
- Development of a traceable particle number concentration standard
- Effect of fuel, lubricant, and exhaust after-treatment on diesel nanoparticle emissions

Who could utilize the results?

- Development of instruments and nanomaterial synthesis processes
- Manufacturers and users of engines, fuels, lubricants, and after-treatment devices
- Emission and air quality policy-making

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Group name

Biomaterials research group

Leader

Prof Minna Kellomäki

Special know-how of the group:

Expertise is in bioabsorbable polymers and polymer-based composites for biomedical use, all steps from processing to a product.

Objectives of the research:

Processing and characterization of biomaterials for different medical and biomedical applications.

The recent significant results:

- Development of two-photon polymerization process and materials, especially for stem cell culture applications.
- Development of memory-shape phenomena for bioabsorbable polymers and polymer composites.

Who could utilize the results?

They can be applied in stem cell studies and in bone fracture fixation devices.

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Group name

Pharmaceutics

Leader

Prof. Kristiina Järvinen

Special know-how of the group:

- Preparation of drug delivery systems for oral and parenteral administration routes
- Characterization of the drug delivery systems
- In vitro and in vivo studies of drug delivery systems

Objectives of the research:

To develop drug carrier systems to solve problems related to the current drug and peptide delivery. Nanostructured drug delivery systems and implants can (i) increase bioavailability of drugs and peptides by protecting molecules from degradation and/or by increasing their solubility and (ii)decrease side-effects by controlling the release rate.

The recent significant results:

- Mesoporous silicon particles are promising suitained and tailorable release systems for peptides.
- Nanoparticles themselves may cause cardiovascular effects after intravenous administration.
- Drugs and peptides can be entrapped as solid powders into the photocrosslinked poly(ester anhydride) network with the release being controlled by surface erosion of the polymer.

Who could utilize the results?

The results can be applied to drug development and several patients can benefit from the results.

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Group name

Materials Chemistry Group

Leader

Professor Tapani Pakkanen

Special know-how of the group:

- Theoretical material modeling Fabrication and characterization of nanomaterials
- Polymer surface chemistry

Objectives of the research:

- Self-cleaning polymer surfaces based on hierarchical surface patterns in micro and nano scale
- Improvement of thermal and mechanical properties of polymers with nano fillers
- Development of nanodispersion and coupling chemistry in nanocomposites
- Prediction of the structures and properties of novel nanomaterials

The recent significant results:

- Preparation of self-cleaning polymer surfaces based on TiO2 photocatalysis
- Multilevel hierarchical surface modification and anisotropic surface structures on polymers

Who could utilize the results?

- Purification of industrial waste waters
- Development of functional technical plastic applications

Contact

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Group name

Pharmaceutical Physics

Leader

Prof. Vesa-Pekka Lehto

Special know-how of the group:

- Production of mesoprous silicon materials with electrochemical etching and their modifications
- Physicochemical characterization of mesoporous or disordered materials.

Objectives of the research:

Development of nanostructured silicon materials for biomedical applications.

The recent significant results:

- Several review articles on the utilization of thermoporometry in characterization of mesoporous materials and of mesoporous inorganic materials in biomedical applications.
- Status of the spear head research in UEF.
- Screening of toxicity, targeting and imaging of various nanoparticles in vivo.

Who could utilize the results?

Materials can be used to increase bioavailability of poorly soluble and/or permeable drugs including peptides, to obtain controlled release and to facilitate drug targeting.

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Group name

Micro- and nanofabrication

Leader

prof. Markku Kuittinen

Special know-how of the group:

- Electron beam lithography and process paths for mass production of micro- and nanostructures.

Objectives of the research:

Fabricate micro- and nanostructures for photonics applications. This include metal structures for plasmonics research and nonlinear photonics, and dielectric structures for manipulation of electromagnetic fields (e.g. control of polarization and coherence).

The recent significant results:

Hydrofobic anti-reflection surface, depolarizing element, plasmonic structures, chiral nanostructures, phase retarders based on gratings, various waveguide resonance elements for enhancement of SHG, fluorescence, and wide band reflection.

Who could utilize the results?

- All kind of displays (mobile devices, etc.)
- Companies on these fields measurement systems which are based on detection of SHG or fluorescense
- Biomedical industry phase retarders as copyable photonics components
- Photonics industry wide band reflection based on resonace waveguide gratings
- Laser makers, IR-source makers

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Group name

Photonics

Leader

prof Pasi Vahimaa

Special know-how of the group:

Theoretical and experimental expertise on nanophitonics and micro-optics

Objectives of the research:

To be one of the best photonics research groups in Europe

The recent significant results:

- About 70 peer-reviewed journal papers on photonics in the best optics journals.
- Several international research projects, several PhD's on photonics each year.

Who could utilize the results?

- Other research groups in various areas.
- Companies on photonics and areas applying photonics.

Contact

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Group name

Nanocarbon Group

Leader

Prof Yuri Svirko

Special know-how of the group:

- CVD growth of large (up to 1 cm^2) graphene films
- Plasma-assisted CVD growth of nanographite films and single crystal diamond needles
- Femtosecond spectroscopy of nanocarbon materials
- Thz spectrocopy

Objectives of the research:

- To improve technology of the manufacturing nanocarbon species including micro- and nanodiamonds, nanographite films, and graphene
- To study optical and electronic properties of nanocarbon materials
- To employ the createded nanocarbon materials in optoelectronics and photonics

The recent significant results:

- Creation of single crystal diamond needles with apex curvature of few nanometers
- THZ emission from graphene
- Study of the ultrafst dynamics of photoexcited carriers in graphene
- Observation of polarization-sensitive photoresponse of nanographite films

Who could utilize the results?

The performed research are fundamental. The results can be employed in the AFM and micromachining tools, and for development of nanocarbon based photonic/optoelecttonic devices

Contact

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Group name

InFotonics center Joensuu

Leader

Prof. Markku Hauta-Kasari

Special know-how of the group:

- Spectral color measurement
- Spectral image analysis

Objectives of the research:

We are doing spectral color research, in which the objective is to measure the most accurate color information from object and to analyze the measurement data by intelligent computational methods.

The recent significant results:

New applied research projects started in the field of forest cluster, medicine and in saw mill applications.

Who could utilize the results?

Results can be applied in the research and development of the industries. Also in medical applications the results can be directly applied in hospitals.

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Group name

Biophysics of Bone and Cartilage

Leader

Prof Jukka Jurvelin

Special know-how of the group:

- Musculoskeletal biophysics and imaging.
- Mechanical indentation.

Objectives of the research:

- Dvelopment of diagnistics for musculoskeletal diseases.
- Tissue characterization using biophysical techniques.
- Nanoindentation of bone and cartilage

The recent significant results:

- About 50 scientific papers on bone and catilage.
- Development of novel bone diagnostic methods using ultrasound. Tissue engeneering.
- About 5 papers are related to nanotechnology methodology

Who could utilize the results?

- Tissue engineering.
- Musciloskeletal diagnostics

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Group name

Aerosol physics laboratory

Leader

Prof. Ari Laaksonen

Special know-how of the group:

- The Aerosol Physics Group has unique facilities and instruments for characterizing both physical properties and chemical composition of atmospheric aerosols.
- The group also uses a wide variety of atmospheric models from process level to general circulation models in co-operation with several national and international partners.

Objectives of the research:

The research carried out in the Aerosol Physics Group is mainly focused on atmospheric aerosols, which are liquid or solid particles suspended in the atmosphere.The group studies how atmospheric aerosols form and the role they play in the Earth's climate through their interactions with clouds.The group has a unique capability of integrating laboratory and outdoor measurements with theories and models in order to understand and predict the impacts of human-caused and natural changes on climate.

The recent significant results:

- Aerosol-cloud interactions
- Atmospheric new particle formation
- Properties and composition of atmospheric aerosol

Who could utilize the results?

- We can measure e.g. nanoparticle size and composition.
- Also water and ethanol vapor adsorption on to the nanoparticle surface or thermal treatments effects to the nanoparticle properties can be measured online.

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Group name

FINE

Leader

Prof. Jorma Jokiniemi

Special know-how of the group:

Gas phase synthesis and physico-chemical characterisation of nanoparticles

Objectives of the research:

Gas phase synthesis of nanomaterials for various applications including energy storage, hydrogen generation, drug nanoparticles, magnetic and optical applications

The recent significant results:

- LTO anade material syntheis for Li-ion batteries
- SiC synthesis for hard material applications
- Magnetic iron/ironoxide particle production

Who could utilize the results?

- Energy industry
- Battery manufacturers
- Catalysts
- Medical imaging
- Drug particle development

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Group name

SIB-labs Kuopio

Leader

Arto Koistinen

Special know-how of the group:

- Electron microscopy
- Optical microscopy
- Spectroscopy

Objectives of the research:

Providing infrastructure, know-how and education for researchers and companies to perform material analyses (service provider)

The recent significant results:

Enhanching infrastructure for modern electron microscopy (a new 200kV transmission electron microscopy with EDS equipment and tomography)

Who could utilize the results?

Several research groups and research institutes can benefit from our experience and equipment in the field of nanomaterials, biological tissues and pharmaceutics

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UNIVERSITY OF HELSINKI

Faculty of Science

Department of Physics

Group name

Soft matter physics

Leader

Prof. Ritva Serimaa

Special know-how of the group:

Synchrotron radiation and x-ray based methods for characterization of the structure of materials like wide and small angle x-ray scattering, grazing incidence x-ray diffraction and reflectivity, x-ray absorption spectroscopy, x-ray microtomography

Objectives of the research:

Studies on the structure and properties soft nanomaterials using x-ray based methods. The applications include nanofibrillated cellulose, natural polymer based nanocomposites and two-dimensional protein coatings.

The recent significant results:

1) Structure of self-assembled films of hydrophobin proteins HFBI and HFBII in situ at the air/water Interface was characterized using synchrotron radiation. **2**) Nanocomposites of transition metal nanoparticles and cellulose was prepared and characterized using anomalous scattering and absorption spectroscopy in co-operation with Inst. of Macromolecular Compunds, St. Petersburg. **3**) Drying and crystallization of natural polymer based film was followed using combined ultrasonics and x-ray experiments **4**) The nanostructure of nanofibrillated cellulose was characterized from nanometer to micrometer scale using x-ray scattering and microtomography.

Who could utilize the results?

Food and paper industry.

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UNIVERSITY OF HELSINKI

Faculty of Science

Department of Physics

Group name

Materials science simulations

Leader

Prof. Kai Nordlund

Special know-how of the group:

- Molecular dynamics simulations
- Density functional theory calculations
- Analytical theory
- Interatomic potential development
- Kinetic Monte Carlo simulations

Objectives of the research:

Understand the ion and cluster ion beam processing of materials on the atomic scale and use these insights to enable development of improved and new materials

The recent significant results:

Combined theoretical and experimental proof that **1**) swift heavy ion tracks in silica are underdense in the core **2**) That ion beams can be used to densify nanocrystalline thin films **3**) That pure metals can sputter chemically

Who could utilize the results?

1) Development of ways to grow nanowires in swift heavy ion tracks **2**) development of nanocrystalline thin films made a new kinds of materials **3**) plasma processing of materials

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UNIVERSITY OF HELSINKI

Faculty of Science

Department of Physics

Group name

X-ray Spectroscopy Group

Leader

Prof. Keijo Hämäläinen

Special know-how of the group:

X-ray based techniques in materials characterization using synchrotron radiation

Objectives of the research:

Fundamental studies of electronic structure in novel materials

The recent significant results:

Development of various experimental and computational tools for electronic structure studies

Who could utilize the results?

In linking the materials macroscopic and electronic structure level properties

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UNIVERSITY OF HELSINKI

Faculty of Science

Department of Physics

Group name

Ion beam group

Leader

Prof. Juhani Keinonen

Special know-how of the group:

The research aims to understand the interaction of energetic ions with atoms of materials and slowing-down of ions in solids, effects of ion implantations on the structure of matter, interaction of defects, host atoms and implanted atoms in matter, and diffusion and solubility of doping atoms. The experimental work on materials physics is complemented by atom-level computer simulations, which can describe both the high-energy collisions induced by ion beams, and the subsequent modification of the equilibrium properties of materials.

Objectives of the research:

The main interests are to obtain new information about physical processes taking place in materials during and after implantation and the development of better processing methods of materials and development of new materials.

The recent significant results:

1) Changes of mechanical and electric properties were defined in single-walled carbon nanotube (SWNT) networks (SWNT paper) irradiated with high energy heavy ion beams. 2) New photoactive defect structures were defined in alpha-quartz doped by ion implantation.

Who could utilize the results?

Results are essential for continuous development of nano-materials and related devices, e.g. in nanophotonics.

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UNIVERSITY OF HELSINKI

Faculty of Science
Department of Physics

Group name

Biophysics

Leader

Prof. Arto Annila

Special know-how of the group:

Statistical physics of open systems.

Objectives of the research:

To acquire holistic understanding of nature from first principles.

The recent significant results:

Derivation of evolutionary equation of motion.

Who could utilize the results?

The natural law of maximal energy dispersal is general. It can be applied to rationalize diverse processes and phenomena.

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UNIVERSITY OF HELSINKI

Faculty of Science

Department of Physics

Group name

Division of atmospheric sciences and geophysics

Leader

Acad. prof. Markku Kulmala

Special know-how of the group:

- Modeling of atmospheric clusters using molecular level methods
- Aerosol dynamic modeling of atmospheric particle formation
- Measurement of world's longest time series in atmospheric nanoparticle formation events and nano-particle size distributions
- Detecting and uncovering the chemical identity of atmospheric nanoscale condensation nuclei
- Instrument and model development
- Intercomparison of theory and experiment

Objectives of the research:

Uncovering the formation mechanisms of atmospheric nanoparticles and their effect on climate and air quality.

The recent significant results:

1) Reduction in aerosol, particle concentrations might enhance to global warming **2**) Developed techniques to detect electronically neutral aerosol particles below 3 nanometers in diameter **3**) Quantitative measurements of the ability of 1-3 nanometer particles act as condensation nuclei **4**) Ion-induced nucleation is not the major particle formation channel in the atmosphere **5**) Developed techniques to measure chemical composition of atmospheric ions **6**) Molecular modeling results of atmospheric nanoclusters confirmed with experiments, theory also assisting instrument development and data analysis

Who could utilize the results?

The results narrow down the uncertainties related to atmospheric aerosols in predicting climate change. They increase information on airborne nanoparticles and nanoparticle physics in general, benefiting materials research. Aerosol dynamic models have a wide range of applications from industrial processes to assesment of environmental issues. End users of the results are policy makers, climate modellers ,process engineers, risk analysts.

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UNIVERSITY OF HELSINKI

Faculty of Science

Department of Physics

Group name

Nano-aerosols, health and safety

Leader

Prof. Kaarle Hämeri

Special know-how of the group:

- Measurement techniques of nano-aerosols
- Real-time and on-line methods
- Aerosol fundamental physics

Objectives of the research:

1) Safety and risks of engineered and pollution nanoparticles 2) Instrumentation and characterization of the physico-chemical properties of nano-aerosols

The recent significant results:

1) Exposure characteristics of nano-particles in several occupational areas 2) Exposure characteristics of nano-particles on mice

Who could utilize the results?

The results can be utilised in developing protection to nanoparticles, in estimating the exposure and investigating the potential risks. The results can be used by all enterprices that are concerned about the risks of their production.

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UNIVERSITY OF HELSINKI

Faculty of Science

Department of Chemistry

Group name

Optical and surface properties of nanoparticles, OPNA

Leader

Prof. Markku Räsänen

Special know-how of the group:

- Molecular spectroscopy
- Infrared, raman, time-resolved luminescence
- Cryogenic techniques from 3 K

Objectives of the research:

1) To understand light amplification in Si-nanoparticles embedded in SiO_2 and structure of the interface between these. **2**) Excited states **3**) To develop further optical memory based on Si nanoparticles embedded in solid SiO_2: Pressure dependence of the phonon band measured by Raman scattering and data density of such memories and integration to known silicon technology. **4**) Chemical compounds formed by noble gases and connection to xenon anesthesia and to the missing xenon problem. **5**) Selective control of molecular conformations
6) Chemical differences of different conformers **7**) Molecular level optical memory

The recent significant results:

1) Writing data to Si/SiO_2 nanoparticles **2**) Synthesis of HXeOXeH, very high energy species **3**) Stabilization of the higher-energy conformer of formic acid by complexation with water.

Who could utilize the results?

Future electronics industry. Connected with the breakthrough of optical computing. May be connected with the molecular level mechanism of Xe-anesthesia. Deepends our understanding of the operation of our nervous system. Paves the way to control chemical reactions selectively. Very high potential value.

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UNIVERSITY OF HELSINKI

Faculty of Science

Department of Chemistry

Group name

Inorganic Chemistry

Leader

Prof. Markku Leskelä

Special know-how of the group:

The group has long experience in ALD. The material selection and number of processes studied in ALD is high. Besides ALD, deposition of thin films are made also by other techniques: SILAR, evaporation, spin-coating. In situ reaction mechanism studies in ALD is one of the specialities of the group. Electrospinning of nanofibers and preparation of nanoporous materials are carried out in the group. Synteses of a variety of layered double hydroxide (LDH) based inorganic-organic nanocomposites has been recently developed in the group.

Objectives of the research:

The materials under study are thin films and nanomaterials. The common basis is synthetic chemistry and the synthesis products are used precursors for thin films and nanomaterials. The thin films are aimed for microelectronics, photvoltaics, photocatalysis, optics, MEMS, protection etc. The function of the thin film materials can be dielectric, conducting, barrier, hydrophobic or catalytic. As materials they are oxides, metals, nitrides or chalcogenides. The research is basic in nature (new chemistry, reaction mechanisms) but basic properties for the selected appplication areas are characterized as well. The nanomaterials studied are nanotubes, nanofibers, nanoporous materials and nanocomposites. Nanomaterial studies are mostly curiosity driven.

The recent significant results:

1) New ALD processes for selenide and telluride films **2**) New ALD processes for metal fluorides **3**) Use of polymers in selective area ALD **4**) Low-temperature processes for noble metal ALD **5**) New ways for making LDH based norganic-organic nanocomposites

Who could utilize the results?

The ALD films and processes studied are applicable in microelectronics, optical and protective coatings. Nanocomposites may find applications as biomaterials and in cosmetics.

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In addition to the mentioned leader, the research profile includes the research of:

prof. Mikko Ritala

UNIVERSITY OF HELSINKI

Faculty of Science

Department of Chemistry

Group name

Miniaturised instruments and neoteric techniques, MINT

Leader

Prof. Marja-Liisa Riekkola

Special know-how of the group:

- Development of miniaturized versatile instrumental techniques applicable to nanodomain interaction studies
- Coating of different surfaces with human materials
- Exploitation of complementary and multidisciplinary approaches, and simultaneous computational and experimental studies.

Objectives of the research:

1) To develop novel/neoteric miniaturised instruments/instrumental techniques vital at nanoscale. 2) To apply advanced computational and numerical approaches for deeper understanding of nanoscale bioprocesses at tomistic and molecular level.

The recent significant results:

Capillary electromigration techniques can be exploited, in addition to separation techniques, as biomimicing instrumental techniques applicable to studies on the understanding of the molecular properties of human surface nanodomains. In the studies, it has been shown that human microemulsions, and several lipoproteins can be employed as stationary phase in electrochromatography (CEC). CEC has also revealed to be an efficient tool for the isolation of apolipoprotein B-100 (apoB-100), the main protein of low density lipoprotein particles (LDL) that, as a coating, is then available for broad interaction studies. Proteoglycans (PGs) are the most abundant compounds of the extracellular matrix (ECM). It is evident that an organized, tight PG network, formed from glycosaminoglycans, has the potential to bind lipoproteins, and the atherogenicity of especially LDL particles is linked to their affinity towards the intimal proteoglycans, and in the interactions and entrapment at least chondroitin-6-sulfates play an important role. In the studies the coating procedures for human proteoglycans have been developed, and interactions of proteoglycan with carefully selected peptide fragments of apoB-100 (the major apoprotein of low-density lipoprotein) have been preliminary clarified. In addition, our studies were dedicated to the construction/parameterization of a PRODRG derived force field for chondroitin-6-sulfate polysaccharide allowing further glycosaminoglycan studies. Density probability analysis on extended dynamics simulations and the subsequent derived dihedrals averages were found to be in a good agreement compared to experimental data. The availability of a force field for a polysaccharide chain of C6S enables other simulations related to C6S - apoB-100 interactions.

Who could utilize the results?

The neoteric instrumental techniques developed will be beneficial in nanodomain studies. Combination of advanced chemical, molecular and computational concepts with novel instrumental microanalytical techniques will be helpful in the elucidation of nanoscale functions of lipoproteins. Computational studies carried out hand in hand with experimental ones will open new avenues for carbohydrate studies, and especially for the elucidation of diseases in which polysaccharides play an important role. The project will generate also a new knowledge useful in separation technology, and in modeling of modern miniaturized systems.

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UNIVERSITY OF HELSINKI

Faculty of Science

Department of Chemistry

Group name

Polymer chemistry

Leader

Prof Heikki Tenhu

Special know-how of the group:

- Synthesis of polymers and various nanomaterials
- Polymer characterization mainly by NMR, light scattering, rheological (dynamic mechanical), and thermoanalytical methods.

Objectives of the research:

The main objective is to apply advanced chemistry to create new materials and to master the methods of their characterization. This includes **1**) Modern methods to synthesize "smart", self-assembling polymers **2**) Water-soluble and/or amphiphilic polymers **3**) Use of the polymers e.g. as carriers for various active substances **4**) Development of the methods to characterize the polymers mainly in aqueous surroundings **5**) A new important group of new materials include various hybrid materials and nanocomposites based on for example gold, silver, copper, or montmorillonite nanoparticles. **6**) Also, water-dispersible conducting polymers are of interest.

The recent significant results:

1) New environmentally responsive star and block copolymers which react strongly to temperature, light, pH, even electric field **2**) Several new hybrid materials/nanocomposites **3**) Stereocontrol in radical polymerization

Who could utilize the results?

The materials under study should find several applications ranging from controlled dug delivery to wood preservatives or even non-linear optics. Nanosized copper was prepared to manufacture conducting patterns on paper, polymer-modified silver nanoparticles have been prepared to obtain safe antibacterial coatings.

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UNIVERSITY OF HELSINKI

Faculty of Pharmacy

Division of Pharmaceutical Technology

Group name

Nanotechnology in Drug Development

Leader

Prof. Jouni Hirvonen

Special know-how of the group:

Prof. Jouni Hirvonen: Pharmaceutical research and development, mechanisms of drug release and absorption, controlled release drug formulations

Doc. Leena Peltonen: Manufacture and characterization of pharmaceutical nanosystems, polymeric nanoparticles and layer-by-layer functionalization, pharmaceutical formulations

Dr. Timo Laaksonen: Physical Chemistry, nanoparticle synthesis and functionalization, drug release modeling, gold nanoparticles.

Dr. Heldér Santos: Nanoporous silicon-based materials, pharmaceutical and physicochemical characterization, mechanisms of oral drug release and absorption, nanotoxicology.

Objectives of the research:

The group studies and develops biodegradable and biocompatible nanoparticles, nanocrystals and nanoporous materials in collaborative national and international projects. Controlled release formulations have been prepared/manufactured, e.g., by nanocrystallization (pure drug substances), nanoprecipitation (interfacial polymer deposition method for PLA- and PGA-type polymers that may further be coated by polyelectrolytes), electrospray (synthetic and natural polymers, nanocoating) and electrochemical etching (nanoporous silicon materials). Improving dissolution/solubility and permeability properties of drugs are key areas of research. Toxicity of the nanomaterials is also investigated.

Main objective of the current research is to reach fundamental understanding on the manufacturing and process parameters of nanosystems. Special focus is targeted to functionalized nano(particle)systems to reach optimal therapeutic response and safety profiles in nanomedicinal applications

The recent significant results:

Large number of high quality publications in the field of (pharmaceutical) nanotechnology.

Albert Wuokko Award for a young pharmaceutical research scientist in 2008: Samuli Hirsjärvi, thesis Preparation and Characterization of Poly(Lactic Acid) Nanoparticles for Pharmaceutical Use

2008 Gust. Komppa prize for the best chemical sciences related thesis of 2007 by Suomalaisten kemistien seura (Association of Finnish Chemists): Timo Laaksonen, thesis Noble Metal Clusters: Electrostatics, Stability and Applications

Who could utilize the results?

Major beneficiaries are drug discovery and drug development companies together with service oriented enterprises. The results are also applicable to other industries dealing with the delivery of molecules to people, animals etc., such as food industry.

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UNIVERSITY OF HELSINKI

Faculty of Pharmacy
Division of Pharmaceutical Chemistry

Group name

Division of Pharmaceutical Chemistry

Leader

Prof. Risto Kostiainen

Special know-how of the group:

Analytical techniques: Miniaturization of analytical devices, mass spectrometry, liquid separation, sample preparation, ion mobility spectrometry.

Objectives of the research:

1) Development of analytical instrumentation using micro- and nanotechnologies 2) Surface fuctionalizing Brain metabolomics

The recent significant results:

Integrated liquid chromatography - heated nebulizer - mass spectrometry microchip, Surface functionalization by atmospheric discarge plasma, micropillar elctrospray ion source, proteomics on the chip.

Who could utilize the results?

High throughput bio- and environmental analysis.

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In addition to the mentioned leader, the research profile includes the research of:

Prof. Tapio Kotiaho

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UNIVERSITY OF HELSINKI

Faculty of Pharmacy
Centre for Drug Research

Group name

Drug Delivery and Nanotechnology

Leader

Prof. Arto Urtti

Special know-how of the group:

Encapsulation of nanodrugs inside nanoparticles and the research on microencapsulated cells..

Objectives of the research:

Drug delivery and targeting with nanosystems and biomaterials. Interesting applications would be nanoparticles that target on to the cancer tissue or to the back of the eye.

The recent significant results:

Light sensitive nanoparticle for controlled drug release.

Who could utilize the results?

Pharmaindustry and companies fabricating the microchips.

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UNIVERSITY OF HELSINKI

Faculty of Medicine

Haartman Institute

Group name

Peptide and Protein Laboratory

Leader

Doc. Hilkka Lankinen

Special know-how of the group:

Doc. Hilkka Lankinen: Protein and peptide chemistry of viral proteins, virion isolations and virus-host cell interactions.
Prof. Antti Vaheri: Basic, medical and diagnostic virology. Microarrays for detection of viral genomes and antibodies.
Prof. Olli Vapalahti: Zoonosis virology and microarrays in virus diagnostics

Objectives of the research:

The group develops arrays for diagnostics of virus infections. The objective is to prepare combinatorial chips for detection of immune responses, viral and host nucleic acids as genetic markers of infections. We study photo-guided surface chemistries based on UV-LED materials in order to improve compatibility of biochips in diagnostics and diagnostic devices.

The recent significant results:

Isolation of a membranous virus, resolving of its structure, surface architecture and envelope protein chemistries in thiol-bridging. Multiplex-PCR and microarrray for detection of herpesvirus DNAs and antibodies. Proof-of-principles for use of peptide arrays in serodiagnostics. Employment of UV-LED photoactivation to capture macromolecules

Who could utilize the results?

These results are of value for diagnostics of viral infections, in research and development of vaccines, antivirals and systems level technologies thereof.

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UNIVERSITY OF HELSINKI

Faculty of Medicine

Haartman Institute

Group name

Cancer Gene Therapy Group

Leader

Prof. Akseli Hemminki

Special know-how of the group:

Developing new virus based nanomachines for cancers lacking effective modalities.

Objectives of the research:

Our group develops oncolytic adenovirus based nanomachines to improve the treatment of cancers lacking currently available effective modalities.

The recent significant results:

Seven oncolytic adenoviruses built, tested and produced by our research group have been used with good results for cancer patients who have already gone through all currently available treatments. We have published over 20 articles in international peer-reviewed scientific publication series.

Who could utilize the results?

Cancer patients who don't benefit from the traditional cancer treatments. Most of the patients treated with our oncolytic viruses have benefitted somehow from these treatments. In addition to several clinical objective responses viral treatments have enabled many patients to live longer or improve their quality of life.

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UNIVERSITY OF HELSINKI

Faculty of Medicine

Institute of Biomedicine

Group name

Helsinki biophysics & biomembrane group

Leader

Prof. Paavo Kinnunen

Special know-how of the group:

Biomaterial (lipids, proteins, nucleic acid) properties and self-assembly

Objectives of the research:

1) Development of nanoparticles for gene delivery and MRI (Magnetic Resonance Imaging) of the inner ear, and MRI-guided drug delivery into cancer cells 2) Detection and abrogation of cancer metastases 3) Mechanisms of action of cytotoxic peptides

The recent significant results:

1) Development of temperature sensitive drug encapsulating liposome nanoparticles 2) Development of Gadolinium loaded liposomes for MRI of inner ear

Who could utilize the results?

MRI-guided HIFU (high intensity focused ultrasound) triggered local drug delivery. Project coordinator is Philips medical, who manufactures MRI-HIFU equipment. Imaging of the inner ear and therapy of hearing loss.

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UNIVERSITY OF HELSINKI

Faculty of Medicine

Institute of Biomedicine

Group name

Klefstrom Group

Leader

Doc. Juha Klefström

Special know-how of the group:

- Use of recombinant lentivirus technology for genetic perturbation analyses in vitro and in vivo
- Genetic programmable switches for inducible gene expression
- New 3D organoid cell culture platforms and genetic reprogramming of the mouse mammary gland

Objectives of the research:

1) Developing genetically programmable nanoparticles using recombinant lentivirus platform **2**) Improving lentiviral transduction efficacy to enable genetic perturbation analyses in vivo **3**) Modeling cancer gene specific circuits by genetic perturbation analyses using lentiviral carriers **4**) Exploring synthetic lethal genetic and small molecule interactions with cancer gene specific circuits to identify therapeutic strategies against cancer

The recent significant results:

1) Expanding the RNAi silencing technology to in vivo mouse tissues **2**) New inducible gene silencing constructs **3**) Mechanistic insights into genetic determinants of breast cancer development

Who could utilize the results?

Better understanding of basic cell biology - Commercial technology-based offshoots - Pharmaceutical industry

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UNIVERSITY OF HELSINKI

Faculty of Medicine
Haartman Institute

Group name

DNA virus research group

Leader

Prof. Klaus Hedman

Special know-how of the group:

- Development of novel diagnostic methods
- Recombinant expression of proteins and virus-like particles
- Immunobiology
- Nucleic acid detection and amplification techniques

Objectives of the research:

To assess the molecular biology, pathogenesis and clinical significance of the recently discovered "live nanomachines", i.e. DNA viruses of humans.

The recent significant results:

Analysing ex-vivo genomes of human parvovirus B19, we observed this single-straded (ss)DNA virus to have an astonishingly high evolution rate, ~10^{-4} nt/year, approaching that of RNA viruses. We developed comprehensive molecular tools and recombinant-protein-based serodiagnostics (IgG; IgM; IgG-avidity) for eight species of recently discovered human DNA viruses - Human bocaviruses (HBoV) 1-4, Parvovirus 4 (Parv4), and Polyomaviruses WU, KI and MC, and the entire genus of Anelloviruses - to elucidate the epidemiology, clinical significance and pathogenetic mechanisms of this "DNA microflora" infesting our tissues and cells. We (i) showed that the HBoV1 infections are systemic, and viremic, and can be diagnosed by qualitative PCR better in serum than in nasopharynx; and that (ii) Parv4 is extremely prevalent (80%) among HIV- or HCV-infected i.v. drug users; and that (iii) the cancer-causing MC polyomavirus occurs ubiquitously in the upper airways of young children, and with increasing prevalence through adulthood (pointing to persistence in tissues). Of note, our in-house-generated virus-like particles (currently existing for six of these species) will furthermore permit high-resolution surface topography studies of these emerging human viruses.

Who could utilize the results?

Health-care units and clinical diagnostic laboratories throughout the world, as well as companies developing or manufacturing diagnostic methods.

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UNIVERSITY OF HELSINKI

Faculty of Medicine
Protein Chemistry Core Facility

Group name

Protein Chemistry/Proteomics/Peptide Synthesis and Array Unit

Leader

Director Marc Baumann

Special know-how of the group:

- Neuroscience
- Mico/nano-chip development
- Proteomics
- Protein/peptide arrays
- Mass spectrometry

Objectives of the research:

We are a group who has three main topics. **1**) We are studying neurosciences and especially interested in misfolding disorders. Through this we have long lasting experience in self-assembling molecules. **2**) We also study micro- and nano structures/surfaces for to produce selective biomolecular chip based devices for clinical diagnostics and medical and biochemical research. **3**) We are developing methods to provide sensitive and fast analyses on proteomic level. These would include secondary modification analyses, glycobiology and label-free quantitation.

The recent significant results:

1) We have shown that some of the known diseases are linked to molecular self-assembling. **2**) We have patented a new type of a micro-chip for protein analyses (automated 2D-gel electrophoresis micro-device for targeted proteomics). **3**) We have published two papers on nanostructures with biomolecular analyses.

Who could utilize the results?

Scientists and companies who would be interested in selective molecule mapping of e.g. DNA/Proteins/phosphorylations/other secondary modifications incl. carbohydrates and lipids.

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Group name

CBL

Leader

Dr. Dos. Olli Pentikäinen

Special know-how of the group:

- Computer-aided molecular discovery
- Molecule design

Objectives of the research:

Development of novel tools and techniques to understand cellular signaling

The recent significant results:

- Development of novel tool molecule for collagen receptor integrin receptor;
- Novel method for ligand discovery

Who could utilize the results?

Especially pharmaceutical companies and academic group involved in similar research, diagnostics etc.

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Group name

NAOBIO

Leader

Prof Matti Vuento

Special know-how of the group:

- Uptake and trafficking of viral nanopaticles in animal cells

Objectives of the research:

Characterizing interactions of carbon nanoparticles with cells, cellular membranes and biomolecules.

The recent significant results:

Studies on interactions of fullerene C60 with membrane lipids and with DNA.

Who could utilize the results?

- Contributing to knowledge of CNP safety
- Use of CNPs as vectors to material delivery into cells

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Group name

Thermal nanophysics

Leader

Prof. Ilari Maasilta

Special know-how of the group:

- Low-temperature measurements down to 20 mK
- Thermometry using superconducting tunnel junctions
- Nanolithography using mostly e-beam lithography
- Pulsed laser deposition of nitride materials (NbN, TaN, AlN etc.)
- Fabrication of self-assembled nanoparticle crystals

Objectives of the research:

- Fundamental and applied research on thermal properties of nanostructures, mostly at low temperatures.
- Development of ultrasensitive bolometric radiation detectors, and their applications.

The recent significant results:

- Demonstration of phonon cooling and low thermal conduction in suspended nanowires at sub-K temperatures
- Demonstration of a technique to reduce 1/f noise in tunnel junctions using thermal annealing

Who could utilize the results?

- Suspended structures: possible application in ultrasensitive bolometry for Far-IR detection and cooling of NEMS detectors
- 1/f noise reduction: improvement of the performance of superconducting qubits, single electron pumps for metrology etc.

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Group name

Quantum Nanoelectronics

Leader

Docent Konstantin Arutyunov

Special know-how of the group:

- Precision electron transport measurements of various nanosystems at ultra-low temperatures
- Ion beam shaping and dimension reduction of nanostructures.

Objectives of the research:

To perform leading-edge research in the field of:

- Quantum size phenomena;
- Interface phenomena at nanoscales; -
- Applied nanotechnology.

The recent significant results:

- Demonstration of quantum phase slip efect in quasi-1D supercondcuting nanosystems
- Experimental determination of the relaxation scales of non-equilibrium quasiparticles injected into a superconductor at ultra-low temperatures
- Patenting of the ion beam processing of nanostructures and application of the method for industrial purposes.

Who could utilize the results?

- Quantum metrology: quantam standard of electric current.
- Ultra sensitive bolometers and transition edge sensors.
- Super-fine surface polishing at industrial scales.

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Group name

Sensitized nanoparticels

Leader

Professor Jouko Korppi-Tommola

Special know-how of the group:

- Spectroscopic and real time dynamic studies of molecules on such interfaces.
- Application of atomic layer deposition (ALD) to create hybdrid materials to improve the performace of the devices.
- Understanding the behavior and use of semiconducting metal oxide nanoparticles.
- Laser based measurement techniques

Objectives of the research:

- To understand basic physics in optoelectronic devices that rely on molecule - semiconductor interfaces.
- Applications include photodetectors, photochromic displays and dye sensitized solar cells that have a potential for cheap mass production.

The recent significant results:

- Unraveling the behavior of ALD barrier layers, and the role of the iodine redox couple in the charge recombination of the dye solar cell.
- Publishing the mesoscopic model for the function of the dye cell.

Who could utilize the results?

The results have been published in refereed scientific journals and hence are public. Beneficiaries are large and small companies working towards commercialization of the dye solar cell.

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Group name

Quantum Control and Dynamics (QCAD)

Leader

Dr. Esa Räsänen

Special know-how of the group:

- Quantum simulations in general
- Low-dimensional nanostructures
- Many-particle theories
- Coherent control
- Quantum transport
- Classical and quantum chaos
- Molecular dynamics
- Intermediate-band solar cells.

Objectives of the research:

- We aim at new insights into control and dynamics of many-particle systems of both technological and fundamental relevance.
- We focus on low-dimensional systems (quantum dots, quantum Hall devices, graphene-like materials), chalcopyrite solar cells, ultrafast phenomena in small atoms and molecules, quantum transport, and chaotic phenomena.
- Active theory and method development is essential alongside active collaboration with experimentalists.

The recent significant results:

- Launching the concept of efficient chalcopyrite quantum-well solar cells.
- Finding of new collective many-electron states in quantum dots.
- Development of several density-functionals to describe 2D electronic systems.
- Optimal control of ionization in small molecules.

Who could utilize the results?

- Applications in spintronics, control of ion production, third-generation solar-cell technology.
- Generally, we can provide expertise for any project needing numerical modeling and/or precise quantum simulations.

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Group name

Nissinen group

Leader

Prof. Maija Nissinen

Special know-how of the group:

- X-ray crystallography
- Small molecule complexation
- Supramolecular chemistry
- Polymorphism.

Objectives of the research:

- Synthetic and structural supramolecular and nanochemistry.
- Weak interactions, polymorphism, cocrystals and solvates.
- Nanoparticles and self-assembling molecules and their potential as functional materials.

The recent significant results:

- Synthesis, characterization and properties of fluoride binding receptors.
- Synthesis, characterization and properties of amphiphilic octapodands
- Synthesis, characterization and properties of novel mono- and ditopic receptors.

Who could utilize the results?

These can be applied in detection of cationic and anionic species (depending on the receptor in question), as thin film materials (amphiphilic receptors) with selective binding properties.

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Group name

Microelectronics and Materials Physics laboratories

Leader

Professor Heli Jantunen

Special know-how of the group:

The group is composed of expertises in materials physics and micro and nano technology with researchers having versatile background (physics, theoretical physics, chemistry and mechanical, electrical and process engineering). The main important knowhow is based on understanding opportunities available with advanced electronics materials for future applications taking into account also fabrication process requirements. Nanotechnology is seen as one of the most important enabling technology for future electronics.

Objectives of the research:

Our research group is concentrating on electronics materials (electroceramics, inorganic nano particles and CNTs) for applications related to actuators, sensors, photonics, energy harvest and wireless communication. Fabrication processes cover both nano and macro scales starting from ultra thin films through e.g. printed electronics up to micromachining.

The recent significant results:

The long-term work with electroceramics has be continued approaching also new application areas (e.g. energy harvest) with also more advanced fabrication methods (nano milling, printed electronics, extrusion, etc.). Especially very versatile materials, electroceramics covering conductive, piezoelectric, ferroelectric and dielectric performance, are utilized in wide application areas with nanotechnology. Additionally opportunities available with CNTs for printed electronics have been demonstrated in high level international journal publications providing interesting applications opportunities.

Who could utilize the results?

The research results opportunities are demonstrated with real industrial applications covering:

- Advanced materials for telecommunication
- Novel electrical coding, photonics,
- Active devices
- Sensors

Over 40 companies have been partners in the research efforts providing them new business opportunities.

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Group name

Applied Chemistry

Leader

Professor Ulla Lassi

Special know-how of the group:

- Heterogeneous catalysis
- Catalytic materials
- Battery chemicals

Objectives of the research:

- Synthesis of catalytic materials and use of them in process and environmental applications
- Preparation of battery chemicals and their applications
- Recovery of metals from industrial flows

The recent significant results:

Scientific publications, theses, patent applications

Who could utilize the results?

Companies can use this knowledge in their product development, research results are also published and will also be applied in new project proposals

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Group name

EMPART Research Group

Leader

Doc. Krisztian Kordas

Special know-how of the group:

- Materials synthesis, structural and electrical characterization.
- Construction of electrical devices by the combination of microfabrication and inkjet printing methods.

Objectives of the research:

Synthesis and modification of 1-D nanoparticles (nanowires and nanotubes) for electrical, sensor and (photo)catalyst applications.

The recent significant results:

- Nitrogen-doped TiO2 Anatase Nanofibers Decorated with Noble Metal Nanoparticles for High-efficiency Photocatalytic Hydrogen Generation
- Electrical transport and field effect transistors using inkjet printed SWCNTs films having different functional side groups
- Three dimensional carbon nanotube scaffolds as filters or catalyst support membranes

Who could utilize the results?

- Printed/flexible/transparent electronics
- Photochemistry
- Solar energy harvesting
- Gas sensing
- Heterogeneous catalysis

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Group name

Functional materials, components and applications

Leader

Docent Jari Juuti

Special know-how of the group:

- 15 years of experience in functional materials, especially in piezoelectrics
- Development of inorganic-organic thermoplastic composites utilising nanopowder fillers and their RF and microwave characterisation
- Ink synthesis for printable electronics especially starting from solid nanosize inorganic powders
- Piezoelectric materials
- FEM modelling of components
- Electrical and electromechanical characterisation (e.g. energy harvester components, high displacement actuators, LTCC integrated actuators/sensors)
- Development of memristor materials

Objectives of the research:

- Development of low loss, high permittivity/permeability composites/inks for printable electronics/high frequency applications
- Efficient piezoelectric energy harvesters for portable electronics and sensor systems
- Development of new functional materials

The recent significant results:

- Thermoplastic composite substrates for antenna applications
- Screen-printable magnetic-dielectric inks for electronics and telecom applications
- Wideband LTCC integrated piezoelectric energy harvester with high energy density
- Development of new memristor material

Who could utilize the results?

Results can be applied/benefit:

- Material manufacturers as new raw materials for different fields
- Processing industry enabling material development and production as components
- Telecom, electronic and sensor industry utilising composite, hybrid or printable materials in their components and applications.

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Group name

Microelectronics and Material Physics Laboratories

Leader

Professor Anita Lloyd Spetz

Special know-how of the group:

- Material Science and Sensor Science.
- Regarding sensors my research group at Linköping University in Sweden has worked on the development of a soot sensor.

Objectives of the research:

To develop a portable nanoparticle detector which detects nanoparticles according to concentration, size, shape and content, since these are parameters which influence their adverse effect on health of human beings.

The recent significant results:

We started this work January 1, 2011.

- We have processed simple finger electrode structures and we are going to start collect nanoparticles at a steel factory.
- we will evaluate the particles with different analytical methods and also impedance spectroscopy, a method with potential to distinguish different size of the particles.
- We will also use tailor made synthesized carbon nanotubes in the laboratory for the development of the nanoparticle sensor.

Who could utilize the results?

Almost all people but especially those that are working with nanoparticles in production or research.

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Group name

MoMic

Leader

Dr Janne Remes

Special know-how of the group:

- Microelectronics
- Transducer technology particularly piezo-based materials
- Thin film techology
- Photonics, focused ion beam technology
- Materials technology

Objectives of the research:

To develop nanotechnology enabled measuring and imaging properties for new-type of biomedical diagnostics devices.

The recent significant results:

Design, fabrication and proof-of-concept of the device.

Who could utilize the results?

The results will be utilised for parasite infection diagnostics and other diseases in third countries.

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Group name

Analytical Chemistry and Bioanalytics Research Group, CEMIS-OULU

Leader

Dr Vesa Virtanen

Special know-how of the group:

- Research and development of Electrochemical and optical biosensors
- Sensor surface modification with nano-materials and characterization
- Micro-fluidics and sample handing.
- Development of bio-measurement methods and standard procedures

Objectives of the research:

To develop biosensors and biomeasurment methods for applications in wellbeing technology, environmental monitoring and mining industry.

The recent significant results:

- Completion of development of a-amylase biosensor (electrochemical method).
- Development of D- and L-lactate biosensor (electrochemical detection).
- Biosensing method for rapid detection of drugs in saliva (optical SPR method)
- Development of a microfludic sample preparation unit
- Develoment of three different electro- oxidative methods for the detection of Insulin, carbohydrates and para-nitrophenol using nanomaterials to enhance the electrochemical working electrode surface.

Who could utilize the results?

- Wellbeing technology (monitoring physiological stress e.g. in care units of senior citizens or in sport medicine).
- Mining industry
- Manufacturers of measurement instruments

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Group name

Department of Otolaryngology

Leader

Professor Ilmari Pyykkö

Special know-how of the group:

- Inner ear imaging
- Physiology and histology of the auditory system.

Objectives of the research:

To deliver drug, genes, and neurotrophin to the cochlea using nanoparticle.

The recent significant results:

- Distribution of lipid nanocapsules and polymersomes in the inner ear post-intratympanic administration.
- MRI visualization of novel superparamagnetic iron oxide nanoparticles and liposomes in the inner ear.
- Gene expression using liposome and hyperbranched polylysine nanoparticles.

Who could utilize the results?

These results can be applied to treat hearing loss and deafness.

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Group name

Porous silicon research groups

Leader

Adjunct professor Jarno Salonen

Special know-how of the group:

- Industrial physics has been focused on the use of thermoanalytical and x-ray diffraction methods in materials research.
- It has collaborated with national and international phamaceutical industry for decades already.
- aboratory has also expertise in research of nanoporous materials in drug delivery and gas sensing applications.

Objectives of the research:

- Development targeted nanoparticlate drug carrier platform.
- Nanoporous gas sensing arrays.
- Multistage drug delivery systems.
- Novel thermoanalytical methods.

The recent significant results:

- Thermal carbonization makes TiO_2 nanotubes semimetallic enabling new type of applications of them.
- We have developed a dual function electo-optical nanoporous silicon gas sensor with enhanced selectivity
- .Sustained in vivo release of peptides using nanoporous silicon drug carriers.
- Enhanced drug permeation using nanoporous silicon nanoparticles.

Who could utilize the results?

Application areas are:
- phamaceutics
- diagnostic
- chemical sensing
- gas sensors.

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Group name

Surface Science Laboratory

Leader

Professor Mika Valden

Special know-how of the group:

- Our core expertise is in experimental investigation of the nanostructure, chemical composition, morphology and reactivity of surfaces.
- We synthesize novel nanostructures, surface coatings and thin films.
- Our special know-how includes utilization of synchrotron radiation in materials science as well as the design and construction of complex ultra high vacuum (UHV) based research systems.
- We also conduct surface analytical contract research for industries.

Objectives of the research:

We are investigating phenomena at surfaces and interfaces of biomaterials, nanostructured materials and semiconductor materials. The main objectives are to gain insights into the physicochemical surface and interface properties at molecular level and to develop novel materials by functionalizing surfaces on the nanometer scale.

The recent significant results:

- Deep insights into the nanoscale physicochemical processes taking place during the oxidation of metals and metal oxides.
- Synthesis of robust, uniform nanoscale silane layers on stainless steel.
- Development of novel biofunctional layers for covalently binding specific proteins on stainless steel surfaces.

Who could utilize the results?

Potential applications include a wide range of topics in materials science and technology: for instance, corrosion, steel manufacturing processes (e.g. bright annealing), nanoscale coating of metals and metal oxides, sensor technologies, anti-microbial surfaces, enzyme catalysis on surfaces, nanobiotemplates and novel materials for biomedical diagnostics.

Our results are already being exploited by the Finnish metal industry (Outokumpu Stainless Oy and the FIMECC Ltd. cluster).

We are currently exploring applications for our biofunctional surfaces in collaboration with foreign and domestic industry and investors, as well as via our own spin-off company.

Contact

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Group name

Magnetism and Superconductivity, Wihuri Physical Laboratory

Leader

Prof Petriina Paturi

Special know-how of the group:

We can make and characterize nanograined materials and thin films with nanosized inclusions of different materials. The experimental methods available are laser deposition of thin films, AFM/STM/MFM/EFM, dc- and ac-magnetometers (1.9 - 500 K, 0-9T), resistivity (1.9 -350 K, 0-30 T), x-ray diffraction with texture analysis, photolithography and furnaces etc for synthesis.

Objectives of the research:

- To nanoengineer flux pinning sites into high temperature superconductors, theoretical modelling of flux pinning.
- Preparation of nanosized powders by sol-gel.
- We also study complex magnetic oxides (mainly perovskites) and their properties.

The recent significant results:

We have shown, both experimentally and theoretically, that the optimal pinning site density and size in high temperature superconductors depends on the intended magnetic field and temperature.

Who could utilize the results?

The results can be used in improving and developing power applications of superconductivity, e.g. generators, fault current limiters, which require large magnetic fields and temperatures.

Contact

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Group name

Nanophysics

Leader

Prof Kurt Gloos

Special know-how of the group:

We specialize in the properties of point-contact interfaces between metals. Instead of the conventional nano-lithography we use bulk metals (like wires or foils) as electrodes to fabricate mechanically-controllable break junctions, spear-anvil or shear type contacts. The experiments are carried out at low temperatures from about 10 K and down to less than 0.1 K. The contacts can be changed at such low temperatures, allowing us to measure their properties as function of interface area.

Objectives of the research:

We investigate the properties of small 'devices' with sizes in the nanometer range. Those devices can be quite complex, but the most simple ones are point contacts between two pieces of metal. Such a contact represents a constriction across which electrons can be accelerated, and their scattering processes observed. Spectacular results can be achieved when at least one of the electrodes is either superconducting or magnetic.

Keywords:

- Point-contact spectroscopy on superconductors and magnetic metals,
- Josephson effect
- Andreev-reflection spectroscopy and its application.

The recent significant results:

- Demonstration that the so-called zero-bias anomaly of point contacts is reproducible when the contact area is changed over a wide range and for a large number of different metals.
- The ambiguity of spin polarization and lifetime effects at superconductor - normal metal contacts where the normal metals are either ferromagnets (like iron) or noble metals (like gold).

Who could utilize the results?

The properties of superconductor-ferromagnet interfaces could, in the widest sense, benefit every one who is working in the field of spintronics.

Possible applications:

- ICT & Electronics & Semiconductors,
- Sensors, research & metrology.

Contact

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Group name

Material Physics

Leader

Prof Kalevi Kokko

Special know-how of the group:

- The growth (manufacturing) and characterization of novel thin films.
- The preparation methods of the materials based on the vacuum technology, and the characterization expertise includeing photoelectron spectroscopy (also synchrotron-radiation based one), scanning tunneling microscopy, and diffraction probes.
- First-principles computational research on metallic and semiconducting alloys and compounds, emphasizing on different atomic-scale processes and their implications on the macroscopic properties of materials.

Objectives of the research:

To investigate surfaces of metallic alloys and compound semiconductors at atomic level and develop new proposals for improved constructions for the development of practical applications.

The recent significant results:

- New type of oxide layers on compound semiconductors.
- Tin-assested deoxidation of compound semiconductors.
- New model of Cr effect on corrosion resistance in Fe-based alloys.

Who could utilize the results?

- Electronics: new materials and properties can be united with the established semiconductor-based technology, e.g., improved transistor.
- Optoelectronics: development of efficient multijunction solar cells.
- Sensor technology based on changes in surface properties.
- Preparation of new well-defined materials and discovering their properties.
- Surface finishing and corrosion protection of alloy surfaces

Contact

Kalevi Kokko (kalevi.kokko@utu.fi)

Group name

Materials Chemistry

Leader

Prof. Carita Kvarnström

Special know-how of the group:

- Characterization (and some synthesis) of derivatized fullerenes with self ordering or complexing properties, graphene oxide and reduced oxide films.
- Electrosynthesis and characterization of organic electroactive materials like functionalized conducting polymers (redox active, chiral or low band gap n- and p-type polymers.
- Characterization of the opto-electronic properties of the organic materials.
- Simultaneous recording of electrochemical and spectroscopical parameters so called in situ spectroelectrochemical measurements in the Uv-vis, FTIR and Raman region.

Objectives of the research:

Preparation and characterization of thin films and well ordered structures of organic semiconductor materials or electron transfer materials (as electronically conducting polymers, fullerenes, graphenes) and of hybride materials i. e. composites of organic semiconductors and metallo-organic complexes or different oxides as titanium dioxide etc.

The recent significant results:

- Development of the in situ ATR-FTIR technique for spectroelectrochemical in situ recording of very thin films.
- FTIR spectra of organic films of thickness down to a few nm are recorded simultaneously as they undergo controlled electrochemical reactions. Both structural and electronic changes can simultaneously be monitored in the film.
- In situ FTIR recording of electrochemical reduction of graphene oxide sheets.

Who could utilize the results?

- Organic acceptor-donor material can be applied in ambipolar transistors.
- Reduced graphene oxide thin films can be applied in optoelectronic devices or as tools in bioimaging.
- Organic electroactive materials can be applied as active layers in organic solar cells as parts in sensors, transistors, LED:s or in memory devices.

Contact

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Group name

Materials Science

Leader

Prof Edwin Kukk

Special know-how of the group:

- Synchrotron radiation electron and ion spectroscopy
- Coincidence spectroscopies
- Preparaption of gas pahse cluster beams.

Objectives of the research:

Study of metal micro- and nanoclusters:

- Electronic structure
- Interaction with x-rays
- Dissociation

The recent significant results:

Developed cluster source suitable for gas phase electron and ion spectroscopy.

Who could utilize the results?

The research is basic science in nature.

Contact

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Group name

Atomic Hydrogen Research Group

Leader

Dr. Sergey Vasiliev

Special know-how of the group:

- Techniques necessary for conducting experiments at low temperatures and in high magnetic fields.
- Methods of magnetic resonance: Electron Spin Resonance, Nuclear Magnetic Resonance, Electron-Nuclear Double Resonance.

Objectives of the research:

- Reaching quantum degeneracy in systems with high concentration of H atoms.
- Detecting phenomena of Bose-Einstein Condensation, superfluidity, metallic conductivity and possibly superconductivity.

The recent significant results:

- We have clarified the origin of the magnetic fresonance shifts caused by the interactions between H atoms.
- We found a spontaneous condensation of magnons in high densit atomic hydrogen gas into the state with lowest energy, similar to the phenomenon of BEC.

Who could utilize the results?

The results may have some use for the improvement of the stability of atomic clocks and frequency standards based on cold atomic gases.

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Group name

Nanophysics

Leader

Prof. Kurt Gloos

Special know-how of the group:

We specialize in the properties of point-contact interfaces between metals. Instead of the conventional nano-lithography we use bulk metals (like wires or foils) as electrodes to fabricate mechanically-controllable break junctions, spear-anvil or shear type contacts. The experiments are carried out at low temperatures from about 10 K and down to less than 0.1 K. The contacts can be changed at such low temperatures, allowing us to measure their properties as function of interface area.

Objectives of the research:

- We investigate the properties of small 'devices' with sizes in the nanometer range. Those devices can be quite complex, but the most simple ones are point contacts between two pieces of metal. Such a contact represents a constriction across which electrons can be accelerated, and their scattering processes observed. Spectacular results can be achieved when at least one of the electrodes is either superconducting or magnetic.
- Point-contact spectroscopy mainly on superconductors and magnetic metals Josephson effect.
- Andreev-reflection spectroscopy and its application, for example in spintronics.

The recent significant results:

- We have shown that for a large number of metals the zero-bias anomaly of point contacts is reproducible over a global scale, that means when the contact size is varied over orders of magnitude. This opens the way to find the origin of this strange kind of anomaly.
- We have shown that Andreev reflection spectroscopy on ferromagnets gives ambiguous results concerning the spin polarization. In its present status, this technique can not be reliably applied.

Who could utilize the results?

Actually all collegues working in the field of point contact spectrocopy might benefit. Technical applications might be in the field of spintronics.

Contact

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Group name

Nanobiomaterials

Leader

Research Prof. Markus Linder

Special know-how of the group:

- The group combines a knowledge of engineering biological molecules and their functional characterization.
- Recombinant DNA techniques are used for molecular engineering.
- Surface techniques are a special area of focus within biophysical characterization.

Objectives of the research:

The group works at the interface between biological and non-biological materials with a focus on molecular and nano-scale functions. The nanochemistry of biological molecules are used to create materials with new functions. The function of biological materials is studied with the aim of understanding underlying principles and use as a source for bioinspiration.

The recent significant results:

Current projects include; the use of biomolecuels to functionalize carbon nanostructures, the biological interface for sensor applications, specific molecular adhesion, self-assembly of biomolecules, bio-based composites, bioinspired tribology, nano-safety, and bio-based functionalization of cellulose nano-fibers. A biological question that we focus on is the structure and function of adhesive proteins called hydrophobins which are found in filamentous fungi.

Who could utilize the results?

The results can be applied in various materials related fields, such as; senors, nanofabrication, adhesives, nanoencapsulation and lubrication. We also aim at understanding mechanisms for biointeractions and the satety of nanomaterials.

Contact

Research Prof. Markus Linder (markus.linder(a)vtt.fi)
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Group name

Simulation of manufacturing processes

Leader

Dr. Jari Larkiola

Special know-how of the group:

Metal forming technology and metallurgy. In addition we work in close co-operation with University of Strahclyde (UK) and TKK.

Objectives of the research:

To develope methods for industrial manufacturing of micro- and nanostrucured metals

The recent significant results:

We have manufactured ECAP-processed micro/nanostructured aluminium bars

Who could utilize the results?

All components where ultimate high strength is required

Contact

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In addition to the mentioned leader, the research profile includes the research of:

Jouko Virta

Group name

Nanoelectronics

Leader

Prof. Jouni Ahopelto

Special know-how of the group:

- Nanoscale electronics
- Nanoimprinting
- Characterisation

Objectives of the research:

1) Nanoelectronics 2) Nanophotonics 3) Nanophononics 4) Nanofabrication

The recent significant results:

1) Demonstration of simultaneous existence of electron and hole gases in ultra thin silicon quantum well
2) Demonstration of directed self-assembly of protein membrane on silicon subrate 3) Large European project on nanofabrication (NaPa, coordinated by us) was selected as one of the success stories in FP6

Who could utilize the results?

Nanostructured surfaces for lighting, nanobiosensors potentially for diagnostics, thermal management for nanoelectronics

Contact

Dr. Mika Prunnila (mika.prunnila(a)vtt.fi)
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Group name

Functional coating and surfaces

Leader

Team leader Amar Mahiout

Special know-how of the group:

- Sol-gel techniques and in general
- Surface treatment and engineering
- Characterization of coating properties

Objectives of the research:

1) To generate added-value for new (large scale) nanocoated metal products of metal industry and to establish a base for new business activity. 2) To give additional value for thin metal coils used in different environments and facing different stresses by manufacturing protective nanocoatings for anti-graffiti purposes instead of conventional paints or lacquers. 3) To get new functional properties for different applications for copper and stainless steel surfaces used in e.g. building and electronics industry 4) To develop sol-gel coatings wihich are suitable for industrial roll-to-roll manufacturing 5) To design and synthesise room light activated antibacterial
(anti methicillin-resistant Staphylococcus aureus, MRSA) hygiene photocatalytic coatings.

The recent significant results:

1) Different conventional (degreasing, etching) and novel (atmospheric plasma, electric discharge) pretreatments were investigated and found to be applicable for sol-gel and ALD coatings 2) Easy-to-clean, wear resistance and corrosion properties of many metallic products/coatings have been improved with the different developed coatings. 3) Enhanced properties for coatings (hydrophobicity, easy-to-clean, corrosion and oxidation resistance, scratch resistance etc.) via different modifications and without changing the appearance of the treated materialsIt was proved that these coating techniques are suitable for large surfaces and industrial production 4) Highly efficient photocatalytic coating materials which are capable of killing MRSA have been developed.

Who could utilize the results?

The results can be applied in construction, processing, transport, electronic, wood and food industry, hospital surfaces, medical devices, etc.

Contact

Team leader Amar Mahiout (amar.mahiout(a)vtt.fi)
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Group name

Inorganic devices

Leader

Dr. Ari Alastalo

Special know-how of the group:

- Application oriented electronic component design and development with a strong materials physics background
- Sintering processes

Objectives of the research:

Development of components, applications and technologies for inorganic printed electronics. These include, but are not limited to sintering processes, transistors and memories.

The recent significant results:

1) Development of a novel electrical nanoparticle sintering process **2**) Operational all-printed $BaTiO_3$ ferroelectric memory components on PET using Gravure-printing.

Who could utilize the results?

Companies working on printed electronics. Companies fabricating for example conductors, antennae, circuit boards. Electronics and communication industry.

Contact

Senior research scientist, team leader Ari Alastalo (ari.alastalo(a)vtt.fi)
www : http://www.vtt.fi/inorganicdevices

Group name

Quantronics

Leader

Dr. Panu Helistö

Special know-how of the group:

- SQUIDs and SQUID applications
- THz detectors and imaging
- Cryogenic electronics and multiplexing
- Superconducting junction devices

Objectives of the research:

1) High performance superconducting and quantum electronics 2) Sensors and sensor systems for industrial and research applications

The recent significant results:

1) Demonstration of high field SQUIDs for MEGMRI 2) Thermoacoustic sound source based on nanowires
3) Superconducting video-rate THz imager

Who could utilize the results?

Combination of MEG and MRI imaging, ultrasonics, space and security

Contact

Chief Research Scientist Panu Helistö (panu.helisto(a)vtt.fi)

Group name

MEMS

Leader

Dr. Jyrki Kiihamäki

Special know-how of the group:

- Silicon based MEMS device process development: deep silicon etching, thin film technology including ALD, wafer bonding and cavity-SOI device fabrication
- Combining of piezo materials into silicon processes
- Use of nanoimprint lithography to MEMS/NEMS fabrication

Objectives of the research:

Development of silicon MEMS processes, process integration, introduction and application of novel process technology and equipment into MEMS fabrication

The recent significant results:

1) Development of visible light Fabry-Perot interferometers **2**) Silicon microresonator development **3**) Studies on ALD nanolaminate layers **4**) Application of HF-vapor to sacrificial layer etching

Who could utilize the results?

MEMS/NEMS device fabrication, suppliers of sensors and miniaturized instruments, semiconductor companies

Contact

Research coordinator Jyrki Kiihamäki (jyrki.kiihamaki(a)vtt.fi
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Group name

Knowlegde centre: Functional Fibre Products

Leader

Technology manager Pia Qvintus

Special know-how of the group:

- Fibre matrices
- Biomaterial applications
- Surface tretament
- Printing techniques

Objectives of the research:

Development of fibre based products by the use on new biopolymers and addition on various functionalities by printing or coating techniques. Main application is packaging.

The recent significant results:

Activities related to the Centre of Nanocellulosic technologies.

Who could utilize the results?

In development of new products and enhancement of competitiveness of existing products of forest industry.

Contact

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Group name

VTT Fine particles

Leader

Team leader Ari Auvinen

Special know-how of the group:

Aerosol based nanomaterials, measurement and characterization of airborne nanoparticles and gases

Objectives of the research:

Techniques for industrial synthesis of nanoparticles. Safe production and use of nanomaterials.

The recent significant results:

Development and patenting of aerosol based synthesis and coating methods for metallic nanoparticles. Development of direct sampling of gas phase nanoparticles for electon microscopy analyses. Development of portable calibration source for airborne nanoparticles.

Who could utilize the results?

Results have already been applied by industry producing and using nanomaterials

Contact

Team leader Ari Auvinen (ari.auvinen(a)vtt.fi)
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Group name

Functional polymers and structures

Leader

Dr. Mika Paajanen

Special know-how of the group:

- Thermoplastic processing of nanocomposites
- Functionalization of nanopartices
- Safe handling of nanopowders

Objectives of the research:

Utilize thermoplastic nanocomposites in applications like:

- Fire retardancy
- UV-protection
- Antimicrobial and antifungal properties
- Electrical insulation
- Thermal conduction

The recent significant results:

- Better transparency of UV protected PP using ZnO nanoparticles
- Optimised flame retarded platics with nanoparticle synergists
- Improved electrical breakdown strenght

Who could utilize the results?

UV-protection, flame retardancy and electrical insulation are very important properties in many mass produced applications.

Contact

Principal scientist Mika Paajanen (mika.paajanen@vtt.fi)
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Group name

VTT

Leader

Senior Scientist Aimo Taipale

Special know-how of the group:

- Air filtration techniques
- Local ventilation system design
- Computational fluid dynamics (CFD)
- Personal protective equipment (PPE) for nanoparticles
- Nanoparticle measurement technologies

Objectives of the research:

- Evaluation and development of nanoparticle exposure control measures
- Industrial hygiene and contamination control
- Occupational health and safety risk management
- Development of nanoparticle measurement techniques

The recent significant results:

- Evaluation of best available technologies (BAT) for controlling nanoparticle exposure in industry
- Development of novel nanoparticle measurement techniques (Pimex monitoring, dustiness measurement)

Who could utilize the results?

Companies producing or using nanomaterials in their prosesses

Contact

Senior Scientist Aimo Taipale (Aimo.taipale@vtt.fi)
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Group name

Molecular Sensors

Leader

Dr., Adj.Prof. Kirsi Tappura

Special know-how of the group:

- Sensor physics
- Physics and chemistry of material surfaces and interfaces
- Synthetic chemistry
- Molecular simulations
- Modelling and simulation of sensors
- Sensor materials and related phenomena
- Sensor electronics

Objectives of the research:

To develop sensing technologies and devices for molecule-specific detection.

The recent significant results:

- A surface-sensitive fluorescence method for molecular detection that enables real-time measurements with enhanced signal levels as well as very high surface-sensitivity and selectivity. The method is highly immune to background fluorescence,
- A novel MEMS sensor exhibiting high Q values both in ambient air and in liquid,
- Self-assembly based high-capacity molecule-specific sensing layers with very low non-specific binding.

Who could utilize the results?

The potential beneficiaries come from a wide range of application areas, such as:

- Medical diagnostics
- Drug discovery
- Drug testing
- Gas detection
- Chemical and environmental monitoring.

Contact

Dr., Adj.Prof. Kirsi Tappura (kirsi.tappura@vtt.fi)

Group name

Organic Electronics

Leader

Prof. R Österbacka

Special know-how of the group:

- Organic Electronics
- Electro-optical properties of disordered organic materials
- Printed electronics
- Solution processable electronic devices

Objectives of the research:

To clarify electro-optical properties of novel materials and to demonstrate novel device concepts based on printed

The recent significant results:

- The demonstration of new ion-modulated transistors
- The reduction of geminate recombination in polymeric solar cells
- The proof of vacuum dipole shift in bulk-heterojunction solar cell materials

Who could utilize the results?

- Materials manufacturing
- Electronics industry
- Paper industry
- Packaging industry
- Printing industry

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Group name

Mössbauer Spectroscopy

Leader

Docent Johan Lindén

Special know-how of the group:

- Mössbauer spectroscopy
- Magnetization measurements
- Solid state smaple synthesis
- Superconducting materials

Objectives of the research:

- To characterize Fe-pnictide superconductivity using Fe-57 Mössbauer spectroscopy
- To studdy and understand the phenomenon of charge-ordered and valence-mixed perovskites
- To characterize other interesting magnetically ordered solids

The recent significant results:

Observation of discontinuity in the hyperfine parameters of superconducting FeSe and Fe(Se,Te) around the critical temperature of the superconducting state.

Who could utilize the results?

Understanding the mechanism behind superconductivity in Fe-pnictides is a goal that many researcher want to achieve. Our measurements can contribute to the formulation of an adequate theory. Also people doing research on other magnetic phases can benefit.

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Group name

Analytical Chemistry

Leader

Prof. Ari Ivaska

Special know-how of the group:

Electrochemical and spectroelectrochemical characterization of conducting polymers and carbon compounds

Objectives of the research:

Development and characterization of electroactive materials for chemical sensors

The recent significant results:

- Modeling of the response of chemical sensors,
- Development of methods of characterization of electroactive materials.

Who could utilize the results?

Materials in solar-cells and electronic devices as well as in chemical sensors

Contact

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Group name

Laboratory of Paper Coating and Converting

Leader

prof. Martti Toivakka

Special know-how of the group:

- Paper as a substrate for for functional surfaces and printed electronics applications.
- Surface and porous structure characterization.

Objectives of the research:

Creation of large area nanoparticle surfaces in roll-to-roll processes for novel natural fiber-based products.

The recent significant results:

- Generation of nanoparticle surface on paper allowing for wettability conversion.
- Demonstration of functioning all-printed organic transistors on paper.

Who could utilize the results?

- Smart packaging and sensor applications
- Paper and board for graphic communication
- Printed electronics

Contact

prof. Martti (Martti.Toivakka@abo.fi)

Group name

Laboratory of physical chemistry

Leader

professor Jouko Peltonen

Special know-how of the group:

Laboratory has long traditions in surface and colloid chemistry. Recent focus areas in materials research include:

- Self-assembled systems and organized monomolecular films
- Hierarchical structures, sol-gel processing and biomaterials
- Functional porous nano-materials, surfaces and interfaces
- Thermodynamic modelling of materials
- Drug development, diagnostics and printed functionality (e.g. electronics)

Versatile instruments for characterization of the crystallographic, topographic, spectroscopic, solution chemical and thermodynamic properties of materials.

Objectives of the research:

- Synthesis and characterization of nanoporous, mesoporous and non-porous micro- and nanoparticles for applications in the fields of medical, diagnostic and energy (solar cell) technology.
- Functional materials for printed functionality is another focus area.

The recent significant results:

- Cancer-cell targeting and cell-specific delivery by multifunctional mesoporous silica nanoparticles
- Topography and wetting of pigment and metal oxide coated substrates
- Sol-gel derived adhesives for industrial use
- Electrokinetics of ionic surfactants, and printed functionality (e.g. transistors on paper-based substrates, reaction plates for biosensors, printed drugs, and electronics demonstrators).

Who could utilize the results?

- Functional materials for printed electronics, medical and environmental diagnostics and energy industry (e.g. solar cells).
- Targeting cancer cells by design of mesoporous metal oxides, and printable array platforms for cell studies, aim for therapeutic applications.
- Development of printable pharmaceutical oral dosage forms, i.e. medicines, has numerous potential applications in pharmaceutical industry.

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Group name

Industrial Chemistry

Leader

Prof. Dmitry Murzin

Special know-how of the group:

The activities are focused on the design, synthesis, and possible applications not only of materials with special functionalities, but also of complex mixtures with specific properties, which could be used in a variety of areas, ranging from fuels to fine chemicals and pharmaceuticals. Among the new materials which are actively researched at PCC are various micro- and mesoporous materials, which are synthesized by different methods and then subjected to modification, e.g. by introduction of metals. The intimate interactions between the metal and sites are sensitive to the applied treatment and could be fine tuned in a way that the molecularly engineering materials have, for instance, a specific acidity. Besides metal-supported zeolites and mesoporous materials, also materials with hierarchical micro-mesoporous structure, as well as metals on other supports, like alumina, silica, active carbon, carbon nanofibres to name a few, were used in heterogeneous catalytic reactions, including hydrogenation, ring opening, skeletal isomerization, dimerization, oxidation, pyrolysis of biomass.

Objectives of the research:

Nanosized catalytic materials: preparation, characterization and testing in various catalytic reactions

The recent significant results:

A particular challenging was development of catalysts, containing gold, which was considered for centuries as catalytically inactive. Various types of supported gold catalysts, including structured ones, were synthesized and tested in reactions, involving carbohydrates, e.g. oxidation, hydrogenation and isomerization of mono- and disaccharides. For example, in the oxidation of lactose to lactobionic acid, gold catalysts turned out to be superiour to classical Pd catalysts. A special way in molecular engineering of catalysts is to have metals in non-zero valence state dissolved in a liquid layer, attached to the solid surface. Immobilization of ionic liquids onto solid materials with subsequent introduction of catalytically active species palladium species and testing the catalyst in liquid phase hydrogenation of citral demonstrated the big potential of this novel catalytic systems

Who could utilize the results?

The development of new products and processes nowadays is indispensable from the application of the principles of green and sustainable chemistry. One of the cornerstones of sustainable technology is application of catalysis, since catalytic reagents are superior to stoichiometric reagents. Our activities cover mainly heterogeneous catalysis and the results could be applied across various industries ranging from oil refineries to pharmaceuticals.

Contact

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European Union
European Social Fund

Leverage from
the EU
2007–2013

Elinkeino-, liikenne- ja
ympäristökeskus