H6L3
Capita Selecta of Nanoscience and Nanotechnology
&
H6N2
Erasmus Mundus Lectures on Nanoscience and Nanotechnology

Prof. dr. ir. Herman Maes
K.U. Leuven, Belgium

IMEC, Kapeldreef 75,
B-3001 Leuven, Belgium

Program and Abstracts

Academic Year 2011-2012
Introduction

Nanoscience and nanotechnology are important and relatively new disciplines and as such are accompanied by many uncertainties as to their impact on modern society. It is expected that nanotechnology will eventually impact on every area of our world and on every aspect of our lives. Nanotechnology is a new category of technologies that involve precise manipulation of materials at molecular or even atomic scale in such a way that it allows to exploit the novel properties that emerge at such scales. Nanotechnology does not only refer to techniques that are used to study the world at nanometer scale (the scale of a few atoms) but also to the technology used to design and fabricate the building blocks with nano-scale precision. These building blocks will allow the development of revolutionary new materials, new applications in the bio field and in information technology, consumer articles and appliances, a promise already made for years now by nano-scientists. But when can we really expect that these new applications will massively become available? And how can and will we deal with these technologies in a responsible way?

These are the type of questions that are treated in the Series of Lectures on Nanoscience and Nanotechnology of which you can find the program and details on time, location and content in this announcement.

In the academic year 2011-2012, we organize for the 6th year in a row an exciting program, Capita Selecta of Nanoscience and Nanotechnology, that comprises 13 lectures that will be given by local and international experts on various and very divergent topics such as new important developments in nanotechnology, the opportunities for nanotechnology applications and some business aspects.

These Lectures are organized in the frame of the Courses H6L3 “Capita Selecta of Nanoscience and Nanotechnology” within the Master of Nanoscience and Nanotechnology at the K.U.Leuven and H6N2 “Erasmus Mundus Lectures on Nanoscience and Nanotechnology” within the Erasmus Mundus Master program of the partner universities K.U.Leuven, TU Dresden, Chalmers University and the Université Jean Fourrier Grenoble. These lectures are therefore compulsory for the students in both Master programs. In fact, students have to follow at least 20 lectures in 2 consecutive years and have to produce a report each year. The lectures are however also open to everyone interested in the latest new developments and in the important scientific, fundamental, ethical, societal or legal aspects of nanotechnology.

These lectures are organized in the second semester of the Academic Year 2011-2012 (period February – May 2012).

Based on the reports and feedback from students and other participants in the previous years and on their suggestions for topics of high interest to them, we have once again tried as much as possible to meet these wishes.
These suggestions included:
• TunnelFET devices
• Non-technical lectures on either business, ethical, environmental issues
• Biosensing
• Characterization of advanced devices
• Health related issues
• Transport in nanomaterials and devices
• Carbon Nanotubes applications and integration
• Biotechnology related topics
• Organic/flexible electronics

Looking at the program that we have put together, it will be clear that we have been able to accommodate some of these wishes.

The types of topics treated this academic year are shown in the next Table:

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<th>Topic type</th>
<th>Advanced nano-electronics</th>
<th>Nano-materials and -technology</th>
<th>Bio-sensors</th>
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The origin of the lecturers is given in the next Table:

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<th>Origin of Lecturers</th>
<th>University</th>
<th>R&amp;D Institute</th>
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All lectures are broadcast live to all participating universities using a Virtual Classroom concept. This process is technically coordinated by the AVNet (Audio-Visual department of the K.U. Leuven). The 7 lectures that are broadcast from Leuven, will be held in the Auditorium “De Molen”, Celestijnenlaan, Heverlee. The other lectures will be broadcast from Chalmers, Sweden (2), Dresden Germany (2) or Grenoble, France (2). All lectures are always followed by a discussion session involving the lecturers, the students and nanotechnology professionals.

We look forward to an exciting new Capita Selecta season and hope to welcome you at one of these lectures.

Prof. Herman Maes, Coordinator H6L3
15 December 2011
Capita Selecta of Nanoscience and Nanotechnology

Program, Abstracts and CV’s

Program

Tuesday, 14 February 2012, 5-7pm (Broadcast from Leuven, Aud. “De Molen”)
Prof. Jo De Boeck, imec and K.U.Leuven, Belgium
From paper to profit....

Tuesday, 21 February 2012, 5-7pm (Broadcast from Grenoble)
Dr. habil. Michael Holzinger, UJF, Grenoble, France
Carbon Nanotubes : a versatile material for biosensors and bio-energy conversion

Tuesday, 28 February 2012, 5-7pm (Broadcast from Dresden)
Dr. Martin Mkandawire, TUDresden, Dresden, Germany
Environmental Nanotechnology

Tuesday, 6 March 2012, 5-7pm (Broadcast from Leuven, Aud. “De Molen”)
Prof. Peter Peumans, imec and K.U.Leuven, Belgium
Nanoelectronics enabling novel life sciences tools for a preventive predictive healthcare system

Tuesday, 13 March 2012, 5-7pm (Broadcast from Chalmers)
Prof. Elsebeth Schröder, Chalmers University of Technology, Gothenburg, Sweden
Atomic-scale theory of sparse nano-materials

Tuesday, 20 March 2012, 5-7pm (Broadcast from Leuven, Aud. “De Molen”)
Prof. Leo J. van Ijzendoorn, Eindhoven University of Technology, The Netherlands
Biosensing Technology based on Magnetic Particles

Tuesday, 27 March 2012, 5-7pm (Broadcast from Leuven, Aud. “De Molen”)
Prof. Bruce McNaughton, University of Lethbridge, Canada
Doughnuts in the Brain: Periodic Boundary Conditions on the Brain’s Spatial Coordinate System

Tuesday, 17 April 2012, 5-7pm (Broadcast from Chalmers)
Dr. Samuel Lara-Avila, Chalmers University, Goeteborg, Sweden
Magnetotransport in Epitaxial Graphene (SiC/G)
Tuesday, 24 April 2012, 5-7pm (Broadcast from Leuven, Aud. “De Molen”)
Dr. Anne Verhulst, imec, Leuven, Belgium
**Tunnel-FETs to replace MOSFETs in future nano-electronics**

Wednesday, 2 May 2012, 5-7pm (Broadcast from Leuven, Aud. “De Molen”)
Dr. Stephanie Teughels, Pepric, Heverlee, Belgium
**The PEPRIC spin-off story (Molecular Imaging)**

Thursday 8 May 2012, 5-7pm (Broadcast from Dresden)
Prof. Lucas Eng, TU Dresden, Dresden, Germany
**Metal Nanoparticle Antennas for Tuning the Linear and Nonlinear Optical Local Interactions**

Tuesday, 15 May 2012, 5-7pm (Broadcast from Leuven, Aud. “De Molen”)
Prof. Liesbet Lagae, imec and K.U.Leuven, Leuven, Belgium
**Functional Nanosystems for cellular and biomolecular interfacing**

Tuesday, 22 May 2012, 5-7pm (Broadcast from Grenoble)
Prof. Cyrille Train, INCMI/CNRS, Grenoble, France
**Molecule-based magnets, a pole of attraction for chemists and physicists**
Capita Selecta of Nanoscience and Nanotechnology

Abstracts & CV’s
Tuesday, 14 February 2012, 5-7pm
Prof. Jo De Boeck, imec and K.U.Leuven, Belgium

From paper to profit....

Major breakthroughs in materials, process technology and device concepts can have great impact in applications. Such potential impact is often enthusiastically described in the introduction of most research papers. Not all predictions of such impact materialize, but some do. In this lecture some examples will be discussed of impactful innovations in the broad arena of semiconductor technology and materials and their route to successful implementation in industry. Recurrent patterns in such innovation tracks, success factors and pitfalls will be discussed.

Prof. Jo De Boeck

Jo De Boeck received his engineering degree in 1986 and his PhD degree in 1991 from the University of Leuven. Since 1991 he is a staff member of imec (Leuven). He has been a NATO Science Fellow at Bellcore (USA, 1991-92) and AST-fellow in the Joint Research Center for Atom Technology (Japan, 1998). In his research career, he has been leading activities on integration of novel materials at device level and new functionalities at systems level. In 2003 he became Associate Vice President at IMEC for the Microsystems division and in 2005 started Holst Centre (Eindhoven) and became CEO of IMEC-Netherlands. From 2009 to 2011 he headed imec’s unit Smart Systems and Energy Technology as Senior Vice President in the imec group. In 2011 he was appointed CTO of imec corporate. He is part-time professor at the KU Leuven and visiting professor at the TU Delft.
Tuesday, 21 February 2012, 5-7pm
Dr. habil. Michael Holzinger, UJF, Grenoble, France

**Carbon Nanotubes: a versatile material for biosensors and bio-energy conversion**

Carbon nanotubes (CNTs) are promising alternatives as building blocks in bioelectrochemical devices due to their unique electrical, mechanical properties, and their high specific surface. In the past decade, the development of biosensors and biofuel cells based on carbon nanostructures were focused. However, the spatially controlled deposition of the biomolecules on nanostructured transducer is a consistent obstacle which has to be overcome. Within this context, nano-architecture associating carbon nanotubes with different nano-objects via organic or organo-metallic connectors to immobilize bioreceptor units led to the construction of high performance biosensors. Beyond immobilization strategies, redox enzyme wiring on nanotubes enabling direct or mediated electron transfer opens possible applications in generating renewable energies. Indeed, CNTs have shown to be particularly appropriate to establish electronic communication with redox enzymes since the thin diameter can be approached closely to the redox active sites enabling therefore the regeneration of the biocatalysts either by direct electron transfer or with the help of so-called redox mediators which serve as intermediated for the electron transfer. The possibility to capture the enzymatic redox processes by obtaining catalytic currents, the use of such CNT-enzyme electrode for biological energy conversion represents a challenging task. The development of CNT based enzyme biofuel cells is a still young but steadily growing research topic where original approaches to construct electron transfer based CNT-bioelectrodes were developed.

**Dr. habil. Michael Holzinger**

Michael Holzinger works since the late nineties in the field of functionalization of single-walled carbon nanotubes. During his Ph.D work in the group of Prof. Dr. Hirsch at the Institute of Organic Chemistry, University Erlangen-Nürnberg, Germany, he firstly reported several new organic chemical reactions for the exoheral modification of nanotubes. After his Ph.D. he joined the group of Patrick Bernier at the university Montpellier II, France, and later at the Max Planck Institute for solid state research in Stuttgart, Germany, in the group of Sigmar Roth where he worked at new functionalization method for hetero nanotubes and nanotube based composites. After a short stay at the Robert Bosch GmbH in Schwieberdingen, he joins the group BEA of Serge Cosnier at 2006. Since that time his research interest is focused on the development of biosensors and biofuel cells based on functionalized nanomaterials.
Tuesday, 28 February 2012, 5-7pm
PD Dr. Martin Mkandawire, TU Dresden, Dresden, Germany

Environmental Nanotechnology

The growing interest in nanoscience as well as nanotechnology is affecting the environmental engineering field both positively and negatively. The positive aspects include intra alia, the potential of using nanomaterials and nanotechnology to improve the environment, which includes cleaning up existing pollution, improving manufacturing methods to reduce the generation of new pollution, and making alternative energy sources more cost effective. On the negative aspects, the interaction of nanomaterials with human and the environment has increased exponentially, yet most nanomaterials have special reactivity resulting from their unique physico-chemical properties and size. Consequently, nanomaterials may have potential toxicological impact in the environment and human health. In view of this, we established a Sub-group of Environmental Nanotechnology to research and teach objectively balanced nanotechnology, where nanotechnology is employed to help our ailing environment on one hand; while on the other, ways of developing safe nanomaterials are investigated vis-à-vis nanomaterials with minimum detrimental effects on human and environmental health. Thus, in the public lecture, we discuss some detailed examples of potential and contemporary application of nanotechnology to environmental issues. For instance, we will discuss the importance of classification of nanomaterial; the application of nanomaterials in clean and green production (i.e. generating less pollution during the manufacture of materials using nanoclusters as catalysts); the potential of nanomaterials in cost-effective production of solar cells and cleaning up chemical pollutants and disinfection of water; and, many others. In last part, we will however, discuss the potential hazards posed by some nanomaterials.

PD Dr. habil. Martin Mkandawire

Martin Mkandawire graduated in physical Chemistry from University of Malawi in 1992 and TU Dresden in 1995. He received MSc degree in 1998, PhD in Environmental Chemistry and Engineering in 2004, and Habilitation degree in Environmental Nanotechnology in 2009. He has been affiliated to different institutes of the TU Dresden in Germany for more than 15 years, where he has worked in different research position in aquatic remediation and toxicology of uranium and arsenic as well as nanobiotechnology. Currently, he is “Privatdozent” for Environmental Nanotechnology in the TU Dresden. His current research focus and activities include, intra alia, development and applications of nanobiosensors devices in environment, biofunctionalisation of inorganic surfaces and living microorganism, use of nanomaterials as catalyst for in water treatment and remediation, real-time tracking of nanomaterials in living cells, as well as using biogenic synthesis of nanowires for electronic and biosensor development.
Nanoelectronics enabling novel life sciences tools for a preventive predictive healthcare system

By intimately connecting biology to integrated microsystems, one radically changes our approach to life sciences. Not only does it lead to smaller and cheaper solutions that replace older technology, but it also enables one to tackle problems that were hitherto intractable. IMEC has invested for a decade in the area life sciences and as a result, has built up expertise in molecular and cell biology, and has developed a set of highly-performing building blocks for life science systems. IMEC is now taking the next logical step to use its core strengths to build systems that are very-large-scale in terms of capabilities and performance, but small in physical size and cost. The impact of such systems on important life science problems such as neurodegenerative brain diseases, cancer, and diabetes, will be discussed.

Prof. Peter Peumans

Peter Peumans leads the lifescience activities at imec as the director of the Bio- and Nanoelectronics Department and Human++ program manager. Prior to joining imec, Dr. Peumans was a Professor in the Electrical Engineering Department at Stanford University. He obtained his PhD from Princeton University and MS from the KULeuven.
Atomic-scale theory of sparse nano-materials

The past few years has brought renewed focus on the physics behind the class of materials characterized by long-range interactions and wide regions of low electron density, sparse matter. Much work has recently been focused on developing the appropriate algorithms and codes able to correctly describe this class of materials. Such materials present challenges, for example, for development of suitable density functional theory (DFT) calculations, the workhorse for predictive characterizations of general matter. The computational challenges arise because accurate descriptions of such systems demand consistent inclusion of dispersive or van der Waals (vdW) forces. In this lecture, I will discuss the nature of the vdW forces and the DFT method development. I show a few examples of the large variety of materials for which the vdW forces are essential for understanding of the materials structure, and I discuss the changes caused by the vdW bonding.

Prof. Elsebeth Schröder

With a background in string theory, Elsebeth Schröder while at the Niels Bohr Institute in Copenhagen started her research in turbulence and pattern formation, providing analysis and theory development for surface turbulence. She later contributed to field-theoretical descriptions of liquid crystals while a postdoc. at Universität Bayreuth, Germany. Now, at Chalmers, Elsebeth Schröder is a long-standing contributor to the development, implementation, and testing of the van der Waals density functional (vdW-DF) method. The vdW-DF development proceeds primarily within long-standing collaborations with the groups of late Prof. D.C. Langreth (Rutgers) and Profs. B.I. Lundqvist and P. Hylgaard (Chalmers) and aims to extend the reach of efficient, first principle DFT calculations to the very broad class of sparse matter (systems which have important regions with low electron density). Her work includes development of theory, application of the method to specific materials systems, and testing.
Biosensing Technology based on Magnetic Particles

Point of care biosensors for proteins at the pM concentration regime are feasible using superparamagnetic particles as labels in immunoassays [1]. This technology involves magnetic particle actuation in microfluidic chambers and uses magnetic forces to discriminate specific and non-specific bonds at a sensor surface. The biochemical and physical interactions of the functionalized particles with the biosensor surface play a key role in the molecular association and dissociation processes. In this talk I will discuss magnetic particle actuation as a toolbox to investigate and quantify molecular interactions and to reveal molecular properties.

Using magnetic field gradients, pulling forces can be applied on magnetic particles that are bound by protein pairs to a surface and molecular dissociation rate constants can be obtained. By applying rotating magnetic fields, torque can be induced on individual particles and the measurement of rotation of many individual particles can be used as a probe for particle association at the surface. When the applied torque is quantified, it can be used to quantify the torsion stiffness of proteins captured onto the sensor surface. The data show that different protein pairs have distinctly different torsion moduli.

Finally, the use of magnetic particles as well as non-magnetic particles will be discussed to study the properties and behaviour of living cells.


Prof. Leo J. van Ijzendoorn

Leo J. van Ijzendoorn (1958) graduated in Applied Physics from Leiden University in 1981. He received a PhD at Leiden University in 1985 on the spectroscopy of astrophysically relevant ices. From 1985 to 1991 he worked at Philips Research where he was responsible for ion beam analysis within the Philips Research organisation. In 1991 he was appointed as an assistant professor at Eindhoven University of Technology and continued working on the applications of ion beams originating from a cyclotron. His work had a strong interdisciplinary character ranging from isotope production and applications of positron emission tomography in catalysis to ion beam analysis of polymers and semiconductors. In 1997 he was appointed as associate professor and continued working on the applications of ion beams in materials science until 2004. In 2005 he initiated a new group at the department of Applied Physics together with Prof. M. Prins focused on “Molecular Biosensors for Medical Diagnostics” after a sabbatical at Philips Research in the group Healthcare Devices and Instrumentation. Dr. van Ijzendoorn published more than 100 papers in refereed international journals.
**Doughnuts in the Brain: Periodic Boundary Conditions on the Brain’s Spatial Coordinate System**

The hippocampal formation of the mammalian brain is crucial to the storage and consolidation of 'episodic' memories: memories for experiences that unfold in space and time. The hippocampus accomplishes its role in memory by generating a unique code reflecting the spatio-temporal context of experiences. This code provides a tag or ‘index’ that links together sub-components of a given experience stored in a distributed form throughout the neocortex. The generation of the hippocampal code is founded on internal (a priori) mechanisms for keeping track of spatial location, and for appending information about external and internal events onto an internal spatial coordinate system or 'cognitive map'. Neurons in thalamus and midbrain ('head-direction cells') generate a 1-D periodic signal of relative head orientation in the horizontal plane as animals rotate their heads; cells in medial entorhinal cortex ('grid cells') fire in a strikingly regular, 2-D periodic, spatial pattern ('grid field') when an animal moves about its world. Head-direction and grid cells can be explained by a theory in which the corresponding underlying synaptic matrices determine ring (1-D) or toroidal (2-D; ‘doughnut-like’) manifolds of allowed states (‘attractors’) of network activity. The speed by which the neuronal state is updated relative to the animal’s physical motion in space sets the scale of the 2-D grid field, and there are multiple such grid cell modules, each with a different movement gain, and thus each expressing a different spatial scale. Next, sets of neurons in hippocampus ('place cells'), which receive spatially periodic grid field information at multiple spatial scales, appear to provide unique (‘essentially’ non-periodic) codes for spatial location, by a Fourier synthesis-like summation on their inputs. Finally, external input to this network modulates the firing rate (but not relative location) of place cell firing, thus generating a conjunctive code for ‘what’ happened ‘where’. Although they exhibit a high degree of experience-dependent neural plasticity, these networks appear to be wired up by a self-organizing process in early post-natal development in a manner that is independent of experience (a priori). Thus, in a sense, Immanuel Kant was correct.

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**Prof. Bruce McNaughton**

*Bruce McNaughton* obtained his M.Sc in Biology at the Carleton University, Ottawa, Canada and a PhD in Psychology from the University of Halifax, Nova Scotia, Canada. He is a Professor at the Department of Neuroscience at the University of Lethbridge. He is a visiting scientist in the NERF program in Leuven. The main focus of his research is the physiological and computational basis of cognition, with particular focus on memory and memory disorders, and the dynamic interactions among neuronal populations and synaptic plasticity mechanisms that underlie these phenomena. He has made significant contributions to the understanding of central synaptic plasticity mechanisms, spatial information processing in the hippocampal formation and cortex, cortico-hippocampal interactions and memory consolidation, and the aging of the nervous system. His current activities focus on understanding the neural mechanisms underlying spatial orientation (‘head-direction’, ‘place’, and ‘grid’ cells in the hippocampal formation and associated networks), the reactivation of memory traces in the cortex during sleep following learning and the role of this process in memory consolidation, and the self organization of synaptic networks during early post-natal development of the temporal lobe memory system.
Magnetotransport in Epitaxial Graphene (SiC/G)

Graphene, a single layer of graphite, is steadily making inroads into the applications that presently rely on semiconductors. Current production methods focus on developing large-area graphene suitable for mass production of novel electronic devices. One of such methods consists in annealing silicon carbide (SiC) to high temperatures in a controlled atmosphere; sublimation of silicon leaves behind a carbon-rich surface which, under the right conditions, reconstructs into graphene (SiC/G).

We study the electronic properties of SiC/G through low-temperature magnetotransport. At high magnetic fields, the observed half-integer quantum Hall effect (QHE) confirms the high quality and 2D nature of SiC/G, demonstrating the structural integrity and uniformity of graphene over hundreds of micrometres, as well as reproducible mobility and carrier concentrations across a half-centimetre wafer. In the low-field limit we have measured quantum mechanical corrections to resistivity and separated the electron-electron and weak-localization contributions; we observed phase coherence over a micrometre length scale, setting the spin relaxation time in this material of at least 50 ps.

As for practical applications, we found that in quantum metrology SiC/G outperforms standard semiconductor devices. In particular, we reported the first direct comparison of the integer quantum Hall effect (QHE) in SiC/G with that in GaAs/AlGaAs heterostructures. Judging from the robustness of the quantization and wide operational parameter space, we propose that SiC/G should replace GaAs/AlGaAs and be the material of choice for quantum resistance metrology.

Dr. Samuel Lara-Avila

Samuel Lara-Avila is a PhD student in experimental mesoscopic physics at the Department of Microtechnology and Nanoscience, Chalmers University of Technology; expected to graduate in May, 2012. His current interests are electronic transport through single molecules and graphene.

2005-2007 MSc in Nanoscience and Nanotechnology, KU Leuven (Belgium) & Chalmers University of Technology (Sweden)
2000-2005 Mechatronics Engineer, ITESM (Mexico)
Tunnel-FETs to replace MOSFETs in future nano-electronics

One of the biggest roadblocks in scaling metal-oxide-semiconductor field-effect transistors (MOSFETs) into the sub-10 nm regime, is the increased power consumption due to a lack of supply voltage scaling. The MOSFET’s supply voltage plateau at about 1 V is caused by the MOSFET’s inherent subthreshold swing limit of 60 mV/decade. Performance improvements which create modest supply voltage decreases are obtained by introducing high-mobility materials, like III-V materials or Ge or by incorporating strain. But to really get down to the 0.3 V supply voltage range, an alternative concept is needed. The tunnel FET (TFET) is today the most promising next-generation transistor.

In this lecture, the TFET concept is described in detail, along with the tunneling history. Other innovative transistor concepts are briefly touched upon and evaluated, after which the focus is exclusively on TFET. The design parameters are looked at one at a time, while illustrations from literature are provided. A discussion is given on how such a quantum-mechanical device can be modeled correctly. The predictive part of the lecture is complemented with an overview on experimental realizations. Both literature and the imec processing are covered. The latter has a focus on FinFET and nanowire-based implementations. At the end, a perspective is given on where the TFET is at today.

Dr. Anne Verhulst

Anne Verhulst received the M.Sc. degree in Electrical Engineering from the Katholieke Universiteit Leuven, Belgium, in 1998. She obtained the Ph.D. degree in Electrical Engineering from Stanford University, California, USA, in 2004. In her Ph.D. thesis, she investigated optical pumping techniques to increase the polarization in nuclear-spin based quantum computers. She performed part of her Ph.D. research, from April 1999 until May 2001, at the IBM Almaden Research Center, California, USA. In March 2005, she joined imec where she is currently a senior scientist. Her research has included the areas of nanowires and carbon nanotubes, addressing the identification of useful applications in nanoelectronics. After the identification of the tunnel-FET for future technology nodes, the investigation, understanding and design of this potential successor of the MOSFET became her focus area. She has authored or co-authored 30 publications in scientific peer-reviewed journals, over 50 contributions at international scientific conferences, including 6 first-author invited presentations, and she is an inventor on 10 patents and patent applications.
Overcoming the current limitations in radiology where quantification is often difficult, especially for biological diseases and processes with slow kinetics, Pepric offers quantitative analysis tools to the molecular imaging labs for drug efficacy tests and therapy development. The product portfolio will consist of ex-vivo and in-vivo analytical instruments, in a first phase for the preclinical segment for drug efficacy and therapy development. In a later stage also clinical detection and imaging tools are envisaged for early diagnosis and therapy monitoring using magnetic nanolabels. All tools determine quantitatively the biodistribution of magnetically labeled cells and biomolecules or of the label itself based on the magnetic resonant detection of the nanolabel. Its uniqueness is situated in the Particle Electron Paramagnetic Resonance (P-EPR) method at low fields and low frequencies on iron oxide spin systems with a broad resonance bandwidth, and the implementation of this method into a hardware set-up. Unlike alternatives the resonant method is selective and sensitive, with a reduced heat dissipation in biological tissues. Unlike PET or SPECT using short living radio-isotopes, the labeling with stable magnetic nanoparticles allows monitoring slow kinetic processes.

Pepric nv was founded in 2009 as an incubation start-up of imec. The founders are imec vzw, Peter Vaes and Stephanie Teughels. It is Pepric’s objective to commercialize equipment for quantitative molecular detection and imaging to monitor processes with slow kinetics.

**Dr. Stephanie Teughels**

*Stephanie Teughels* is co-founder and CEO of Pepric. Previous to the start of Pepric, she prepared and assisted spin-off projects at Imec as Venture Development Manager. During her PhD she worked at several international particle accelerator facilities (France, US, Japan) on nuclear magnetic resonance techniques, on dipole and quadrupole resonances, on the production of spin-oriented short living radio-isotopes, and on the detection of gamma and beta radiation.

She obtained a postgraduate degree in Corporate Finance (2006) and a postgraduate degree in Business Administration (2005), and obtained her PhD in nuclear physics (2001), a Master degree in Physics (1996) and a Bachelor degree in Civil Engineering (1992), all at the KULeuven.
Tuning and improving the local interaction by the use of plasmonic nanoantennas has witnessed a huge interest for the last decade. Enhancing the local response in absorption, fluorescence and Raman spectroscopy experiments down to the molecular scale hence becomes possible. Crucial, however, are the effective antenna properties. We have developed protocols to tune individual nanoparticles through photochemical means, thus controlling their shape, material composition, and anisotropy. Tuning may be applied to individual particles, but equally to particle arrays in 2D and 3D. Hence core-shell systems are easily fabricated, such as Au-FePt nanoparticles for magneto-plasmonics. We apply such nanoparticles both in the linear and nonlinear optical regime for enhancing the local absorption, fluorescence and Raman cross sections, but equally use them for tuning efficient second harmonic generation (SHG). Our experimental findings are backed-up by a thorough theoretical modeling involving also the powerful Discontinuous-Galerkin Ansatz that allows us also to treat SHG and two-photon-photoluminescence.

Prof. Lucas Matthias Eng

Lucas Eng is with the Institut für Angewandte Photophysik of the TU Dresden, Germany. He obtained the Diploma in Physics, Chemistry and Mathematics in 1986 and the PhD degree in 1990, both from the University of Basel/Switzerland. From 1990-1991 he was with BASF AG, Germany working on Nanotechnology, SPM, Polymers, LC and small molecules, charge-transfer complexes and LB films. From 1993-1997 he was with ETH Zürich, Institute of Quantum Electronics, working on non-linear optics, MBE, SNOM, SPM and ferroelectrics. In 1998 he obtained the Habilitation in Physics from the University of Basel and became a Full Professor for Experimental Physics/Photophysics/Nano-optics; Surface Plasmons, Ferroelectrics, Polymers, high resolution SPM, single molecules and Nano-(Bio-)Technology. From 2000-2003 he was Dean for Study affairs, Physics Department at the TU Dresden and since May 2003 he is Director of the Institute of Applied Physics.
Tuesday, 15 May 2012, 5-7pm
Prof. Liesbet Lagae, imec and K.U.Leuven, Leuven, Belgium

Functional Nanosystems for cellular and biomolecular interfacing

As research in nanotechnology extends the tools for IC fabrication to nanometer dimensions, new bio-analytical and diagnostic tools are being developed that can interact and detect with biology at the cellular and the molecular level. Lab-on-a-chip systems use versatile nanotechnologies to manipulate, sort and detect cells, proteins and DNA molecules, intelligently combined to do full diagnostic analysis. Nanomagnetics, nanoplasmonics and nanofluidics are emerging scientific fields which may be put at work in these novel biosensing devices and systems. This presentation will give an overview on state of the art nanobiosensing devices in my group at IMEC today.

Prof. Liesbet Lagae

Liesbet Lagae received her degree from the KU Leuven, Belgium for her work on Magnetic Random Access Memories in 2003. She has pioneered the field of molecular biochips based on magnetic, plasmonic and electrical sensing principles at IMEC, Belgium. She is currently research group leader and program manager of IMEC’s HUMAN++ /Life sciences program. She has (co-) authored 72 peer-reviewed papers in international journals and holds 12 patents in the field. She is also part-time professor in nanobiotechnology at KU Leuven/Physics department.
Molecule-based magnets, a pole of attraction for chemists and physicists

Molecular magnetism aims to design, synthesize by chemical means and study by physical methods materials based on spin-bearing (interacting) molecules. This mere definition emphasizes that this field is at the crossroad between chemistry and physics. After recalling fundamental concepts of this field, its intrinsic interdisciplinarity will first be exemplified by results taken from the literature.

The specific properties of multifunctional molecular magnets will then be detailed to show how the close collaboration between chemists and physicists may lead to original results. By introducing and mastering chirality in this type of multifunctional materials, it is possible to observe magneto-chiral dichroism (MChD), a second-order optical effect that can exist only if spatial and time-reversal symmetries are broken simultaneously within a material, as well as Magnetisation-induced Second Harmonic Generation (MSHG).

Multiferroics are materials that combine ferromagnetism and ferroelectricity. They appear as essential materials for the development of spintronics. Current efforts towards molecular multiferroics will be presented as an open conclusion to this lecture.

Prof. Cyrille Train

Cyrille Train received his PhD degree in Material Science from the Université Paris XI in 1998. It was directed by Dr. C. Chappert and devoted to the magneto-optical properties of ultrathin metallic layers. Then he joined Prof. M. Verdaguer's group at UPMC-Paris 6 as an Assistant Professor to study molecular materials combining magnetism and chirality. He also developed the coordination chemistry of verdazyl-based compounds. In 2009, he was awarded a JSPS fellowship to stay in Prof. S.I. Ohkoshi's group at Tokyo University and joined Université Joseph Fourier as a Professor to develop molecular chemistry in relation with the high magnetic field facilities of LNCMI. In 2011, he was elected as a Junior Member at Institut Universitaire de France.