2017 Conference Program

May 28 - 30, 2017

Hotel Sofitel Warsaw Victoria
Warsaw, Poland
May 28, 2017

Session P1: Plenary I

16:00 Welcome Address: Romuald Beck, CEZAMAT (r.beck@cezamat.eu)

16:05 Thomas Skotnicki, ST Microelectronics (thomas.skotnicki@st.com)

*Energy Harvesting for Self-Sustained IoT Sensors*

16:35 Arkadiusz Sitek, Philips Inc. (arkadiusz.sitek@philips.com)

*Future Role of Artificial Intelligence in Healthcare*

We experience an exponential growth in the popularity of artificial intelligence applied in healthcare. Medical imaging is at the frontier of the possible utilization of AI because of a tremendous progress done in the computer image recognition in recent years. During the talk, I will provide background and address the key question: will soon the human role in making healthcare decisions be phased out or is it a fantasy?

17:05 Wojciech Knap, University of Montpellier (knap.wojciech@gmail.com)

*Terahertz Imaging and Wireless Communication with Nanometer Field Effect Transistor Arrays*

17:35 Gabriel Rincón-Mora, Georgia Tech (Rincon-Mora@gatech.edu)

*Energy-Harvesting IoT Microsensors*

Wireless IoT microsensors can not only monitor and manage power consumption in small- and large-scale applications for space, military, medical, agricultural, and consumer markets but also add cost-, energy-, and life-saving intelligence to large infrastructures and tiny devices in remote and difficult-to-reach places. Ultra-small systems, however, cannot store sufficient energy to sustain monitoring, interface, processing, and telemetry functions for long. And replacing or recharging the batteries of hundreds of networked nodes is prohibitive, and often impossible. This is why alternate sources are the subject of ardent research today. Except, power densities are low, and in many cases, intermittent, so supplying functional blocks is challenging. Plus, tiny lithium-ion batteries and super capacitors, while power dense, cannot sustain life for extended periods. This talk illustrates how emerging charger-supply microsystems draw energy from ambient sources to power tiny IoT wireless sensors.

Session N1: Welcome Reception

19:00 Welcome Reception

Kitchen Gallery

Chairs: Kris Iniewski, ETCMOS (kris.iniewski@gmail.com)
May 29, 2017

Session A1: Devices and Circuits

9:00 Belweder A

Chairs: Witold Machowski, Akademia Górniczo-Hutnicza (machowsk@agh.edu.pl)

9:00 Tomasz Brozek, PDF Solutions (tomasz.brozek@pdf.com)

Manufacturing FinFETs – Challenges and Solutions

The adoption of new FinFET device architecture and new integration solutions has been really remarkable, and shows the technology potentials and scalability. After initial introduction at 22nm it became the mainstream technology for 14/16nm, with proven performance and manufacturing yield.

FinFET manufacturability is a very complex task, and involves mastering new integration, patterning, and material choices. FinFET transistor itself enables much better control and reduced variability, even if more complex processing is involved. Improved electrostatic control of the channel and reduction of Short Channel Effects enable very good parametric yield at reduced operating voltages. This new technology, however, requires good maturity of multiple processing steps, and that demands repeatability and process control. The key enablers are: 1) Overlay (Misalignment) control; 2) CMP uniformity control for patterning DoF process window; (3) Etch process selectivity for Contacts and Vias; (4) Device performance variability control.

New, more precise tools and methods are needed to control the process and enable manufacturability of new designs for FinFET technologies. They include in-line metrology and in-line defect inspection scans, but needs full electrical validation at early stages of manufacturing to be efficient of in early detection of Yield problems.

9:20 Jayna Sheats, Terecircuits (sheats@terecircuits.com)

System Integration and Composite Chips

The Internet of Things is expected to revolutionize many aspects of our lives, from personal convenience through healthcare to agricultural and industrial operations. It promises to confer sensory "awareness" on virtually everything, connected with the broad world of analytical capabilities already offered by the Internet.

The density of sensors required for the full realization of this vision is far larger than anything which has been implemented up to now, either in consumer or industrial applications. Conventional electronic systems occupy too much bulk, cost too much, and are too difficult to redesign for changing needs.

Terecircuits' system integration technology, which yields an effective "composite chip" in place of a complete PCB system, holds promise for overcoming these obstacles, while simultaneously improving performance (especially signal integrity, power consumption and reliability). The process can be cost-effectively applied to any type of microelectronic component, including also microLED displays and the dis-integration approach to IC design in which "hard IP blocks" which are produced en masse and assembled into systems as needed.
9:40  Sudip Shekhar, University of British Columbia (sudip@ece.ubc.ca)

Silicon-Photonics Circuits for Datacenters

With warehouse-scale datacenters proliferating around the world, there is a great demand for high-throughput optical interconnects that can span short-to-medium reach distances, from a few meters up to a few kilometers. Vertical-cavity surface-emitting laser (VCSEL)-based optical links with multi-mode fibers (MMFs) have been the mainstream choice for datacenter applications up to 300m. For larger distances, silicon photonic links based on Mach-Zehnder (MZ) modulators are being currently designed to be used in conjunction with single mode fibers (SMFs).

A lower-power alternative to MZ based link is to employ microring-resonators as modulators. We present an analysis of microring-based links from the holistic perspective of optical devices, CMOS circuits, and system-level link budget and energy-efficiency. Design considerations and tradeoffs for the receiver, transmitter and the overall link are presented, and comparisons are made to the mainstream VCSEL-based and recent MZ-based links. Finally, research opportunities are highlighted for further improving the energy efficiency of single-channel and wavelength division multiplexing (WDM)-based silicon-photonics links.

10:00  Guy Torfs, Ghent University (guy.torfs@intec.ugent.be)

25Gbps All-Digital Clock-and-Data Recovery Circuits

All-digital clock-and-data-recovery (CDR) circuits allow compact integration of high-speed receivers in CMOS technologies. However, contrary to all-digital PLLs, the CDR's phase detector works at the very high data rate. To limit the sampling speed, the bang-bang phase detector is parallelized using different phases of a slower clock. This topology allows a higher propagation delay through the phase detectors and relaxes the design constraints of the phase detector. The different clock phases can be conveniently generated using a CMOS ring oscillator. Another advantage of the bang-bang phase detector is that the binary output is suited for digital filtering. Furthermore, as the loopfilter's cut-off frequency is limited, the phase information can be subsampled to reduce the processing power. To reduce the aliasing effects, an inverse alexander phase detector is proposed. Another side effect of the subsampling is the possible increase in consecutive identical digits. Without any data transitions, the feedback loop of the CDR temporarily opens and puts the oscillator in free-running mode and causes phase wandering. This, together with the quantization noise introduced by the digital loop filter is quantified such that error-free operation can be guaranteed. The resulting prototype is a 25Gbps 107mW CDR implemented in a 40nm CMOS technology.

10:20  COFFEE BREAK (FOYER)

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10:40  Kenichi Okada, Tokyo Institute of Technology (okada@ssc.pe.titech.ac.jp)

Synthesizable Digital PLL Using Injection-Lock Architecture

In this presentation, synthesizable PLLs using the injection-locked technique will be discussed. Synthesizable PLLs using common digital synthesis tools can be portable and scalable for process technology, which is advantageous in advanced CMOS technologies. An injection-locked PLL is one of the good candidates of synthesizable PLL because the feed-forward phase-lock mechanism can relax the fine timing design. Some design examples will also be presented.
11:00 Andreas Burg, École Polytechnique Fédérale de Lausanne (andreas.burg@epfl.ch) with A. Bonetti and A. Teman

*Improving Energy Efficiency of Reconfigurable FIR Filters with Approximate Computing*

11:20 Souvik Mahapatra, Indian Institute of Technology Bombay (mahapatra.souvik@gmail.com)

*Bias Temperature Instability in HKMG MOSFETs - Characterization, Process Dependence, DC / AC Modeling and Stochastic Effects*

A common framework involving mutually uncorrelated trap generation and trapping sub-components is introduced to explain NBTI and PBTI degradation in HKMG MOSFETs. The framework can explain experimentally observed impact of different HKMG processes on BTI, including that of IL scaling and Nitridation. The underlying trap generation and trapping sub-components are independently verified by direct characterization techniques, and their relative impact on overall BTI is established for different HKMG processes. The similarities and differences between NBTI and PBTI mechanisms are highlighted using carefully designed HKMG process splits. A comprehensive physics-based model is established for prediction of time evolution of degradation and recovery during and after DC and AC stress at different bias and temperature, and AC stress at different frequency and duty cycle. The model can predict end-of-life degradation for DC and AC stress. The framework is extended to explain stochastic BTI observed in small area devices. The relative impact of process variability and BTI variability is discussed.

11:40 Jiro Ida, Kanazawa Institute of Technology (ida@neptune.kanazawa-it.ac.jp)

*Super Steep Subthreshold Slope PN-Body Tied SOI FET with Ultra Low Drain Voltage for IoT Applications*

We have proposed and demonstrated the PN-Body Tied SOI FETs which show the super steep SS (=35μV/dec) over 3 decades of the drain current with the ultralow drain voltage of 0.1V at IEDM2015 and IEEE SNW2016. However, those needed the body bias over 5V. We have also reported that the body bias reduces from over 5V to below 1V when the impurity concentration of the N layer have been redesigned from the N+ (around 1E20/cm3) to the N- (around 1E17-1E18/cm3) at IEEE S3S 2016. We also clarified the role of the floating body effect on the super steep SS mechanism of the device at IEEE EDTO2017. In this talk, we reviewed the update of our research status on the device.

12:00 Subhasish Mitra, Stanford University (subh@stanford.edu)

*Transforming Nanodevices into Nanosystems: The N3XT 1,000X*
**Magnetism in Topological Insulators**

Exchange interaction between magnetic impurities deposited on the surface of a thin TI-film is calculated provided that the chemical potential is pinned to a middle gap position in the surface electron spectrum thus preventing free electrons and holes to exist in the ground state. Despite free carriers are absent, the interaction function oscillates in space recalling RKKY-interaction behavior. This oscillating Bloembergen-Rowland exchange is mediated by massive Dirac fermions and presents a signature of the topologically nontrivial state.

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**Nanomagnet Networks as Building Blocks for Ising Computing**

We show that spin-coupled nanomagnets are promising building blocks for developing a probabilistic computing network. Owing to its non-volatile nature, magnetization switching in nanomagnets allows for logic computing with built-in memory. Starting from an initialized unstable condition, the probability of a final state occurring is strongly dependent on the input signals and interaction among nanomagnets. By introducing coupling through spin currents or other reconfigurable controls, such blocks can be interconnected to solve complex optimization problems.

By using a network of weakly dipolar coupled nanomagnets, we experimentally demonstrate for the first time the convergence of the network's magnetization towards the ground state of the associated Hamiltonian. Our experimental results are in excellent agreement with the Ising model and stochastic magnet dynamics simulations.

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**Stochastic Spin Networks: Ising Computers and Belief Networks for Intelligent Circuits**

Belief networks represent a powerful approach to problems involving generative probabilistic distributions and inference. They have found widespread application in the fields of machine learning and artificial intelligence. But much of the work in this area is software based utilizing standard deterministic hardware based on the ubiquitous transistor which provides the gain and directionality needed to interconnect billions of them into useful networks. In this talk, we draw attention to the possibility of inherently probabilistic magnetic networks for such applications. To this end, a transistor like device that could provide an analogous building block for probabilistic networks is proposed. Using experimentally benchmarked models to represent the electrical characteristics of such devices, we show two examples of belief networks, one reciprocal as in Ising computers and one non-reciprocal as in Bayesian networks, implemented using the proposed device.
Ferromagnetic Microswimmers

Self-propelling magnetic micro-robots have potential to transport biomolecules, yielding applications in targeted drug delivery and microfluidic devices. However, microscale hydrodynamics prevents propagation if swimming strokes are time-reversible, requiring novel strategies to produce net motion. Based on earlier proposed model [1-2], here we demonstrate swimming in lithographically-defined micro-robots composed of ferromagnetic particles connected by an elastic link. Differences in anisotropy enable the particles to switch independently, resulting in alternating attractive/repulsive dipolar interactions that facilitate breaking of time-reversal symmetry. Multi-stage photolithography was used to pattern Co based magnetic particles connected with an elastic link. Swimming performance was characterised by the propagation direction and velocity, which were determined by the field frequency and amplitude. The maximum velocity (31.5 µm/s) was comparable with similarly sized rival microswimmers, but propagation direction could be defined over 360°. By demonstrating a lithographically-defined swimmer driven by a uniaxial field, we establish a versatile system capable of satisfying real-world requirements of biomedical applications.


Metallic Nanocatalysts – A Versatile Route for Graphene Synthesis

Graphene is conventionally synthetized on transition metal substrates e.g. on copper or nickel foils. The subsequent transferring of the atomically thin carbon film to a dielectric or semiconductor substrate greatly hampers the use of graphene in industrial scale. That is implementation of the graphene into electronic and photonic components a scalable graphene synthesis directly on a dielectric substrate. For synthesis of highly ordered graphitic material the presence of metallic catalyst is mandatory at low temperature regime (>1000°C). As a catalyst is regenerated in the process of graphene synthesis one can consider minimizing the amount of metal involves, i.e. using ultrathin films instead of bulk foils. Experimentally we deposited nanometrically thin copper and nickel films on a dielectric surface to assist graphite synthesis in the CVD process. This resulted highly crystalline a few layer or multilayered graphene films on a dielectric substrate.
11:00 Patrizia Lamberti, Università degli Studi di Salerno (plamberti@unisa.it)  
with L. Egiziano, G. Spinelli, V. Tucci and P. Kuzhir  

*Sensitivity Analysis of a Multilayer Shielding Device Based on Graphene*

The MATLAB® RSTool is here used in order to derive an analytic expression of the shielding effectiveness (SE) of a device obtained by stacking a variable number of CVD graphene planes (GP) on poly-methyl methacrylate (PMMA). The range [1-9] of GP/PMMA number of stacking is explored taking in to account available experimental results. This parameter is considered as "controllable parameter" whereas the electrical conductivity of the GP as "uncontrollable parameter" with fixed nominal and tolerance value, since it is a new-generation material and its fabrication intrinsically suffers from heavy uncertainties. Moreover, the thickness of the PMMA, which nominal value can be changed, is also considered as "uncontrollable parameter" due to the technological limitation to control it. A quadratic expression of the SE is derived by interpolating a few number of numerical solution obtained by FEM-solving the electromagnetic problem in particular points of the parameter space, chosen according to a Design of Experiment (DoE) approach. Vertex Analysis, applied on the equation obtained for a fixed number of layers, is used to assess the sensitivity of the device with respect to the heavy and not avoidable uncertainties that affect the production process.

11:20 Albert Nasibulin, Skolkovo Institute of Science and Technology (a.nasibulin@skoltech.ru)

*Single-walled Carbon Nanotube Films for Future Electronics*

11:40 Francis Balestra, MINATEC (balestra@minatec.grenoble-inp.fr)

*Novel Materials for Low-Power and High-Performance Nanoscale FETs*

We are facing many challenges for future nanoelectronic devices in the next two decades dealing with scaling, power consumption and performance.

This paper presents the most promising solutions for the end of the roadmap in the More Moore and Beyond-CMOS fields, including innovative nanomaterials such as ultra-thin Si-Ge-III-V/OI, 2D layers (graphene, phosphorene, transition-metal dichalcogenides), 1D semimetals, Heterostructures using strained materials, Ge, III-V (InAs, GaSb, AlGaSb, graded layers, quantum wells, ...).

These innovative boosters can be combined with advanced Nanoscale FET architectures, especially ultimate multigate NanoCMOS and Nanowire FETs, Small Slope Switches like Tunnel FETs, and combinations of these nanoscale transistors such as FeTFET or TMOSFET [1-4].

Hollow Carbon Spheres and Regular Foams for Microwave Absorption Applications

The ability to use carbon porous structures (hollow carbon spheres [1] organized in metamaterial-like surface, carbonized 3D printed or polymer-templated [2] carbon lattices) as almost perfectly absorbing surfaces for electromagnetic radiation, as well as to utilize their resonance behavior in microwave-THz frequency ranges for device applications are discussed. Collected results for carbon porous monoliths and metamaterials are compared with what can be achieved with graphene/polymer heterostructures [3] and 3D printed sandwiches [4] of sophisticated geometries made from nanocarbon-polymer composite fiber and a pure polystyrene fiber. The advantages of each type of carbon structures depending on particular application are emphasized.

Session C1: IoT Technologies

Chairs: Sirpa Sandelin, Satakunta University of Applied Sciences (sirpa.sandelin@samk.fi)
Sari Merilampi, Satakunta University of Applied Sciences (sari.merilampi@samk.fi)

9:00 Marcel Baunach, Technische Universität Graz (baunach@tugraz.at)

Flexible Computing Platforms for a Dependable Internet of Things

A central demand on the Internet of Things is its ability to provide continuously changing services and functions dependably on an unprecedented number of heterogeneous IoT devices. While today's embedded devices are mostly statically designed for a particular application, future software as well as hardware has to be much more flexible. In fact, highly adaptive computing platforms will be required to allow the dynamic composition of functions and even the modification of computational units at runtime (maintainability). At the same time, and independent from any adaptation, operations must still be completed within guaranteed response times (real-time), and the devices must remain protected against alteration due to environmental perturbation or deliberate attacks (security, safety). Mastering these challenges demands for completely new design concepts for future embedded systems. This presentation addresses novel approaches in both hardware and software that aim on co-designing highly flexible software and MCU architectures for compositional embedded systems in the setting of a dependable IoT.

9:20 Gord Harling, Innotime Technologies (gharling@innotime.ca)

with F. Kalinian

Electronics for Wearables and Smart Fabrics: The Need for Performance

The market for wearables and flexible circuits is in steady growth but the technology still has its limitations. Flexible and printed circuits are limited in speed and density and power storage will continue to be an issue. Some functions, such as wireless transmission for Body Area Networks may not be achievable in the near term using printed electronics. One solution is the creation of extremely dense modules which combine different technologies including high performance digital CMOS, analog components, MEMS, passive components for energy storage, and optical devices. Silicon Interposers can fill the gap by allowing users to create extremely dense modules and to mix and match components in different fabrication technologies.
Monday, May 29, 2017

9:40 Pawel Gburzynski, Olsonet Communications Corporation (pawel@olsonet.com)

*Ad-hoc Networks for Independent Living: Value Added Sensing*

We present a wireless-mesh meta-application (dubbed praxis in our parlance) a subset of which we have successfully deployed in several Independent Living (IL) facilities in Belgium, France, and the USA. The praxis is based on a certain philosophy of building indoor wireless sensing systems which departs somewhat from the leading industrial trends. It capitalizes on ad-hoc (maximally opportunistic and inherently multi-hop) communication, even in environments that do not explicitly call for this kind of feature. It employs a simple (yet powerful and frugal in terms of energy) forwarding scheme allowing it to easily and automatically adapt to the unpredictable and variable RF propagation characteristics of the deployment area. The IL application of our (generic) praxis illustrates collective sensing whereby readings collected by multiple nodes amount to an "added value", i.e., a new kind of measure emerging from the cooperation. One interesting example of such a measure, discussed in our talk, offers a solution to a variant of the indoor location tracking problem.

10:00 Sari Merilampi, Satakunta University of Applied Sciences (sari.merilampi@samk.fi)

*RFID Supporting IoT in Health and Well-Being Applications*

Linking of real world and virtual world (data collection) and smart data handling for monitoring and controlling purposes are the essential functions in Internet of Things (IoT) systems. Radio Frequency Identification technology (RFID) is commonly used in IoT systems especially for data collection. The aim of the presentation is to introduce the capability and possibilities of RFID technology in well-being related applications.

10:20 COFFEE BREAK (FOYER)

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10:40 R. Bogdan Staszewski, University College Dublin (robert.staszewski@ucd.ie)

with M. Babaie, S. Ferreira Binsfeld and F.-W. Kuo

*Frequency Synthesis and RF using Advanced CMOS for Internet-of-Things*

Ultra-low-power radios underpin short-range communications for Internet-of-Things (IoT). Yet, the IoT system lifetime still tends to be severely limited by a power consumption of a radio-frequency (RF) transmitter (TX), receiver (RX) and frequency synthesizer, as well as the available battery technology. State-of-the-art radios currently consume several mW of power during TX and RX, and thus they can continually operate for only a few hours on a single battery of a size comparable to the IoT module. This would trigger inconvenient battery replacements, which diminishes their market attractiveness. Energy harvesting (e.g., photovoltaic) from the surrounding environment now comes to the rescue. However, the harvesters tend to provide lower supply voltage (e.g., 0.25 - 0.75V) than the supply of even the advanced CMOS devices (~1V). What is more, the produced voltage varies widely over time. To be able to power the IoT devices directly from the harvested voltage, thus extracting the maximum energy, re-invention of the traditional design of RF, analog and digital circuits needs to take place. This presentation covers such ultra-low voltage and ultra-low power circuit and architectural solutions.
11:00  Oskar Z. Olszewski, Tyndal National Research Lab (zbigniew.olszewski@tyndall.ie)
with R. Houlihan, A. Blake, A. Mathewson and N. Jackson

Piezoelectric MEMS Energy Harvester

In recent years, much attention has been placed on the Internet of Things (IoT) where a large number of nodes exchange the data across the network. The individual nodes are typically powered by batteries with limited lifetime and currently the IoT urges for development of energy-autonomous nodes and energy harvesting is a key technology addressing such a demand. Vibrational piezoelectric harvesters have recently received much attention. This is, because vibrations are ubiquitous in most applications, devices have relatively simple structure and high conversion efficiency. Moreover, advances in thin piezoelectric films such as Aluminium Nitride (AlN) offer high-volume, wafer scale fabrication and integration capabilities.

A key challenge of vibrational harvesters is that inherently they have a narrow frequency bandwidth that must be broadened for most applications. An alternative approach to bandwidth broadening is to select an application that provides a stable source of frequency. This paper reports on vibrational piezoelectric energy harvester that scavenges energy from a magnetic field surrounding a wire carrying an AC current. This solution, when implemented over a standard 50 Hz power-line, could provide a stable excitation source to vibrational harvesters for the IoT application. The device operation, MEMS AlN-based fabrication process and experimental results are demonstrated.

11:20  Takahiro Hanyu, Tohoku University (hanyu@riec.tohoku.ac.jp)

Challenge of MOS/MTJ-Hybrid Nonvolatile VLSI Processor for IoE Applications

Nonvolatile spintronic devices have potential advantages such as fast read/write, and high endurance together with back-end-of-the-line compatibility, which offers the possibility of constructing not only stand-alone RAMs and embedded RAMs that can be used in conventional VLSI circuits and systems, but also standby-power-free high-performance nonvolatile CMOS logic employing logic-in-memory architecture, called Nonvolatile Logic-in-Memory Architecture. The advantages of employing magnetic tunnel junction (MTJ) devices combined with CMOS circuits are discussed and the current activities of the MTJ-based VLSI computing paradigm is presented along with its prospects and remaining challenges. In my presentation, some concrete logic-circuit examples based on MOS/MTJ-hybrid nonvolatile logic-in-memory architecture are presented and their suitability for Internet-of-Things (IoT) applications are discussed.
11:40  Mirka Leino, Satakunta University of Applied Sciences (mirka.leino@samk.fi)

*Machine Vision Enabling IoT Possibilities*

In the next few years the focus of IoT development will be on the operationalisation of the systems. The big questions will be how the IoT infrastructures should be monitored, managed and secured. Machine vision will be one of the key technologies at least in monitoring and controlling of the systems. Machine vision will enable a wide range of new and enhanced products, which will add value to the users by more intelligent and responsive features. Machine vision technologies improve particularly the functionalities of the machine-to-machine IoT, as they will be able to issue alerts by themselves directly to other machines. In the future IoT machine vision can work e.g. in surveillance and controlling jobs but it can also act as the eyes of a robot. As the "sense-plan-act" behaviour of machine vision solutions is developing, the amount of intelligent and independent machines is undoubtedly increasing. This presentation introduces examples of machine vision enabling IoT versatility and draws some perspectives to these opportunities.

12:00  Marko Kukka, Satakunta University of Applied Sciences (marko.kukka@samk.fi)

with S. Rantamäki

*Small-Scale Energy Production Generalizing IoT*

IoT has been coming on strong on several areas of industry during these last years but most of the solutions already in wide use are still considered being part of the digitalization rather than IoT. Remote energy monitoring is basically providing a service on the internet. The actual nudge towards IoT at the moment is the different solutions from which the energy is monitored. So called intelligent devices are becoming more and more common and their price is getting lower almost each day.

Energy networks are moving towards more distributed networks having multiple, small, producers in addition to the current model of large power plants. In addition to this, even households are moving towards hybrid energy production, for example having a solar energy system, a fireplace, geothermal (or other) heat pump and a grid connection to the electric grid all in a single household. This results to a system that is complex and needs controlling and thus, provides an opportunity for IoT and its generalization to the consumer markets.
Sensing Platforms for Monitoring and Analysis of Body Fluids

Nowadays, the healthcare systems are strongly promoting the prevention and early detection of diseases, and the real-time monitoring of patients to provide personalized therapies in order to reduce costs and improve patient’s quality of life. Point-of-Care (POC) technologies and home monitoring are becoming familiar terms, but they require new sensing approaches to provide fast and reliable results. We present non-invasive or minimally invasive sensors, protocols and instrumentation that can be used for monitoring and analysing biological fluids such as breath, saliva, sweat and exudate. Our work will show some possible applications for therapeutic monitoring, biomarkers detection, drugs detection and delivery, and patient screening.

Cascaded-systems Analysis of the Imaging Performance of Spectroscopic X-ray Imaging Methods

Spectroscopic x-ray imaging detectors have the potential to improve x-ray image quality and enable novel energy-dependent methods. However, stochastic image-forming processes will degrade the performance of spectroscopic x-ray imaging methods. A prevalent approach to describing the performance of x-ray imaging detectors involves the use of Fourier-based metrics of image spatial resolution and image noise. Theoretical analysis of these metrics has proven useful in understanding the performance of, and optimizing, imaging systems that use conventional x-ray detector technology, including dual-energy systems, fluoroscopic systems, and computed tomography systems. Such a theoretical formalism for understanding the factors governing the performance of spectroscopic x-ray systems would provide a framework for system optimization and interpretation of experimental data, and would enable performance assessment independent of the limitations of existing technologies. Each of these are critical in the design and development of next-generation technologies. This presentation will report on progress made toward developing a comprehensive, generic formalism for describing the imaging performance of spectroscopic x-ray imaging detectors. The influence of x-ray fluorescence, electronic noise, charge sharing between neighbouring detector elements, and incomplete collection of electron-hole pairs on the large-area gain, spatial resolution, and image noise of spectroscopic x-ray imaging methods will be discussed. Results will be presented for cadmium telluride and silicon-based spectroscopic x-ray imaging systems.
11:10  Kalle Levon, New York University (kalle.levon@gmail.com)

*Extended Gate FET with a Coating of Organic Electronics for Enzymatic Biodetection*

Our custom disposable platform exploits ion-sensitive FET (ISFET) technology. Via simple surface modifications the design allows a broad range of analytes to be tested with low cost. We have compared our read-out device to a commercial potentiometer using K+ as an example species analyte. The developed sensing system has a slightly better limit of detection and is notably less susceptible to external noise, which is commonly observed with potentiometers. The designed platform is fabricated using standard electronic processes with gold surface and we used commercial discrete transistors as the transducing element. It can be mass produced with high yield and low cost. To circumvent the drift that typically occurs with modified solid state electrodes we incorporated a transducing layer between the electric conductor (gold pad) and the ionically conducting ion-selective membrane. The polyaniline doped with dinonylnaphtalene sulfonic acid (PANI-DNNSA) was used as a transducing layer for the first time. The PANI-DNNSA layer significantly reduces the drift of the electrodes compared to a configuration without the transducing layer. In addition, it allows convenient organic chemistry for the immobilization of antibodies or enzymes for monitoring biological binding events. Such a hand-held sensing system using a transistor based multiplexed platform allows coupling the electrochemical information wirelessly to a smartphone.

11:30  Yasar Murat Elcin, Ankara University (Y.Murat.Elcin@ankara.edu.tr)

*Organ-on-a-Chip Systems for Personalized Medicine*

Biological lab-on-a-chip systems essentially aim to achieve automation and high-throughput screening by imitating biological systems or processes in micro scale. Microfluidic cell cultures attempt to facilitate simultaneous manipulation and analysis of cultured cells. Organ-on-a-chip systems have come into prominence as three-dimensional microfluidic cell cultures simulating physiological responses and activities of organs/organ systems, and as novel in-vitro multicellular human organism models for toxicology, drug discovery and personalized medicine research. It is expected that organ-on-a-chip systems will address the challenging pharmacological and physiological gaps between humans, animal models and classical monolayer cultures. Mimicking the conditions of tissues or organ systems is a step forward to multi-organ systems known as the body-on-a-chip. This approach recapitulates organ functions under biomimetic conditions for "micro-organs" inter-connected with microfluidic channels that serve as arterial and venous lines. In general, these models demand tissue-engineering expertise, as they involve use of cells, biochemical molecules, and tunable microenvironments. This talk focuses on the major restrictions and state-of-the-art in organ-on-chip technologies from tissue-engineering perspective.
11:50 Sylvain Martel, École Polytechnique de Montréal (sylvain.martel@polymtl.ca)

Transforming Magnetotactic Bacteria to Act as Medical Nanorobots with Communication, Navigation, and Sensory Capabilities

Still believed to be within the domain of science-fiction, nanorobots are now a reality with extraordinary capabilities made possible by recent significant scientific progress enabling the integration of nanotechnology with principles of robotics. Such new field opens new possibilities particularly in the medical and the pharmaceutical industry. For instance, swarms of hundreds of millions of these robots only a tiny fraction of a human hair thickness can now navigate in blood vessels and swim deep inside tumors before autonomously detecting active cancer cells and deliver their cargos at locations where therapeutic effects would be optimal. Since the implementation of such nanorobots at such a scale is well beyond technological feasibility, the strategy has been to harness special bacteria that when exposed to a computer-controlled magnetic field, these bacteria behave as natural nanorobots with all the characteristics and functionalities necessary to enable them to target and deliver any therapeutics in regions of active cancer cells.

12:10 Ferruccio Pisanello, Istituto Italiano di Tecnologia (ferruccio.pisanello@iit.it)

Micro and Nanotechnologies for Multipoint Control of Neural Activity in Deep Brain Regions

The possibility to optically interface with the mammalian brain is allowing for unprecedented investigations of functional connectivity of neural circuitry. A new generation of optical neural interfaces is being developed, mainly thanks to the exploitation of micro and nanotechnologies. After reviewing recent advances in this framework, the presentation will focus on a new technology to obtain multisite optical control of neural activity in deep brain regions. It is based on modal demultiplexing properties of tapered optical fibers to adapt light delivery depth to the size of functional structures and to obtain spatial-resolved optogenetic control of neural activity in sub-cortical regions such as the striatum or the thalamus. Depending on the geometry of the volume of interest, the light-confinement properties of the tapered optical fiber can be engineered to obtain both site-selective or wide-volume light delivery, allowing for unprecedented flexibility in in vivo experiments on rodents. The simplicity of this technique, together with its versatility, reduced invasiveness and compatibility with both laser and LED sources, indicate this approach can greatly complement the set of existing tools for light delivery in optogenetic experiments.
Design, Fabrication, and Characterization of High-temperature Selective Thermal Emitters

Harvesting the full spectrum of sunlight with a hybrid of photovoltaics and solar thermal offers the potential for higher efficiencies, lower power production costs, and increased power grid compatibility than any single technology by itself. A key technology required for widespread adoption of such an approach is a highly selective solar absorber made from simple, stable structures capable of surviving high temperatures. Here, we consider semiconductor-metal selective solar absorber designs, which are based on commercially available silicon wafers. They have been fabricated and measured at different temperatures, to properly reflect the operating conditions associated with concentrated solar input. Both high solar absorption and low thermal re-radiation of the devices are obtained at temperature as high as 490°C, and the structure is demonstrated to be mechanically and thermally stable even at slightly higher temperatures (up to 535°C). Increased free carrier absorption and lattice absorption of silicon is observed at elevated temperatures, which increases thermal re-radiation dramatically. To mitigate this effect, a thin silicon film-based selective absorber has also been computationally designed and optimized; it is predicted to exhibit even higher thermal transfer efficiency (60-70%) at a wide range of solar concentration (20-100 suns). Using such a simple, CMOS-compatible process to create a mechanically and thermally stable structure may enable low-cost silicon substrate-based selective solar absorbers to find widespread applications in solar hybrid energy conversion systems.

Very High Speed Directly Modulated InP-on-Si DFB Lasers

Heterogeneously integrated DFB lasers, consisting of thin InP membranes coupled to low loss Si wire waveguides can not only be easily integrated with passive silicon photonics components, but also possess several advantages compared to traditional all-InP DFB lasers. The thin membranes give large optical confinement factors and their small surface area results in small parasitic capacitances. When the diffraction gratings are etched into the silicon and a thin bonding layer is used, then also large coupling coefficients and small mirror losses can be achieved. All these properties make the lasers very well suited for high speed direct modulation. The low loss silicon wire waveguides however are also suited very well for the implementation of low loss external cavities. Coupling membrane DFB lasers to such an external cavity allows to exploit photon-photon resonances in the modulation response.

In the presentation, we will discuss in detail how to design these heterogeneously integrated DFB lasers for optimum modulation bandwidth. We will show how the fabricated lasers can be modulated at very high speed, both using On-Off-Keying as well as some more advanced modulation formats. We will also report on link experiments with the modulated signals and how the maximum reach can be extended.
9:40 Satadal Dutta, University of Twente (s.dutta@utwente.nl) with V. Agarwal, A-J. Annema, R. J.E. Hueting and J. Schmitz.

**Optocoupling in Standard CMOS for Smart Power**

Monolithic integration of optical links can enable smart power applications, where high-speed data transfer is sought for between multiple blocks of the same chip with large differences in their operating voltages, and thus are required to be galvanically isolated from each other. Such an optical link is shown to be functional in a standard silicon-on-insulator CMOS technology. Although silicon is an indirect-bandgap semiconductor usually exhibiting low-efficiency near infra-red electroluminescence, biasing the same diode in avalanche-mode leads to a broad-spectrum electroluminescence at relatively shorter wavelengths of light which have high responsivity when detected by a silicon photodiode. In this presentation we discuss the possibility to use silicon light emission in a standard smart-power silicon technology. We focus on optocoupling, that is, the transfer of digital information over an optical channel. Optocouplers were designed in industrial CMOS, comprising a light emitting diode, an optical channel, and a photodiode. Coupling efficiencies were analyzed, both for avalanche light emission and for band-to-band emission. The designs were analysed for their data communication potential, for different light emission modes, and as a function of the distance between emitter and detector. We found that besides an optical signal, thermal coupling can also occur.

10:00 Mariusz Martyniuk, University of Western Australia (mariusz.martyniuk@uwa.edu.au)

**Dynamically Tunable MEMS-based Optical Filters for Spectrally Adaptive Sensing and Wave Manipulation from Visible, through Infrared, to Terahertz**

Improving current state-of-the-art infrared (IR) detector and imaging focal plane array (FPA) technologies includes adding so-called multi-colour capability, which allows real-time spectral information to be gathered from multiple wavelength bands. Multi-spectral imaging results in improved target recognition and is applicable to numerous remote sensing spectroscopy/imaging applications. In order to provide a reduced size, weight and power (SWaP) solution, a micro-electromechanical systems (MEMS) based electrically tuneable adaptive filter technology has been developed for important IR wavelength bands of the electromagnetic (EM) spectrum.

Subsequently, we report on the progress towards the realisation of a platform technology that is, for the first time, sufficiently generic to span wavelengths from the visible, through infrared, to terahertz. This unified approach towards realisation of novel low-cost miniature devices for spectroscopic, spatial, and temporal manipulation of radiation spanning this vast EM range relies on the integration of MEMS with composite materials, or metamaterials in order to control metamaterial resonance and achieve independent tuneability of their electric and magnetic properties allowing both reflective and transmissive optics with spectroscopic discrimination. We demonstrate an on-chip solution for frequency filtering within the THz band. The achieved tuning range, mechanical sensitivity, modulation contrast and speed places our prototypes among the best-performing tunable THz filters achieved to date, particularly in device thickness and tunability.

10:20 COFFEE BREAK (FOYER)

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Ultra-low Power 56Gb/s VCSEL-based Optical Links

With ever growing bandwidth requirements optical data links get increasingly limited by the power that these links can consume inside a chip package or module. On the other hand, typical traffic in data centers has link utilization numbers far away from 100%, which means that most sent data packets are IDLE. To exploit this fact, we propose an optical link architecture which features fast (<20ns) wake-up to drastically reduce power consumption, and describe the trade-offs between power, link utilization and wake-up time. Also, we will show how high data rates and high sensitivity can be achieved in a VCSEL-based optical link by proper equalization on the TX and RX side. We describe the design of a 56Gb/s low-power optical receiver in 14nm CMOS, which was measured to receive NRZ data up to 64Gb/s error-free with <1.5pJ/bit energy consumption. Finally, we discuss how our power adaptive techniques relate to present standards (e.g. Green Ethernet) and what would be required to enhance the standards in the future.

Giant Unconventional Stark Effect in Two-Dimensional Semiconductors

Two-dimensional semiconductors combine easy fabrication and mechanical flexibility with particularly strong light-matter interaction. I will discuss the relaxation dynamics of photoexcited electrons in MoS2 and WS2, with particular emphasis on the formation of excitons and free carriers, as well as the strong optical signatures of many-body effects. Moreover, we observed a particularly strong electroabsorption in MoS2. Contrary to known variants of the Stark effect, the absorption broadening increases linearly with the applied field. The achievable modulation depths bear the scope for extremely compact energy-efficient electroabsorption modulators for integrated photonics.

III-nitride on Silicon Photonic Circuits

Photonic integrated circuits are key elements for signal processing and development of quantum information devices. The III-N materials present a series of key advantages for the development of photonic circuits from the near-infrared to the visible and ultra-violet. The III-nitride materials have a very large transparency window and their crystal symmetry allows second-order nonlinear processes.

In this talk, we will present recent progress achieved with III-nitride photonic circuits grown on silicon(111). A silicon platform is a key advantage for integration on large surfaces at low cost using the CMOS fabrication environment. We have developed two-dimensional photonic circuits integrating photonic crystals, microdisks and suspended waveguides as well as couplers. Quality factors up to 80000 have been achieved in the near-infrared for microdisks (34000 for photonic crystals). Second-order and third-order nonlinearities have been demonstrated at room temperature under cw excitation. We will show that third-harmonic generation can be used for near-infrared mode imaging with sub-wavelength spatial resolution and pattern analysis equivalent to the one obtained with near-field scanning probe microscopies. Phase-matched second harmonic generation has been demonstrated in microdisks by varying the disk diameter by steps of 8 nm and achieving double resonance for the pump and harmonic with whispering gallery modes.
Husam Alshareef, King Abdullah University of Science & Technology (husam.alshareef@kaust.edu.sa) with Z. Wang and F. Alshamri

**Oxide-Based Transparent Devices and Circuits**

The field of transparent electronics based on metal oxide conductors and semiconductors has attracted much attention recently because fully transparent devices will not only enable higher performance displays, but will also usher in a new era of transparent electronics and sensors. However, work on fully transparent circuits has almost exclusively relied on indium tin oxide (ITO), indium doped zinc oxide (IZO) or other indium-containing oxides. However, indium supplies have been a constant concern for the display and touch screen industries, thus it is necessary to find alternative transparent oxides.

Here we demonstrate all-oxide robust processes for fully-transparent electronics with the following features: (1) A unique multilayer semiconductor channel composed of alternating layers of hafnium oxide (HfO2) and zinc oxide (ZnO), which gives significant improvement in the electrical stability of our devices; (2) entirely indium-free transistors (gate, SD, channel, dielectric are all indium-free); (3) all-oxide, truly fully-transparent devices and circuits (no metals, only transparent oxide conductors and semiconductors); (4) single deposition technique (ALD) for all materials, which means uniform and conformal deposition is possible on both planar and three-dimensional device architectures; (5) maximum process temperature of 160°C which allowed us to demonstrate the process on both rigid glass and flexible substrates. In addition to transparent devices and circuits, we show that this process can be used to make photo sensors, temperature sensors, and photovoltaic devices.

Wissam Hamad, Technische Universität Berlin (w.hamad@tu-berlin.de) with W. Hofmann

**Extracting Figures of Merit of Ultra-High-Speed VCSELs**

The VCSEL as cost- and energy-effective optical component is an enabling technology for the next product generation. For example, the next generation of Apple’s iPhone is going to use VCSELs for advanced optical 3D imaging. Further, VCSEL-based optical interconnects will enable ultimate speed ratings for future access networks and data-centers.

Analyzing the small-signal of our latest generation of VCSEL devices (an optimized version of our very successful high-speed, temperature-stable 980 nm VCSELs) with modulation bandwidths exceeding 30 GHz turned out to be non-trivial [1].

Consequently, a more refined small-signal analysis was performed including multiple carrier reservoirs, multiple modes and nonlinearities like spatial hole burning.

The extended model can replicate the measured data very well. The common set of figures of merit is extended consistently to explain and predict dynamic properties caused by VCSEL-specific modal properties and inherent non-linearity.

**References:**

Energy Recovery for Ultra-Low Dissipation Logic

Power dissipation is the most severe limiter of progress in computation today. The heat produced by laptop computers is the most familiar manifestation, but issues are even more serious for large-scale computing. The Landauer principle postulates that energy in computation must necessarily be dissipated only when information is destroyed. However, current CMOS technologies are very wasteful in energy because the information stored in the system is destroyed at each logic transition. Recent experiments have shown that the Landauer principle is correct, so that in theory there is no lower limit on energy dissipation. Using adiabatic logic and logically-reversible architectures the destruction of information can be avoided and the energy used to encode information can be recovered and reused.

This presentation will examine issues facing adiabatic, reversible computation. Adiabatic computing was dismissed in the past because the computing performance is reduced. However, due to the constraints of cooling, which sets a maximum power density, performance trade-offs are currently made with multi-core and dark silicon. Adiabatic computing can also reduce dissipation, and this presentation will explore the circumstances when this approach make sense vs. the more established multi-core and dark-silicon methods.

Novel Quantum Dot Based Memories with Many Days of Storage Time: The Last Steps Towards the Holy Grail?

Solid state memory technology is fundamentally divided into volatile memories (e.g. DRAMs, allowing for fast data access, unable to store data for periods of time longer than a few ms), and non-volatile memories (e.g. Flash, for which the opposite holds true). Hybridisation of both, bringing together the advantages of both types, i.e. long storage times, short write, read and erase times, has been referred to as the "Holy Grail"[1] of solid state memory devices. This Holy Grail would offer unique functionalities, and could ensure future progress of memory development after the end of Moore’s law. The feasibility of our QD-Flash concept and its fast write and erase times have previously been demonstrated, the goal of non-volatility (i.e. storage time > 10 years) has not been achieved yet, 230 s being the best result reported yet [2]. Here we report on extending the storage time of holes in GaSb QDs embedded in a GaP matrix to 4 days at room temperature [3]. Further extension to 10 y based on GaP-based heterostructures seems now to be possible.

High Performance STT-MRAM and 3D NAND Memory with Vertical MOSFET Technology

Recently in semiconductor memories such as SRAM, DRAM and NAND memory, it is becoming difficult to meet the target performance only by scaling technologies. Especially for 1X nm high speed working memories and beyond, the large power consumption brings more serious issues due to rapidly increase memory capacity, operation speed and leakage current of scaled CMOS. Moreover, the speed gap between each memory levels in addition to the speed gap between the operation speed of MPUs and that of working memories have expanded year by year.

In this invited talk, it is discussed the directionality of the semiconductor memory hierarchy structure in the future from the background mentioned above. It is introduced that with using 3D NAND memory, Vertical MOSFETs and STT-MRAMs, the current issues of cell density, speed gap and power consumption will be simultaneously overcome, and novel memory hierarchy structure will be achieved. In addition, from the viewpoint of future high-end memory system, the impact of memory technologies hybridized with Vertical MOSFETs and spintronics devices such as MTJs is discussed. Finally, nonvolatile logic as one of application of STT-MRAM is shown.

Acknowledgment: This work was supported in part by CIES’s Industrial Affiliation on the STT MRAM program and ACCEL Program under JST.

References:
14:30  Ann Gordon-Ross, University of Florida (ann@ece.ufl.edu)

*Design Space Exploration for Hardware/Software-based Embedded Systems*

Embedded systems that contain software processors coupled with a field-programmable gate array (FPGA) offer more potential for optimizations as compared to software-only based systems, because performance-critical functionality can be partitioned to execute on the FPGA. Partial reconfiguration (PR) enhances traditional FPGA reconfiguration with benefits such as reduced resource requirements, increased functionality, and uninterrupted FPGA execution if only a portion of the FPGA is reconfigured. Since fully realizing these PR benefits requires addressing both challenging, traditional hardware/software (HW/SW) co-design principles, extensive PR design flow knowledge, and knowledge of the target FPGA's low-level architectural details, PR has not yet gained widespread usage. To alleviate manual design-time effort, we present the design automation for partial reconfiguration (DAPR) design flow for HW/SW co-designed systems. DAPR's design flow isolates low-level PR design complexities involved in analyzing PR designs with different performance parameters to make PR more amenable to designers.

14:50  Frédéric Wrobel, University of Montpellier (frederic.wrobel@ies.univ-montp2.fr)

*Monte Carlo Approach to Simulate Bit Flip Induced by Energetic Particles*

Energetic particles coming from cosmic rays are able to produce malfunctions on-board planes, launchers, and satellites. One kind of malfunction is the bit flip during which a bit state is upset from 0 to 1 (or vice versa). The occurrence of the bit upset is quantified by the bit flip cross section, which corresponds to the total area of the chip that is sensitive to radiations. The knowledge of this quantity is crucial to predict the reliability of a system during a given mission. The use of Monte Carlo tools to evaluate this quantity is presented during this talk. The method deals with different physics fields such as radiation-matter interaction, semiconductor physics and electronics. We present how each step is modelled and simulated and the way we can optimize simulations in order to make the CPU time acceptable. We give some results for heavy ions, protons and neutrons for different technologies and show the advantages and drawbacks of the method.

15:10  Yusuf Leblebici, École Polytechnique Fédérale de Lausanne (yusuf.leblebici@epfl.ch)

*Hardware Realization of Neuromorphic Architectures Based on Nonvolatile Memory Arrays*

15:30  COFFEE BREAK (FOYER)

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Nanowires for Tandem Junction Solar Cells

Semiconducting nanowires have been suggested for high efficiency solar cells due to excellent light absorbing properties [1, 2, 3]. Using NWs covering only about 12% of the surface, efficiencies have been reported for InP NWs of 13.8% [1] and for GaAs NWs of 15.3% [4].

In order to further optimize the performance of NWPV and integrate them on Si in a tandem junction configuration, nanowires with dimensions corresponding to optimal light harvesting capability are necessary. We developed nano imprint lithography for patterning of catalytic metal particles with a diameter of 200 nm in a hexagonal pitch of 500 nm. We found that the metal particles move during annealing, destroying pattern fidelity before nucleation. A pre anneal and nucleation step was necessary to keep the particles in place during high temperature annealing to remove surface oxides. We intend to transfer such nanowires to a Si platform (existing PV), either by direct growth on Si, or by nanowire peel off in polymer, followed by transfer and electrical contacting, or by aerotaxy and alignment for transfer to Si. The optimal band gap in combination with Si is about 1.7 eV, achievable by use of GaInP or GaAsP.

14:10 Usha Varshney, National Science Foundation (uvarshne@nsf.gov)

The Modes of International Collaborations in Research and Education at the National Science Foundation

The presentation will focus on National Science Foundation's vision, mission organization structure and various funding opportunities in the emerging areas of technologies related to this meeting. It will highlight various research and education programs supported by the Office of International Science and Engineering specifically that encourages international collaborations with European countries. The goal of this office is to advance the frontiers of science and engineering research and education excellence by establishing international collaborations and partnerships in science and technology, and to develop a globally engaged workforce. Primary goal of this presentation will be to discuss "who receives NSF funding and how to receive such funding" for international collaborations.

14:30 Hoe Tan, Australian National University (hoe109@physics.anu.edu.au)

Nanowires and Nanostructures for Optoelectronic Device and Energy Applications

The excitement of nanowire research is due to the unique electronic and optical properties of these nanostructures. Both axial and radial heterostructure nanowires have been proposed as nano-building blocks for the next generation devices. The unique properties stem from their large surface area-to-volume ratio, very high aspect ratio, and carrier and photon confinement in two dimensions. These nanowires are usually grown by the so-called vapor-liquid-solid mechanism, which relies on a metal nanoparticle to catalyze and seed the growth. An alternative technique to grow the nanowires is by selective area growth technique, where a dielectric mask is first patterned on the substrate prior to growth.

I will present an overview of compound semiconductor nanowire research activities at The Australian National University. The optical and structural properties of binary and ternary III-V nanowires grown by metal-organic vapour phase epitaxy will be presented. Various issues such as tapering of the nanowires, compositional non-uniformity along nanowires, crystal structure and carrier lifetime will be discussed. Our results of enhancing the quantum efficiency of nanowires by using plasmonics are promising to improve the performance of nanowire devices. Finally, the results from our nanowire lasers, photodetectors, solar cells and photoelectrodes for water splitting will be presented.

14:50 Joachim Knoch, RWTH Aachen University (knoch@iht.rwth-aachen.de)

Electrostatic Doping in Nanoscale Field-Effect Transistors

Doping one of the most important techniques in semiconductor technology since it allows adjusting a potential landscape within the device enabling a desired device functionality. However, with aggressive downscaling of transistor dimensions and the advent of novel materials realizing appropriate doping is not obvious. Therefore, replacing conventional doping with additional gate electrodes in the source/drain contact areas is a viable option. Furthermore, the realization of a potential landscape with gate electrode instead of stationary dopants allows also the dynamic adjustment of the functionality of the device and facilitates, e.g. reconfigurable field-effect transistors. We will show recent results on field-effect transistors based on buried multi-gate substrates that allow, e.g., to realize device operation as n-type, p-type and as band-to-band tunneling field-effect transistor.
Nanowire-Channel III-Nitride HEMTs for High-Linearity mm-Wave Applications

III-Nitride based High Electron Mobility Transistors (HEMTs) are good candidates for next generation mm-wave communication applications. Besides high output power density and high efficiency, high linearity of the device is also critical. In this talk, we will present our recent results on Fin-like nanowire-channel InAlN/GaN HEMT which achieved significant improvement in the device DC and RF linearity. The 80nm gate length InAlN/GaN HEMTs are fabricated on epi structures grown by MOCVD on silicon substrate. One key physical mechanism affecting the linearity is the increase of the access resistance at a higher channel current. By adopting the Fin-like nanowire-channel structure, we are able to overcome this problem and achieve improve linearity with flatter transconductance and cutoff frequency versus gate-bias. Furthermore, we have also introduced a planar nanowire-channel structure by means of implantation isolation instead of the conventional trench etch approach for the Fin-like nanowires. This planar approach successfully reduces the parasitic capacitance which in turn increases the cut-off frequency while maintaining the high linearity. Finally, to resolve the issue of gate leakage at high positive gate biases, we also developed a Metal-Insulator-Semiconductor (MIS) structure which further increases the device operational biasing range while simultaneously achieving high device linearity.
The ATTRACT Initiative: Opportunities to Develop Breakthrough Detection and Imaging Technologies in Europe

ATTRACT stands for breAkThrough innovaTion pRogrAmme for a pan-European deteCtion and Imaging ecosysTem. It is a novel R&D&I collaborative framework and bottom-up programme around Detection and Imaging Technologies. It engages both the research communities using European Research Infrastructures (ERIs) and Industry with special attention paid to the Small and Medium size Enterprises (SMEs). It seeks the benefit of these stakeholders and the European society at large. ATTRACT focuses on Detection and Imaging Technologies because they are crucial enablers for industrial competitiveness. They are as well key for pushing the limits of scientific knowledge pursued by ERIs. They also constitute an essential element for future applications, products or businesses targeting upcoming Societal Challenges.

Ultrafast Imaging Technology: From Visible Light to High-energy X-ray Photons

We are now in the era of ultrafast imaging, which is the ability to observe transient events with a time duration no longer than 100 ps (one billionth of the time for eye blinking). Innovative methods have demonstrated photography at the mind-bending speed of one trillion frames per second. Several recent advances make ultrafast imaging possible: ultrashort lasers and X-rays for illumination, abilities to harvest ultrafast responses in materials for efficient photon and electron detection, innovative ways to store and process data. It will be shown that ultrafast imaging technology is a natural fit to mesoscopic science. Meanwhile, ultrafast imaging technology also permits photography of macroscopic objects around the corner or hidden away from the direct line of sight. One recent LANL interest in ultrafast high-energy X-ray imaging is driven by MaRIE. Some material challenges will be highlighted towards a GHz frame-rate burst mode camera for photons at above 30 keV energies.
14:10  Masayuki Ikebe, Hokkaido University (ikebe@ist.hokudai.ac.jp)  

*Time-Based Column ADCs using Multi-Phase Clock Signals for High-speed and Low-Power Imagers*

This paper proposes 3D stacked module consisting of image sensor and digital logic dies connected through inductive coupling channels. Evaluation of a prototype module revealed radiation noise from the inductive coils to the image sensor is less than 0.4-LSB range along with ADC code, i.e., negligible. Aiming at high frame rate image sensor/processing module exploiting this attractive off-die interface, we also worked on resolving another throughput-limiter, namely power consuming Time to Digital Converter (TDC) used in column parallel ADCs. Applying an n-bit TDC to Single-slope ADCs reduces the conversion time by a factor of $2^n$, and using multiphase clock signals achieves timing consistency and realizes robust meta-stability. We focus on the operation time of the TDC and apply a scheme for limiting the TDC operation period in order to reduce the TDC power dissipation. We designed and fabricated a 12-bit ADC, which consists of a 4-bit TDC and an 8-bit single-slope ADC, by using a 0.18 μm CMOS process. The ADC operated at 200 kS/s. Its DNL was $+0.26/-0.23$ LSB. Novel intermittent TDC operation scheme presented in this paper can reduce its power dissipation 57% from conventional ones.

14:30  Samantha Colosimo, University of Liverpool (sjc@ns.ph.liv.ac.uk)  

*DEPICT: Design of a CZT-based Quantitative Imaging System for Molecular Radiotherapy*

Molecular Radiotherapy using Iodine-131 is a well established tool in the treatment of thyroid conditions and cancers. In order to determine the absorbed dose and therefore efficacy of treatment, real-time dosimetry would ideally be performed. Within nuclear medicine, the use of diagnostic gamma cameras is common for most imaging studies. However, limitations in capabilities of standard systems, dead time arising from high count rates (3-10GBq initial dose) and limited energy resolution have meant that accurately determining the quantity and distribution of the Radioisotopes in MRT treatments is not possible. Using commercially available Cadmium Zinc Telluride detectors as well as custom designed collimators, we aim to create an imaging system capable of dosimetry for MRT measurements. A simulation of the system has been written using GAMOS, a GEANT4 framework, and has been experimentally validated. Two collimators been designed using this simulation package. The designs were studied through the parameters of sensitivity and spatial resolution for the application of high activity thyroid treatments. The collimators have been commissioned for the DEPICT system. We present the final collimator design as well as imaging results taken with a clinical thyroid phantom.
**Photon Counting, Spectral X-ray Imaging Detectors**

We describe our development of room temperature single photon counting x-ray imaging pixel detectors for medical imaging applications including computed tomography (CT), dual energy x-ray absorptiometry (DEXA), and digital mammography (DM). The imaging detectors are made using direct conversion semiconductor sensors integrated with mixed signal application specific integrated circuits (ASICs) which readout the counts above four independently set discriminators per pixel. Each of the detectors has sufficient output count rate (OCR), spatial resolution (lp/mm), and dynamic range (kVp) for its application and provides good energy resolution. The use of energy information in CT and DM, obtained using energy integrating detectors and switching energy levels on the x-ray tube, is leading lower dose for comparable image quality and/or increased contrast for a specific imaging task in the clinic. Photon counting detectors could outperform these methods provide the energy resolution is good and all other performance requirements are met. The detectors we present are designed differently for the applications and those differences are driven by the OCR, lp/mm, kVp, and the field of view (FOV) which depends on the application. We demonstrate the tiling of modules to achieve these requirements along with results from developed arrays for CT, DEXA, and DM.

**Ultrafast 32k Channels Integrated System for Single Photon Counting Detectors**

We report on a readout integrated circuit called UFXC32k, designed for hybrid pixel semiconductor detectors used in X-ray imaging applications. The UFXC32k integrated circuit, designed in a CMOS 130 nm process, contains about 50 million transistors in the area of 9.64 mm x 20.15 mm. The core of the IC is a matrix of 128 x 256 square shaped pixels of 75 µm pitch. Each pixel contains a charge sensitive amplifier, a shaper, two discriminators and two 14-bit ripple counters. The analog front-end electronics allow processing of sensor signals of both polarities (holes and electrons). The UFXC32k chip is bump-bonded to a pixel silicon sensor and is fully characterized using X-ray radiation. The measured equivalent noise charge for the standard settings is equal to 123 e-rms (for the peaking time of 40 ns) and each pixel dissipates 26 µW. Thanks to the use of trim blocks working in each pixel independently, an effective offset spread calculated to the input is only 7 e-rms with a gain spread of 2.5%. The maximum count rate per pixel depends mainly on effective CSA feedback resistance. Dead time in the front-end can be set as low as 85 ns. In the continuous readout mode a user can select the number of bits read out from each pixel to optimize the UFXC32k frame rate. Currently the maximum frame rate is equal to 70 kfps measured at the synchrotron in 2 bits mode.
Andrzej Mycielski, Polish Academy of Sciences (mycie@ifpan.edu.pl)

State-of-the-Art of (Cd,Mn)Te Single Crystals for Use as Material for X-ray and Gamma-ray Detectors

In our opinion (Cd,Mn)Te crystals are good candidate for large area plates for X and gamma ray radiation detector devices. We are speaking about monocrystalline plates with dimensions from 40x40x3-5 mm3 and larger. The talk will be focus on growth of 1,5 and 2 inch diameter crystals by the Low Pressure Bridgman method. The material is compensated by Indium or Vanadium.

We will show results of annealing the samples under appropriate conditions as a method which allow to changing material properties. Monocrystalline samples are annealed to obtain homogeneous and high resistivity. The reduction of concentration of cadmium vacancies and mineralization of the concentration of tellurium inclusions are obtained by such thermal treatment. The material resistivity maps and $\mu\tau$ parameter will be measured by TDCM method. The PL measurements for samples before and after annealing will be presented.

The work was partially funded by the National Science Centre, Poland through grant 2014/13/B/ST3/04423 and by the European Union within the European Regional Development Fund through the Innovative Economy grant MIME (POIG.01.01.02-00-108/09).

Ikuo Kurachi, KEK, High Energy Accelerator Research Organization (kurachii@post.kek.jp)
with K. Kobayashi, M. Mochizuki, M. Okihara, H. Kasai, T. Hatsui, K. Hara, T. Miyoshi and Y. Arai

Analysis of Radiation Induced Gate Length Modulation Mechanism in SOI MOSFETs

Degradation mechanism of fully depleted silicon on insulator metal-oxide-semiconductor field-effect transistor (FD-SOI MOSFET) due to X-ray irradiation has been investigated in detail. For FD-SOI MOSFET, the major cause of degradation is generated positive charge in buried oxide (BOX). However, the generated positive charge in BOX can be compensated by applying adequate back gate bias for long channel length MOSFET. On the other hand, it is hard to compensate the characteristics of short channel length MOSFET by the back gate bias because of Radiation Induced Gate Length Modulation (RIGLEM). To clarify the RIGLEM mechanism, the analytical model has been proposed based on effects of positive charge in sidewall spacer and interface state generation in the channel. The model well predicts the degradation for both N and P channel MOSFETs. In the case of N channel MOSFET, the generated interface states at gate edge act as the major cause of RIGLEM because of mobility degradation by the generated interface states. In the case of P channel MOSFET, the major cause of RIGLEM is the generated positive charge in sidewall spacer. It is found that higher LDD dose can improve RIGLEM. Thus, design of LDD process is key for high radiation hardness MOSFET.
Growth and Characterization of CdTe-based Compounds; Crystal Characterization Focused on Microscopy Techniques

The crystals such as (Cd,Mn)Te, (Cd,Mg)Te, (Cd,Mn)(Te,Se) and Cd(Te,Se) belong to the family of CdTe-based compounds. These materials are considered as a base for X and gamma ray detector devices. For such applications the fulfillment of several conditions is important. At first a large surface area monocrystalline wafers is crucial. The homogeneous high resistivity about 10⁹ - 10¹⁰ Ωcm is important condition. The low cross-section of active trapping of electrons and holes are also essential. The energy gap greater than 1.5 eV is necessary to prevent the formation of thermal noise in the signal collected by the detector.

The talk will focus on characterization of the material properties were carried on by different microscopy methods. Optical studies (infrared and optical microscopy) give information about external defects like i.e. the grains, twins, inclusions. Scanning electron microscopy (SEM) measurements give information about inclusions and material composition.

The talk will present the results obtained for the different materials.

Acknowledgements:
The work was partially funded by the National Science Centre, Poland through grant 2014/13/B/ST3/04423 and by the European Union within the European Regional Development Fund through the Innovative Economy grant MIME (POIG.01.02.00-108/09).
Semiconductor radiation detectors (SRD) for x- and gamma rays are currently manufactured mainly from CdTe based compounds. The Bridgman growth, as one of the major methods, yields good quality crystals of CdTe, (Cd,Zn)Te or (Cd,Mn)Te.

Applying the crystals as detectors requires high quality electrical contacts. Our investigations are focused on a single approach to making electrical contacts to high-resistivity crystals. An amorphous layer of doped semiconductor was deposited on the crystal surface by evaporation, and covered with an Au layer. In our case for depositing contact amorphous layers of different thicknesses we have used different methods to prepare the surfaces of the crystals.

We have employed an MBE apparatus to evaporate thin amorphous layers as electrical contacts to different CdTe based compounds. We have explored the surfaces of the crystal plates and contact layers with a mass spectrometry, with an atomic force microscopy, and using SEM microscopy. We made a series of measurements of the I-V characteristics. Resistivities of the crystals were also measured by a contact-less method using the "EU-ρ-SCAN" apparatus.

Our findings suggest that the evaporation of the amorphous contact layers seems to be the best repeatable process providing good contacts to (Cd,Mn)Te crystal plates and other CdTe based compounds of high resistivity.

Acknowledgements:
The work was partially funded by the National Science Centre, Poland through grant 2014/13/B/ST3/04423.
The work was partially supported by the European Union within the European Regional Development Fund through the Innovative Economy grant MIME (POIG.01.01.02-00-108/09).
Imaging-Guided X-Ray Induced Photodynamic Therapy (XPDT) Using Novel Nanoparticles

We have been developing a Molecular RadioNano-Theranostics Research Program, emphasizing on integrating nuclear medicine technology with nanotechnology to deliver precision medicine using novel molecular diagnostic imaging and image-guided molecular therapy approaches. We have successfully developed following key emerging technologies with a central theme on X-ray induced photodynamic therapy (XPDT): (1) multi-modality molecular imaging instrumentation in PET, SPECT, CT and optical imaging using novel semiconductor-based radiation detector technologies; (2) molecular radionano-theranostic chemistry integrating radioimmuno-technology and nanotechnology with target delivery considerations; (3) image reconstruction, processing and analysis using accurate physical modeling, novel algorithm designs, and fast computing techniques. We will illustrate our progresses by demonstrating the uses of x-ray nanoscintillators capable of generating significant amount of cytotoxic reactive oxygen species (ROS) under low-dose, low-energy x-ray activation in XPDT treatment of ovarian cancer. Our nanoplatform Y2O3:Eu@mSiO2 is used not only to generate singlet oxygen but to also deliver radiosensitizing and other therapeutic drugs. In animal experiments using ovarian cancer models, we are using several innovative imaging devices, designed and developed in our own laboratories, to monitor the luminescence and fluorescence signals for treatment planning and assessment, as well as for evaluation of the tumor progression and therapeutic effects after the XPDT treatment using SPECT and PET radiotracer imaging methods.
Peptide Monolayers at Bionic Interfaces

In this contribution we describe the effectiveness of peptide monolayers as bioelectronic interfaces in neuroelectronic hybrids and medical diagnosis. Signal transduction schemes covering bio-cues mediated field potentials recording and small molecules sensing via molecular dipoles modulated surface potentials will be reviewed. A new sensing strategy, charge-transport gating through peptide monolayers, will be described systematically for monitoring cellular signaling pathways. Kinase-mediated phosphorylation plays a major role in regulating signaling pathways in cells. Abnormal phosphorylation has been reported to facilitate cancer development. Here we present an integrated approach for highly sensitive identification and validation of substrate-specific kinases as cancer biomarkers. Our approach combines phosphoproteomics for high throughput cancer-related biomarker discovery from patient tissues and an impedimetric kinase activity biosensor for sensitive validation. Using non-small-cell lung cancer (NSCLC) as a proof-of-concept study, label-free quantitative phosphoproteomic analysis of a pair of cancerous and its adjacent normal tissue revealed phosphoproteins that are over-phosphorylated in NSCLC. Phosphorylation of the monolayer by ERK2 and dephosphorylation by alkaline phosphatase were detected by electrochemical impedance spectroscopy, square-wave voltammetry and surface roughness analysis. Compared to other methods for quantification of kinase concentration, this label-free electrochemical assay offers the advantages of ultra-sensitivity as well as higher specificity for the detection of cancer-related kinase-substrate pairs. With implementation of multiple kinase-substrate biomarker pairs, we expect that this integrated approach can be a high throughput platform for discovery and validation of phosphorylation-mediated biomarkers.

Low-Power Integrated Circuits for Multichannel Neurobiological Experiments

We report on a low noise low power neural recording Integrated Circuits that occupy a very small silicon area and are suitable to integrate with multielectrode arrays in cortical implants. We analyze main problems in neural recording systems processed in modern submicron technologies, i.e. leakage currents, ability to obtain very large and precisely controlled MOS based resistances and spread of the main system parameters from channel to channel. We also introduce methods allowing to mitigate them. Finally, we present methods allowing to calculate optimal channel dimensions of the recording channel's input transistors in order to obtain the lowest Input Referred Noise (IRN) for given power and area requirements. The proposed methodology has been applied in the integrated recording ASICs dedicated to the broad range of neurobiology experiments. Each of the recording channels is equipped with the control register that enables to set main channel parameters independently. Thanks to this functionality, the user is capable of setting lower cut-off frequency within the broad range from mHz up to few hundred of Hz. The upper cut-off frequency and voltage gain can be also modified dependable on required experiment. A single recording channel consumes few µW of power, while its input referred noise is equal to few µV. The presented ASICs were used in both systems for In Vitro and In Vivo experiments and their results will be shown too.
14:10 Adam Woolley, Brigham Young University (awoolley@chem.byu.edu)
with B. Uprety, T. Westover, J.K. Jensen, N.T. Humphries, R.C. Davis and J.N. Harb

*Nanoscale Electronic Structures Formed from DNA Templates*

Scaffolded DNA origami allows for the creation of nanostructure designs with resolution of a few nanometers for the placement of nanomaterials. We have utilized this capability to create and characterize conductive metal nanowires from gold nanorod seeds placed on DNA origami. We are presently using DNA origami as scaffolding to place nanomaterials with controlled spacing as a way to systematically test and optimize plating conditions for making nanowires. We are also utilizing three-dimensional DNA origami constructs with potential application in making vertical nanowire transistors. These designed DNA systems have excellent potential to provide new routes for making nanostructures with applications in electronics.

We are grateful to the Semiconductor Research Corporation (contract 2013-RJ-2487) and the National Science Foundation (CMMI 1562729) for funding this work.

14:30 Megumi Akai-Kasaya, Osaka University (kasaya@prec.eng.osaka-u.ac.jp)

*On the Growing Polymer Neural Networks*

We present a prototype of molecular neural networks consisting of conducting polymer PEDOT/PSS [poly (3, 4-ethylenedioxythiophene) doped with poly (styrene sulfonate) anions] wires. The PEDOT wire grow dendritically and connect between the electrodes immersed in its monomer solution. The typical conductance of PEDOT/PSS wires between the electrodes increases 2 or 3 orders of magnitude from the initial state to the full connection. The maximum conductance were about 0.1-0.2 mS. By using external learning controllers, wires are selectively grown between appropriate electrodes by applying controlled growth voltage across the electrodes, which results in the formation of dendritic polymer-wire networks. Through real experimental, we demonstrate that the molecular networks acquire basic logical functions as a result of the supervised learning. A neural-network skeleton having differential inputs and readout electrodes (neurons) in the solution has been used to demonstrate a neural network learning growth of the polymer wires. These results implies that they expand variety of present neuromorphic computing architectures designed mainly for solid-state CMOS devices.
Tailoring Conducting Polymer Scaffolds for Bioelectronics

Advances in tissue engineering have demonstrated that physical architecture of tissues has a direct influence on correct differentiation and the function of cells in vitro. Considering the limited physiological relevance of 2D cell culture experiments, significant effort was devoted to the development of scaffold materials that could support 3D cell cultures in vitro and more accurately recreate the in vivo cellular microenvironment. A prime example of such a material is conducting polymers (CPs) that are capable of hosting cells in 3D due to their possibility into porous architectures, biocompatibility and compliant mechanical properties. These materials aim to integrate functionality into the "passive" scaffolds, while addressing the problem of rigidity of 2D metal electrodes. In this talk, I will demonstrate the development of CP scaffolds with a dual purpose – to both host and monitor/stimulate cells. The adhesion and pro-angiogenic secretions of mouse fibroblasts cultured within the scaffolds can be controlled by switching the electrochemical state of the polymer prior to cell-seeding. The same device infiltrated by kidney cells, on the other hand, acts as a live-cell monitoring platform that enables electronic sensing of cells. Moreover, the ease of preparation of different compositions of materials allows for the tunability of different properties such as mechanical stiffness and conductivity. I will show how such properties influence the performance of the devices, but also enable tailoring scaffolds for building specific tissue types.
Session E2: Photovoltaic Technologies

Chairs: Peter Bermel, Purdue University (pbermel@purdue.edu)
13:30 Santosh Kurinec, Rochester Institute of Technology (skkemc@rit.edu)

Advances in Contact Technology for Silicon Photovoltaics

Since 2005 the annually installed capacity of photovoltaics (PV) has grown over 2700%. One of the main forces behind this growth is the unprecedented decrease in price per Watt of PV power. As such, competition for market share and the will to reduce production costs are at an all-time high. Silicon PV represents 90% of the industry. Conventional silicon solar cells employ silver as the front metallization and aluminum as the back metallization. Silver front metallization is the largest single cost factor, representing more than 7% of the cost of goods sold, or nearly 50% of the cost of the cell itself. Screen printing has been the method of metallization. However, alternative techniques such as plating, hybrid, ink-jet and new concepts are emerging. Copper presents a viable and sustainable alternative to silver with the potential to reduce metallization costs by approximately 50% while maintaining device performance in preliminary investigations. The primary concerns with copper are due to its quick diffusion in silicon where it acts as a deep level trap, greatly diminishing the efficiency of the device. Nickel monosilicide (NiSi) is a strong contender as a contact, as it shows promise as a copper diffusion barrier, makes a low resistance contact with silicon and has been investigated thoroughly for use in the integrated circuit industry. Further improvements in contacts need to minimize surface recombinations while maintaining low contact resistivity. Carrier selective tunnel oxide passivated contacts (TOPCon) enable a low interface recombination and are being explored for high efficiency advanced solar cells structures such as HIT and IBC cells. The NiSi/Cu metallization scheme is investigated on high efficiency, textured, solar cells with passivated tunneling contacts. The viability of NiSi in this regime is evaluated by photoluminescence (PL), and TLM measurements. Implied VOC values near 700 mV and contact resistivities below 10 mΩ-cm can be achieved in NiSi/poly-Si:P/SiO2/c-Si contacts. Accurate measurement of contact resistance will also be discussed.

13:50 Lionel Vayssieres, International Research Center for Renewable Energy (lionelv@xjtu.edu.cn)

On the Design of Advanced Materials for Efficient and Cost-effective Solar (Sea)Water Splitting

The latest improvements in low-cost advanced materials design strategies, and atomic-scale fundamental understanding of the performance and stability of photoelectrodes for water oxidation and overall water splitting will be presented. The detailed effects of dimensionality, confinement, surface chemistry, orbital character and symmetry, interfacial electronic structure, polarization, electrical properties and surface termination will be demonstrated on low-cost semiconductors for efficient and large scale hydrogen generation from sunlight and seawater.
Hybrid Perovskite Materials For Radiation Sensing

The neutron detector most widely used today is the pressurized 3He tube, which was designed in the 1970s.

Given its high cost, these gas-filled tubes cannot be used in large area arrays. Thermal neutron imaging using two dimensional arrays are desirable for a wide range of applications such as real-time imaging in security and health sectors. There are essentially four elements suitable for solid-state (or bulk) thermal neutron detectors (B, Cd, Gd and Li), but all of them are difficult to produce at low temperature. 10B is particularly interesting because of its larger thermal neutron absorption cross section. In this research, a hybrid perovskite material (e.g. CH3NH3PbI3) doped with boron is demonstrated as a neutron detector. Both simulation as well as experimental results show that perovskite can be used as the active sensing element for thermal neutrons. In particular, we present a strategy to prepare different perovskite single crystals using inverse temperature crystallization technique (ITC) and its integration into neutron sensing diode structures. The incorporation of B into the crystal lattice was confirmed by the EDX, XPS, Raman spectroscopy and X-ray diffraction.

Our approach for neutron detection conversion layers consists on the well known 157Gd and 10B neutron interaction. When a thermal neutron is captured by either 157Gd or 10B, beta particles (electron), gammas and alphas are expelled with one of numerous possible energies. For 157Gd, if the highest energy beta (~70 keV) is completely absorbed by the active layer of a diode (i.e silicon p-i-n), the primary beta particle could generate up to 10,000 electron-hole pairs, more than enough for adequate detection with conventional electronics. However, for optimal sensitivity the thicknesses of the absorber must be optimized. For example, the mean free path of a ~70 keV beta in Gd2O3 is ~4 µm; therefore, a Gd layer in this thickness regime will be required, but different thicknesses will be required for a particles (> 1MeV) produced by a detector containing 10B. For particles with large mean free paths the diode dimensions can be increased but only at the expense of lower signal to noise. However, the energy of the electrons escaping from the gadolinium will be lower than their initial energies, increasing the probability of capturing them in the diode in the bulk detector configuration, but creating fewer electron-hole pairs in the process. This highlights the fact that, besides optimizing the converter layer, the diode thickness must also be optimized for optimum detection. In this presentation we present hybrid organic-inorganic perovskites (HPV) as thermal neutron sensor material using both thin-film-coated or single crystal bulk detectors with novel perovskite materials. We take advantage of the long diffusion lengths characteristic of the perovskites to tune its electronic properties and implement them as active semiconductor for thermal neutron detectors. For the single crystal, we evaluate the incorporation of B and Gd the perovskite matrix to use it as embedded neutron conversion layer.
Optimization of n-Si Heterojunction Solar Cell with Molybdenum Oxide as a Hole Selective Contact

We investigate the influence of Si doping concentration (ND), transparent electrode, barrier layer, and native oxide on the performance of n-Si/molybdenum oxide (MoOx) heterojunction solar cell, where MoOx serves as a hole selective contact. The power conversion efficiency (PCE) of the cell is noted to be nearly constant at 10.1-10.2% for ND over the range 10¹⁴-10¹⁶ cm⁻³, and it drops to 6.9% at higher ND of 10¹⁷ cm⁻³. Using thin evaporated indium tin oxide (ITO) as a water barrier layer, solar cell with poly(3,4-ethylenedioxythiophene):polystyrenesuphonate as the transparent electrode can be fabricated with high open circuit voltage (Voc) of 0.592 V and fill factor (FF) of 67.3% but with low short circuit current density (Jsc) of 28.4 mA/cm², yielding a PCE of 11.3%. On the other hand, n-Si/MoOx solar cell with sputtered ITO based transparent electrode enables a higher Jsc of 34.3 mA/cm² and results in an improved PCE of 11.6%, despite its lower Voc and FF. The results will be discussed in the context of the optical and physical characteristics of the cells with different structures, and the electrical transport across the n-Si/MoOx junction.

Calcium Barium Niobate Thin Film-based Electro-optical Devices: Recent Progress and Challenges

To overcome the present limitations of the Electro-Optic (EO) modulators technology, one main issue is to develop new thermally stable materials with high EO coefficient that can be integrated as thin films in advanced devices. We have shown that calcium barium niobate (CaxBa1-xNb2O6) in the form of thin film is a promising material for integrated EO devices applications, due to its unique EO properties (EO coefficient of 130 pm/V) and high Curie temperature (above 250°C). We successfully used Pulsed Laser Deposition to grow high quality CBN epitaxial thin films on various substrates including magnesium oxide (MgO), platinum coated MgO and silicon. An advanced patterning method using a nickel hard mask and a chlorine plasma was developed. Waveguides were fabricated (as building block of EO device) as well as CBN thin film-based optical grating couplers to enable efficient light coupling in very thin waveguide based devices.
15:50  Tsuneyuki Ozaki, INRS (Tsuneyuki.Ozaki@emt.inrs.ca)

Nonlinear Terahertz Spectroscopy of Graphene

Graphene has shown a transition state between semiconductor-like and metal-like properties dependent on its Fermi level, which has been revealed by optical-pump / THz-probe (OPTP) spectroscopy. This behavior is mainly attributed to an interplay between the relative increase in the Drude weight of the photoconductivity of graphene and the relative increase in the carrier scattering rate by increasing the Fermi level (or the doping concentration). In this work, we employ optical-pump / intense-THz-probe (OPITP) spectroscopy to study nonlinear THz field effects in photoexcited graphene when the Fermi level is set to be a minimum. A crossover from negative to positive differential THz transmission (or from semiconductor-like to metal-like properties) is observed when the THz probe field strength is increased. We attribute this behavior to a THz field-induced increase in the carrier scattering rate which dominates over the increase in the Drude weight in the photoconductivity. We also study sample temperature effects on the carrier dynamics in monolayer graphene, using THz time-domain spectroscopy (THz-TDS) as well as OPTP spectroscopy. We attribute our observations to extreme sensitivity of carrier density and mobility to environmental changes.

16:10  Jonathan McKendry, University of Strathclyde (jonathan.mckendry@strath.ac.uk)

Structured Illumination for Communications and Bioscience using GaN Micro-LED Arrays Interfaced to CMOS

Gallium-Nitride-based light-emitting diodes (LEDs) have emerged over the last two decades as highly energy-efficient, cost-effective, compact and robust light sources. While general purpose lighting has been the dominant application thus far, a variety of other applications can also exploit these advantageous properties, including optical communications, fluorescence sensing and bioscience.

Micro-LEDs arrays of individually-addressable LED pixels, each pixel typically 100 µm or less, offer further advantages over conventional LEDs such as extremely high modulation bandwidths and spatio-temporally controllable illumination patterns. These arrays are also readily compatible with flip-chip integration with CMOS electronic driver arrays.

Here we report how these CMOS-controlled micro-LED arrays enable "smart lighting" solutions, capable of providing services such as wireless data communication and indoor navigation in conjunction with illumination. We also demonstrate how this smart functionality opens up novel bioscience applications, including depth-specific in-vivo optical neural probes and wireless transfer of measured data.
In the "real world", the optical breakdown of a material will occur at electric field intensities that are many orders of magnitude lower than those observed in laboratory ultra-short pulse experiments covering microscopic volumes. This behavior can often be attributed to contamination or defects and is usually dismissed as a random or unpredictable occurrence that can at best be explained by statistical means. Most prior work in the area deals with absorption and thermal transfer. However, it has recently been noted that dielectric materials with large bandgaps appear to be less susceptible to contamination-induced breakdown than those with small bandgaps. In this presentation, these results are described and multiple potential physical mechanisms to explain the data are discussed. When contamination-induced breakdown occurs, a flash of light is usually seen indicating that the contaminant has been heated to extremely high temperature and is evaporating. This can be accompanied by thermal transfer to the substrate, but other processes such as the excitation of free carriers in the material by UV photons emitted by the contaminant can play a larger role as can interactions with electrons that have been excited past the ionization energies of their atoms. These physical models explain much of the behavior observed but much work remains to be performed. The entire evolution of the contaminant from particle to evaporated residue or damage crater can take less than a millisecond and is often accompanied by particle mobility and fragmentation or coalescence.
RFIC Design by Mathematics

Design by Mathematics is an inventive design approach dedicated to high performance integrated circuits. It is based on mathematical principles and techniques, such as Riemann's integration or Fourier's transformation. These mathematical tools are used to optimize a specific signal processing and conditioning. A given tool behavior is then copied as much as possible within a silicon implementation, yielding to mixed-signal integrated circuits that demonstrate innovative system architectures and disruptive approaches. While using Design by Mathematics does not imply one will achieve better performances than when using classical design techniques, it offers a substitute that can counteract key technical bottlenecks and pave the way to new opportunities. In this talk several Design by Mathematics examples will be presented, focusing on wireless systems. These systems include next generation standards such as 5G and its carrier aggregation technique in the radiofrequency range. Fourier's and Walsh's transformations will used, as well as Fourier's recombination and Riemann's integration, for either the receiver path or the transmitter path of a system.

Trade-offs in Decimation Filter Design for Analog-to-Digital Converters based on Sigma-Delta Modulators

Analog-to-digital converters (ADC) based on Sigma-Delta modulators are commonly used in such applications that require high signal resolutions, at the digital side, and relatively low data rates when compared with the Nyquist-rate ADCs. The modulator provides a highly oversampled, low resolution signal (usually 1-bit) with large quantisation noise. The modulator is usually followed by a multi-stage decimation filter, whose role is to remove the quantisation noise, to reduce the data rate and simultaneously to increase the resolution of the signal at the output of the ADC. Decimation filter is typically composed of a chain of finite impulse response (FIR) filters, and frequency decimating blocks. The design of the decimation filter is challenging if its structure have to be optimized in terms of the chip area (the number of transistors) and the power dissipation. The frequency response of the filter, and thus the values of its coefficients have a very strong influence on the chip area. To reduce the number of transistors, the values of the coefficients have to be rounded to reduce their resolution in bits. However, it leads to reduction of the attenuation of the filter. As a result, various trade-offs can be indicated between the chip area, the precision of the filter and thus the attainable resolution of the ADC. The paper discusses these trade-offs, providing examples of practical realizations of such filters.
16:40 Yan Lu, University of Macau (yanlu@umac.mo)

**CMOS Circuits and Systems for Wireless Power Transfer**

The applications of wireless power transfer (WPT) are on the critical point of an exponential growth. Based on CMOS technologies, highly integrated and highly efficient WPT solutions have been demonstrated for medical implantable devices and low-power portable devices. In this talk, recent innovations on WPT at both system- and circuit-level, including the advanced load impedance modulation and efficient power converter design techniques, will be introduced and discussed first. And then, a reconfigurable bi-directional wireless power transceiver for allowing mobile devices to charge each other without additional hardware, namely battery-to-battery (B2B) wireless charging, will be presented.

17:00 Edwin C. Kan, Cornell University (kan@ece.cornell.edu)

**Indoor Radio Real-Time Localization and Identification**

Among all of the advances in electronic and information technology, radio-frequency (RF) technology for indoor precision real-time locating system (RTLS) still remains unreliable for many applications, including 3D human-machine interface (HMI), biomedical monitoring, prosthetic feedback control and indoor navigation. In addition, Internet of Things (IoT) will be heavily constrained if the physical location of the "thing" remains unknown or inaccurately known. Many local area network (LAN) and body area network (BAN) breakthroughs can be enabled if an indoor radar-like technology can be broadly deployed. The detection and ranging principle of indoor RTLS is similar to outdoor radar, but has many unresolved challenges such as unspecific reflection, path obstruction, and multi-path interference.

Different from the received-signal strength (RSS) method which is insensitive to location and has serious ambiguity problems for indoors, the continuous wave (CW) phase-based ranging method is simple, flexible and precise, but vulnerable to phase offsets and interferences. I will present passive broadband harmonic tags to fundamentally rectify previous CW problems. Because phase information is now contained within the second harmonic (SH) rather than the fundamental frequency, interferences and phase errors caused by direct reflections of the interrogating signal are greatly reduced. The passive harmonic tag is now the only radiation source in SH within the indoor ambient, which enables many radar techniques like channel coherence, beamforming and synthetic aperture to improve precision, evaluate measurement quality and reduce spectral cost. Multiple but sparse frequencies are employed to resolve the integer ambiguity and to achieve millimeter-level precision under phase error tolerance towards total of +/-90°. Human movement causes distinctive magnitude and phase channel fading, and can be equalized for better tag reading. Furthermore, digital beamforming can be used for multi-path evaluation and tag movement for synthetic aperture, both of which can further improve precision and reliability. With the help of known harmonic landmark tags, the tagless objects within the reading range can be further mapped out with redundant angular and frequency diversity, which enables many additional applications. I will show realistic indoor experiments to validate our models and algorithms.
17:20 Ramesh Harjani, University of Minnesota (harjani@umn.edu)

Jitter Reduction Techniques for High-Speed Data Converters

With advances in digital signal processing, ADC performance has rapidly become the bottleneck for high speed, high resolution systems. Wideband ADC performance is ultimately limited by the clock jitter, where the jitter-induced error increases linearly with the input signal frequency, imposing stringent requirements on clock jitter in high-speed high-resolution ADCs. We analyze and develop a novel sampling technique that addresses the clock jitter problem in high resolution wideband ADCs. The proposed sampler shapes the jitter-induced error in a manner similar to a ΔΣ ADC. The clock jitter at the sampler is suppressed by the loop filter. As opposed to prior studies, we show that a ΔΣ sampler suppresses the jitter error by more than 10X even at low OSR. As an example, a 2nd-order ΔΣ sampler increases the SJNR by 9dB/Octave, corresponding to more than 3-bit improvement in the achievable SNR with and OSR of 5.

17:40 Kiichi Niitsu, Nagoya University (niitsu@nuee.nagoya-u.ac.jp)

CMOS Bioelectronics for Healthcare and Bio-Analysis IoT

This talk will introduce recent topics on CMOS bioelectronics for healthcare and bioanalysis IoT. First, a self-powered healthcare IoT using CMOS bioelectronics and biofuel cells will be introduced. The proposed healthcare IoT includes a biofuel cell as a power source and a sensing frontend that is associated with the CMOS integrated supply sensing sensor. In newly-proposed supply-sensing architecture, supply voltage obtained from the biofuel cells whose output varies depending on bio concentration is converted to time-domain information (frequency) without any power-management circuits nor ADCs. By adopting supply-sensing architecture and current-driven inductive-coupling transmitter, required supply voltage was reduced to 0.19V, which is compatible with self-powered operation using biofuel cell. A prototype in 65-nm CMOS successfully demonstrated 53-µW operation and proximity communication with capability of temperature monitoring. This can be applied to health monitoring such as wearable Lactate monitoring. Second, a bio-analysis IoT using CMOS amperometric biosensor array will be introduced. By introducing the newly-proposed electroless gold plating technique for electrode formation, a 1.2µm-by-2.05µm, 1024-by-1024 microelectrode array was developed, which is world’s smallest and compatible with direct bacteria counting. A prototype in 0.6-µm CMOS successfully demonstrated direct counting of the bacteria-sized microbeads and HeLa cells. This can be applied to portable pathogen counting.
Current-injection Terahertz Lasing in Graphene-based Transistor Lasers

This paper reviews recent advances in the research of current-injection terahertz lasing in graphene-based transistor lasers. Optical and/or injection pumping of graphene can enable negative-dynamic conductivity in the THz spectral range, which may lead to new types of THz lasers. A forward-biased graphene structure with a lateral p-i-n junction was implemented in a distributed-feedback (DFB) dual-gate graphene-channel FET and observed a single mode emission at 5.2 THz at 100K. The observed spectral linewidth fairly agrees with the modal gain analysis based on DFB-Fabry-Perrot hybrid-cavity-mode modeling. When the gain overlapping could not satisfy the lasing threshold condition, a broadband spontaneous THz emission was observed, confirming the incoherent broadband THz light-emitting transistor operation. Although the results obtained are still preliminary level, the observed emission could be interpreted as THz lasing in population-inverted graphene by carrier-injection. The promising physical mechanisms and device structures enabling room-temperature intense THz lasing will also be addressed.
Michal Marcinkiewicz, University of Montpellier (michal.marcinkiewicz@umontpellier.fr)


Terahertz Studies of Massless Fermions in HgCdTe Heterostructures

Bulk films and heterostructures based on HgCdTe compounds can be engineered to fabricate "gapped-at-will" structures. Therefore, 1D [1], 2D [2] and even 3D [3] massless particles can be observed in topological phase transitions driven by intrinsic (quantum well thickness, Cd content) and external (magnetic field, temperature or pressure) physical parameters. So far, the phases of 2D [1] and 3D [4] topological insulator have already been experimentally demonstrated in HgCdTe-based heterostructures. More recently, clear experimental evidence of the existence of 3D electronic states with conical-like spectrum was obtained in HgCdTe bulk films at specific Cd content [3]. These 3D massless particles, called Kane fermions, have unique symmetry properties, which are not equivalent to any well-known case of massless particles in the relativistic limit of the quantum electrodynamics.

In this work, we report on our recent experimental results obtained by Terahertz (THz) and Mid-Infrared magneto-spectroscopy, on topological phase transitions driven by temperature in HgCdTe-based QWs [5] and bulk films [6]. These transitions are accompanied with the appearance of 2D and 3D massless electrons called Dirac and Kane fermions, respectively. We will also present first results on THz emission coming from radiative recombination of such particles [7]. Our research paves the way towards future efficient and magnetically tunable THz detectors and emitters.

References:
16:40 Jacek Marczewski, Institute of Electron Technology (jmarcz@ite.waw.pl)

Prospects and Limitations of Si-CMOS Technology for THz Photovoltaic Detectors

Spectacular progress in THz detection with the use of standard CMOS technology have shown that such a solution has the potential to be the leading method of manufacturing low-cost THz sensors with integrated readout systems and monolithically integrated antennas. The presentation, based on the author’s experience, presents the advantages and disadvantages of this solution. Several examples of some hints, especially regarding design of detectors and readout systems, are shown. CMOS technology seems to be optimal for the production of inexpensive imaging systems for sub-THz frequencies; however more demanding applications are also possible. The main problem concerns the lack of cheap and efficient sources of THz radiation that could be produced in the standard CMOS technology.

17:00 Grzegorz Cywiński, Institute of High Pressure Physics PAS (gc@unipress.waw.pl)

Innovative GaN Terahertz Devices

Nitride based unipolar devices, due to their physical properties, are promising for applications in high frequencies (HF). Especial interest is for HF devices based on GaN/AlGaN two-dimensional electron gas (2DEG) epistructures, which already compete on the market with GaAs devices in HF GHz range. In spite of not fully matured technology, nitride field effect transistors outperform arsenide devices in sense of 2DEG densities, their mobilities, working voltages and handled power levels. However, to increase of cutoff frequencies towards terahertz range significant reduction of RC product is required. This usually led to advanced processing technology, which is using submicron device layouts to minimize parasitic capacitances and impedances. Our approach was to use lateral Schottky barrier diodes, where the Schottky contact is formed to GaN/AlGaN 2DEG on the side of an etched wall of a mesa. This lead to forming an extremely small contact area i.e. one dimensional (1D) contact and causes in a very small capacitance. Moreover, using a special regrown contact for an ohmic part of the diode one can significantly reduce the access resistance. We will discuss our technology details of lateral Schottky design, finFET based on this lateral approach and a new "edgeFET" design, towards possible applications at sub-THz and THz range for mixers, multipliers and detectors. We will present our preliminary results of sub-THz photoresponse of lateral Schottky devices.
Stéphane Le Calvé, University of Strasbourg (slecalve@unistra.fr)  
with C. Trocquet and P. Bernhardt  

*Development of a Microfluidic Analytical Method for a Continuous Real-time Monitoring of Airborne Formaldehyde Concentrations: Application to Field Measurements*

Formaldehyde is a major and harmful pollutant of indoor air due to its multiple sources and its carcinogenic effect. This work reports the development of a novel analytical method based on microfluidic technologies for the detection of low airborne Formaldehyde concentrations, representative of those found in indoor air, i.e. 10-100 µg.m⁻³. The new analytical technique operates as follows: 1) gas sampling, 2) gaseous Formaldehyde uptake into the aqueous solution using an annular gas/liquid flow at room temperature, 3) derivatization reaction with acetylacetone solution at 65°C producing 3,5-Diacetyl-1,4-dihydrolutidine (DDL) and 4) fluorimetric DDL detection. Laboratory experiments were performed to determine the experimental conditions permitting to obtain a stable annular flow, i.e. gas to liquid flow rate ratios greater than 1000. From liquid and gas calibrations, an uptake yield of 102% and a detection limit of 1 µg m⁻³ were determined. Finally, our 4 kg instrument fully controlled by homemade software has a response time of 10 min, a temporal resolution of 2 seconds and an autonomy of 98 hours with 100 mL reagent. This formaldehyde microanalyzer was then deployed during several field campaigns and compared with the ISO 16000-3 reference method (active sampling on DNPH cartridges).

Alireza Sharifi, University of Thessaly (sharifi@mie.uth.gr)  
with D. Valougeorgis and S. Le Calvé  

*Modeling and Simulations of BTEX Adsorption/Desorption in a Preconcentrator of a VOC Micro Analyzer*

The preconcentrator of a volatile organic hydrocarbons (VOC) analyzer detecting BTEX down to a few ppb is simulated by successfully modeling the adsorption and desorption processes in real time. The efficiency of the device is optimized by investigating the effect of all involved parameters related to geometry, flow conditions and applied materials. Experimental results are used to support and validate the implemented modeling.
16:40  Myeongsub (Mike) Kim, Florida Atlantic University (kimm@fau.edu)

Microfluidics for Interfacial Carbon Dioxide Dissolution

Carbon capture and sequestration is a promising technology for mitigating increasing levels of carbon (CO2) emissions to the atmosphere. Among many storage areas, geologic saline aquifers could safely store significant amounts of CO2 over hundreds of years. Previous research has shown the potential use of nickel nanoparticles for enhancement of CO2 dissolution in saline aquifers. However, the fundamental mechanisms of the increased CO2 dissolution by nanoparticles have been untapped. To fully understand the dissolution process and to store much larger amounts of CO2, the nanoparticle-driven CO2 dissolution process should be investigated. In this study, a cost-effective microfluidic approach was adopted in order to visualize the mechanism by which nickel nanoparticles can augment CO2 dissolution into a saline solution. Using a series of CO2 bubbles, the interfacial interactions between nanoparticles and CO2 during the dissolution process were successfully quantified at microscale through high speed optical imaging in real time. At various concentrations of nickel nanoparticles, the CO2 dissolution behaviors to the saline solution were characterized in terms of the diameter of CO2 bubbles. The results show that the catalytic property of nickel nanoparticles contributes to the significant enhancement of CO2 dissolution and this catalytic effect reaches to the maximum at the nanoparticle concentration of 30 mg/L. The detailed experimental results and relevant physics behind nanoparticle-assisted CO2 dissolution will be further discussed.

17:00  Felix Holzner, SwissLitho (holzner@swisslitho.com)

Thermal Scanning Probe Lithography and its Applications

Thermal scanning probe lithography (t-SPL) has recently entered the lithography market as first true alternative to electron beam lithography (EBL). By now, the first dedicated t-SPL systems, called NanoFrazor, have been installed at research facilities in Europe, America, Asia and Australia by the company SwissLitho, a spinoff company of ETH Zurich.

Core of the technology - which has its origins at IBM Research and their Millipede project - is a heatable probe tip which is used for patterning and simultaneous inspection of complex nanostructures. The heated tip creates arbitrary high-resolution (<10 nm half-pitch) nanostructures by local decomposition and evaporation of resist materials. The patterning depth can be controlled with 1 nm accuracy, enabling patterning of extremely accurate 3D nanostructures in a single step.

The patterning speed of t-SPL is comparable to that of high-resolution Gaussian shaped EBL, and a scan speed of 20 mm/s with a pixel rate of 500 kHz has been demonstrated. The written nanostructures are inspected by the cold tip in parallel with the patterning process, which enabled new methods for stitching and overlay with sub-5 nm accuracy without the use of artificial marker structures.

Pattern transfer methods based on reactive ion etching, lift-off, electroplating, directed self-assembly and more have been demonstrated in combination with t-SPL. Various examples of realized applications that demonstrate the unique capabilities of the NanoFrazor will be shown. Such examples include 3D optical devices like phase plates, gratings and computer generated holograms. Furthermore, devices made of graphene and MoS2 flakes or carbon tubes and InAs nanowires will be shown. Such examples benefit from the accurate overlay process and the fact that no potentially damaging charged particle beam is used during the lithography itself.
Physical Design Automation for Microfluidic Large Scale Integration Biochips

Microfluidic Large-Scale Integration (mLSI) chips are poised to revolutionize biochemistry and bioengineering through automation, miniaturization, and programmability, targeting applications such as DNA sequencing, drug discovery, detection of influenza and other pathogens, biothreat detection, and water purification. The key enabling technology is the programmable microvalve, the fluidic analogue to the transistor. Although several microvalve technologies exist, the highest integration densities have been achieved using soft lithography fabrication in polydimethylsiloxane (PDMS), a silicon-based organic polymer. Similar to how several transistors can be assembled to implement arbitrary logic functions, sets of microvalves can be organized to form useful components, including peristaltic pumps, rotary mixers, pressurized latches, logic gates, and many other useful components. Scientists presently must design new devices for each application by hand. This may take weeks or months for complex applications. In recent years, there has been a movement to adopt computer-aided design techniques from the semiconductor industry to mLSI chips. Successful productization of such a tool that automatically converts a scientist’s biological application into a physical device layout that can be fabricated and used would significantly enhance scientific productivity and lower the barrier-to-entry for new users. This talk will summarize the ongoing development of a software infrastructure for the automated design, verification, and evaluation of mLSI chips, focusing specifically on recent advances in physical design automation.

Importance of Fundamental Theoretical Development in the Context of Modern Microelectronics Technology

GaN based HEMTs (high electron mobility transistors) have received extensive interest in the research community over the last two decades for high frequency and high power applications. Epitaxial growth of these heterostructures by MBE (molecular beam epitaxy) technique is advantageous due to low impurity incorporation, sharp interfaces and the capability of in-situ growth monitoring. However, III-nitride growth on Si substrate as a possible cost-effective solution is challenging due to high lattice and thermal mismatch, which results in cracking of these epitaxial layers. This presentation focuses on the growth and optimization of AlGaN/GaN HEMT heterostructures on high resistivity 100 mm diameter Si (111) substrates by MBE growth process. The stress management in device structures using stress-mitigating layers (SMLs) to obtain crack-free epilayers with good 2DEG-properties will be discussed. The effect of carbon doping on the structural and electrical properties of GaN buffer layer has been investigated to possibly suppress the parallel conduction in AlGaN/GaN HEMT structures. For SH-HEMTs, a reduction of buffer leakage currents by two orders in magnitude has been obtained. Finally, studies on obtaining improved confinement of 2DEG and higher buffer breakdown voltage in the case of DH-HEMTs will be presented and compared with SH-HEMTs.
EDA Beyond its Electronic Roots: Toward a Synthesis Methodology for Wavelength-Routed Optical Networks-on-Chip

Technology maturity is not the only requirement for the industrial uptake of emerging interconnect technologies. The additional challenge is given by the need to bridge the gap between technology developers and system designers, who need to do system-level design with the new technology. This requires the abstract specification of an interconnect fabric matching the requirements of the system at hand, and an automatic synthesis toolflow capable of refining such an abstract view into an actual implementation, going through all the intervening abstraction layers. Not surprisingly, this is what typical electronic design automation flows do for digital design. The level of design automation for chip-level nanophotonic interconnection networks is lagging far behind in this respect. The effectiveness of the design process largely depends on designers' intuition, thus most of the design space is still unexplored. This talk illustrates a synthesis methodology that brings wavelength-routed optical network-on-chip design into new ground. The methodology is rooted in basic interconnection primitives and in criteria for their legal combination, which potentially leads to any higher-order switching structure. Finally, the physical mapping steps are detailed by assuming a 3D-stacked parallel computing system. Overall, the key contribution of this talk consists of the capability to understand all topology design points in the context of a unified design framework.

The Integrated Toolbox: Co-designing Integrated Systems Leveraging Multiple Technologies

The continued scaling of integrated circuits (ICs) driven by Moore's law over the past 50 years drastically increased their application space and functionality well beyond the digital processing market. These ICs can now can contain not just digital and analog circuits, but radio frequency circuits up through hundreds of GHz, including electromagentics and on-chip antennas. On the other side of the scale, the push toward mobile applications that never require charging has led to ultra-low power circuits that can be powered solely by harvesting energy from the surrounding environment. All of these new applications require advanced design techniques and technologies that must be tightly co-designed at the system level to enable the required level of performance and efficiency. This talk will explore the tools that IC designers now have in their toolbox and how they can be combined to enable the applications of the future. Examples include the co-design of digital and millimeter-wave circuits to improve yield and self-heal when failures occur, the co-design of millimeter-wave circuits and antennas on-chip to create novel electromagnetic radiators, and the co-design of passive detectors with ultra-low power digital circuitry to create receivers operating at power levels below the self-discharge rate of a battery.
Mattias Palsgaard, QuantumWise A/S (mattiaslau@gmail.com)

**Atomistic Modeling of Semiconductors and their Interfaces**

We present a method to obtain the band offset of semiconductor heterointerfaces from Density Functional Theory together with the nonequilibrium Green’s function method. Band alignment and detailed properties of the interface between Cu2ZnSn(Se/S)4 and CdS are extracted directly from first principles simulations. The interface is important for photovoltaics applications where in particular the band offsets are important for efficiency. The band bending pose a problem for accurate atomistic simulations of band offsets due to its long range. Here we investigate two different methods for dealing with band bending directly.

Studying the bandstructure of the interface in detail we identify detrimental localized states that narrow the band gap at Cu2ZnSnS4 surfaces. A CdS buffer layer does not adequately passivate the localized states, which inevitably results in the dominance of interface recombination in Cu2ZnSnS4/CdS solar cells. By taking the localized states into account in a device model, the outcome of previously published temperature-dependent open circuit voltage measurements on Cu2ZnSnS4 solar cells can be reproduced quantitatively without assuming a cliff-like conduction band offset with CdS. We demonstrate that the success of Zn-based alternative buffer materials is likely due to the ability of Zn to passivate those localized states.

Lanny Lewyn, Lewyn Consulting (lanny@pacbell.net)

with N. Williams

**Design and Verification of a 4 GSPS 16b ADC in Deep-Nanoscale Fabrication Nodes**

A 4 GSPS 4-leaf 16b ADC has been designed to provide direct fabrication technology portability from 250nm (N250) down to N28. At technology nodes past N28, conventional DUV lithography is far beyond the Rayleigh limit. Multi-patterning physical design techniques are then required until EUV is ready for mass production. Past N10, main-stream Fin-FET technology is encountering more difficulty with source-channel barrier control. The resulting significant increase in gds, reduced subthreshold Id-Vg slopes (lowering gm), and collapsing supply voltages are forcing high speed operational amplifier into a new regime. Main op-amp support from many power-efficient additional sub-amplifiers are then required to achieve high speed and high gain in high resolution ADC applications. The resulting complexity in physical design and number of subcircuits (>4K) require an extremely hierarchical design and a new generation of tools to verify the design of a single ADC. This paper will discuss several key issues related to the design and verification of high-speed, high-resolution ADC design technology-portable down to N28 and beyond.

Fabrice Vallee, Université de Lyon (fabrice.vallee@univ-lyon1.fr)

**Mechanical Response of a Macro- to Nano-size Oscillator**

Acoustic vibrations of nano-objects are usually described using a macroscopic mechanical resonator model where the object is described as an elastic body. To investigate the size limit of this model, we have studied the vibrations of metal nanoparticles formed by few hundreds to few atoms using ultrafast pump-probe spectroscopy. The results show that this model can be used for sizes as small as 1 nm, i.e., about 30 atoms. Deviations occurs for smaller sizes, for which a molecular type of description has to be used to reproduce the experimental data.
10:40  COFFEE BREAK (FOYER)

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11:00  Katarzyna Grzesiak-Kopec, Uniwersytet Jagiellonski Krakow (katarzyna.grzesiak-kopec@uj.edu.pl)
with M. Ogorzalek

*Solving the Real 3D IC Floor Plan Puzzle*

Full 3D chip fabrication without in-plane and layered-structure constraints is still beyond the realms of possibility. We propose an approach to solving the floor-planning problem in a 3D game-like manner. The chip modules are physical manifestations of virtual autonomous agents that navigate around their world to solve the floor plan puzzle. They make move decisions solely applying Newtonian physics and different moving behaviors, namely flocking behavior and gravity. The agents start in random positions and begin the space exploration according to the topological partitioning heuristics. Their main goal is the chip volume minimization. The approach is illustrated by the example application to one of the MCNC benchmark netlists. The game is implemented using Godot that is an advanced open source game engine.

11:20  Fabio Di Francesco, Università di Pisa (fabio.difrancesco@unipi.it)
with B. Melai, N. Calisi, P. Salvo, A. Kirchhain, F. Vivaldi and R. Fuoco

*Disposable Temperature and pH Sensors based on Graphene Oxide and Reduced Graphene Oxide*

The longer life expectancy in Western countries brings forth the challenge of a growing burden of chronic illnesses like chronic wounds. Wearable sensors are creating great expectations for improving knowledge on the biochemical processes in action in these wounds and combining quality of treatment and low cost. SWAN-iCare is a project funded by the European Commission developing temperature, pH and metalloproteases activity sensors for monitoring and managing chronic wounds.

We report here the fabrication, testing and validation of disposable sensors, namely a resistive sensor based on reduced graphene oxide for the measurement of temperature and a potentiometric sensor based on graphene oxide for the measurement of pH in the wound bed. In-vitro validation with model solutions and real samples established accuracies of ±0.5°C (range 20-40°C) and ±0.2 pH units (range 5.5-9 pH units). Issues concerning biocompatibility for the use in contact with the wound bed are addressed as well as the potential applications in other fields.
Daniel Filippini, Linköping University (danfi@ifm.liu.se) with G. Comina and A. Suska

3D Printed Devices for Cell Phone Chemical Sensing

Disposable lab-on-a-chip devices, as only accessory for chemical detection with cell phones, pose considerable demands on the design and capabilities of such devices. Ideally, they should be autonomous, integrate the optical coupling elements, and contain all the required actuators. In addition, quantitative detection with unmodified cell phones requires the integration of a calibration range and the selection of robust detection methods.

Classical microfabrication techniques are conceived for repetitive and parallelized operations but are costly and inflexible to accommodate drastic modifications along the development and optimization cycles. Similar considerations could be made about the fabrication of plastic optical components.

Additive microfabrication, in this case using a laser stereolithography (SLA) 3D printer, has several advantages for low-cost fast-prototyping of disposable lab-on-a-chip (LOC) devices and optical components. We present the unibody-LOC concept, which centralizes all fabrication tasks in a single monolithic printout, independent of user skills, and involving typical costs of 0.5 USD/devices and fabrication times of 20 min. 3D printed devices such as unibody-LOCs can incorporate any number of 3D features and modifications in each development iteration, for the essentially the same cost. The same workflow and costs are involved in the polishing-free fabrication of optical components shown in this work.

Agata Michalska, University of Warsaw (agatam@chem.uw.edu.pl)

Conducting Polymers Nanospheres for Optical and Electrochemical Sensors

Conducting polymers have been attracting research attention in context of sensors for many years now; however, mostly in the format of layers used for electrochemical sensors.

For some polymers, e.g., polythiophenes, fluorescence properties depend on the state of the polymer. Moreover these materials can be easily obtained in the form of nanoparticles using nanoprecipitation. The compatibility of these materials with ionophores, opens a possibility to obtain nano-optodes. In contrary to conventional optodes, the proposed sensors do not require presence of pH-sensitive dyes and show turn-on, optical responses with a linear dependence of emission intensity on the logarithm of analyte contents in a broad range (a few of orders of magnitude).

For electrochemical sensors it is vitally important that nanoparticles of conducting polymers are characterized with uncompromised electrochemical activity, which is usually difficult to achieve using conventional synthetic approaches. The recently proposed by us novel templateless method of conducting polymers nanoparticles preparation yields formation of nanospheres of highly active surface, free from modifications and forming stable suspensions in aqueous phase. Thus obtained structures are characterized with high electrochemical activity and can be used to construct electrochemical or optical sensors, moreover they can be applied either as transducers or receptors.
12:20  Gerard Wysocki, Princeton University (gwysocki@princeton.edu)

*Integrated Laser Spectroscopic Sensors for Sensitive and Selective Trace-gas Detection*

There is a strong interest in technologies that can provide sensitive spectroscopic detection of chemicals using a compact integrated photonics systems. Ideally high spectral resolution systems that can provide broadband coverage in the near- and mid-IR spectral region would allow to detect both large molecules with broadband absorption spectra and small molecules with well-resolved spectral lines. In this work I will discuss systems utilizing semiconductor Fabry-Perot quantum- and interband-cascade-lasers to perform broadband multi-heterodyne spectroscopy of chemical species capable of measuring both attenuation, and optical dispersion (phase) of light interacting with the sample. These semiconductor laser systems are all-electrically driven and fully integrated, which enables monolithic or hybrid integration with other photonic platforms. I will also present our progress on integrated silicon photonic sensors for evanescent field spectroscopy of gases that hold the potential to enable truly scalable trace-gas sensor technology for applications in wireless sensor networks for industrial emission monitoring or in consumer products.
Cooling Nanoelectronic Structures to Ultralow Temperatures

Many solid-state quantum technologies must be cooled to sub-kelvin temperatures to operate properly. For example, superconducting qubits and quantum-dot based semiconductor qubits are normally studied at millikelvin temperatures inside a dilution refrigerator. Cooling such nanoelectronic devices presents significant challenges in maintaining thermal contact between the electrons in the device and an external cold bath. When cooling below ~10mK, it is typically found that the electrons in a device are heated significantly above the bath temperature. This problem is likely to persist, or grow, as quantum devices become increasingly complex. This talk will present our efforts to reach low-millikelvin electron temperatures in nanoelectronic devices through efficient thermalisation and active cooling of the electrons. To measure the temperature unambiguously, we study devices that are primary thermometers of their internal electron temperature. We show that electron temperatures below 4mK can be reached by immersing a device in the 3He/4He mixture of a custom dilution refrigerator. We also demonstrate a new approach in which the electrons directly by on-chip magnetocaloric refrigeration. This technique allows the low-millikelvin regime to be reached in a commercial, cryogen-free dilution refrigerator.

Bradley et al., Nature Communications 7, 10455 (2016)
Bradley et al., arXiv:1611.02483 (2017)

First-Principles Modeling of Electron-Phonon Coupling and Mobility in Nanostructures

The interaction between electrons and phonons is an important scattering effect limiting the mobility of carriers in nanoscale materials. In this contribution, we present a conceptually simple method for treating electron-phonon scattering and phonon limited mobilities. By combining density functional theory (DFT) with Green's function based transport calculations and molecular dynamics (MD), we obtain a temperature dependent transmission from which we evaluate the mobility. We validate our approach by comparing to mobilities and conductivities obtained by the Boltzmann transport equation (BTE) for different bulk and one-dimensional systems. For bulk silicon and gold we successfully compare against experimental values. Compared to alternative approaches for mobility calculations, such as BTE or perturbative non-equilibriums Green’s function theory (NEGF), the present method naturally includes finite-temperature and anharmonic phonon effects, and allows for simulations of mobilities in non-crystalline and defected materials. All the calculations have been performed using the Atomistix ToolKit software.
9:40  Hans Boschker, Max Planck Institute for Solid State Research (h.boschker@fkf.mpg.de)  
*Heterostructures from Quantum Matter*

Combining the power and possibilities of heterostructure engineering with the collective and emergent properties of quantum materials, quantum-matter heterostructures open a new arena of solid-state physics. Unique electronic states can be engineered in these structures, giving rise to unforeseeable opportunities for scientific discovery and potential applications. I will discuss some examples of quantum-matter heterostructures including a novel atomically thin, ferromagnetic, and conducting electron system.

10:00  Marek Korkusinski, National Research Council (Marek.Korkusinski@nrc-cnrc.gc.ca)  
with A. Bogan, S. Studenikin, G. Aers, L. Gaudreau, P. Zawadzki, A. Sachrajda, L. Tracy, J. Reno and T. Hargett  

*Control of Hole Spin in Lateral Gated Quantum Dot Devices*

In semiconductor materials, the wave functions of holes are built from p-type atomistic orbitals. This leads to a weaker hyperfine interactions of the hole spin with nuclear lattice spins and thus promises longer coherence times compared to those of electron spins [1,2]. However, holes are also subject to much stronger spin-orbit interactions (SOI). This talk explores the new physics brought about by the SOI for few carrier systems and discusses how it influences the magneto-transport spectra of GaAs lateral double quantum dots (DQD).

We start with a systematic analysis of the properties of a single hole in the DQD potential. We map out the spin-conserving and spin-flipping tunneling (SFT) processes, of which the latter is due to the SOI. In contrast with silicon hole devices, where the SOI are much weaker [3], in our GaAs heterostructure both tunneling processes are of similar magnitude. This allows us to understand our single-hole DQD as a hybrid spin-charge system, in which all degrees of freedom can be controlled electrically. This is in clear contrast to single-electron devices, where coherent rotations of single electron spin typically require non-uniform or time-dependent magnetic field. By analyzing the tunneling current through our system under microwave-frequency modulation of gate voltages (photon-assisted transport) we extract the characteristic coherence and relaxation times for our device.

We also populate our DQD with two holes and study the transport in Pauli spin blockade regime [4,5]. In electronic devices, this regime allows for the spin-to-charge conversion, enabling electrical preparation and measurement of the total spin of two carriers. In GaAs two-hole DQD, the strong SFT lifts the Pauli spin blockade except for the regime of very small magnetic fields. While it complicates the spin-to-charge conversion, the SFT allows to measure directly the effective hole g factor as a function of the direction of the magnetic field. As is typical for heavy holes, we find that the g factor is strongly anisotropic, and is nearly zero for the magnetic field oriented in the plane of the DQD.

Spin-Dependent Hopping in Tunnel Junctions

The Pauli exclusion principle results in strong spin correlations affecting transport through quantum dots and causing large magnetoresistance and luminescence effects in OLEDs. The spin-dependent resonant tunneling is responsible for a large signal in three-terminal spin accumulation experiments; however, the relevant expression for magnetoresistance is under discussion.

To resolve the controversy, we generalized the method of single-electron hopping to include spin. Only in the case, when the magnetic field is aligned with the ferromagnetic contact magnetization, the tunneling is determined by two eigenvalues of a 4x4 transition matrix corresponding to the spin-up and down Zeeman levels. In the general case of an arbitrary field orientation all four eigenvalues contribute to the transition rate. Thus, an expression for magnetoresistance obtained by considering only two eigenvalues is incomplete.

The method enables to calculate the shot noise at spin-dependent hopping. We demonstrate that, due to the Pauli blockade, the Fano factor is enhanced above its value at direct tunneling. This fact can serve as an additional characteristic capable to distinguish between spin-dependent trap-assisted tunneling and spin accumulation due to direct tunneling that causes the experimentally observed large signal in the three-terminal spin-injection setup.
Alberta Bonanni, Johannes Kepler Universität (Alberta.Bonanni@jku.at)

*Perspectives for Spin-orbitronics and Piezoelectro Magnetization Effects in III-nitride Semiconductors*

Besides their significance for opto- and high-power-electronics, gallium nitride (GaN) and related alloys possess also a number of features particularly attractive for spin-orbitronics, enabling, e.g., spin-charge interconversion via spin-orbit coupling associated with inversion asymmetry and leading to a sizable Rashba field and piezoelectric properties. Furthermore, through the addition of magnetic dopants fostering the formation of active magnetic complexes or driving the system to the state of a condensed magnetic semiconductor, these materials are expected to open wide perspectives in both fundamental and application-oriented research.

We provide here an overview on how we have unraveled and we can now control by fabrication parameters and co-doping a number of features of these systems, like the self-aggregation and performance of functional magnetic nanocrystals FexN and Mn-Mgk complexes embedded in GaN or AlxGa1-xN, which are optically active in the mid-infrared.

Moreover, we have demonstrated the generation of pure spin current in bilayers Py/n-GaN:Si – at room temperature and through spin pumping. We have found for n-GaN:Si a spin Hall angle $\theta_{SH}=3.03\times10^{-3}$, exceeding by one order of magnitude those reported for other semiconductors, pointing at III-nitrides as efficient spin current generators.

Finally, we show – by direct magnetization measurements – the electrical control of the magnetization in (Ga,Mn)N. In this dilute magnetic insulator the Fermi energy is pinned by Mn ions in the mid-gap region, and the Mn3+ ions show strong single-ion anisotropy. We have established that (Ga,Mn)N sustains an electric field up to at least 5 MV/cm, indicating that Mn doping turns GaN into a semi-insulating material. Under these conditions, the magnetoelectric coupling is driven by the inverse piezoelectric effect that stretches the elementary cell along the c-axis and, thus, affects the magnitude of the magnetic anisotropy. In this way, our work bridges two fields of research developed so far independently, namely: piezoelectricity of wurtzite semiconductors and electrical control of magnetization in hybrid and composite magnetic structures with piezoelectric components.

Artur Erbe, Helmholtz-Zentrum Dresden-Rossendorf (a.erbe@hzdr.de)

*Switching and Doping in Single Molecule Electronics*

We have developed the mechanically controllable break junction (MCBJ) technique for determining the properties of electronic transport through single organic molecules. The molecular energy levels participating in the charge transport through the junctions and the metal-molecule coupling can be characterized using this technique. Further developments are based on the use complex molecules, which can, for example, be used as single molecule switches. We present the first demonstration of a single molecule junction, in which the molecule is switched in situ from the non-conducting "off"-state to the conducting "on"-state. Further development towards realistic electronic circuits based on single molecule devices requires a broad range tuning of the conductance values, especially towards high conductance values. We show that the incorporation of metal ions into a single molecule can increase the conductance of the molecular junctions by orders of magnitude. This method resembles doping of semiconducting materials as it is used in electronic circuits. Therefore, the structures presented here can be regarded as steps towards applications using single molecule electronics.
11:40  Aida Todri-Sanial, Centre National de la Recherche Scientifique (aida.todri@lirmm.fr)

*Charge-based Doping of Carbon Nanotubes as Back-end-of-line Interconnect Material*

12:00  Ji Ung Lee, SUNY Polytechnic Institute (jlee1@sunypoly.edu)

*Three Fundamental Devices in One: A Reconfigurable Multifunctional Logic Device in Two-Dimensional Transition Metal Dichalcogenide Semiconductors*

The three pillars in semiconductor device technologies are (1) the p-n diode, (2) the MOSFET and (3) the Bipolar Junction Transistor (BJT). They have enabled the unprecedented growth in the information technology that we see today. Here, we will report on a single device that can reconfigure into these three fundamental devices. These devices allow us to provide fundamental linkages between material properties and device performance not possible by fabricating them individually. We will describe our method of fabrication and discuss both the electrical and optical properties of these devices. Finally, we will describe compact logic circuits that can be realized from the single reconfigurable device.

12:20  HongYu Yu, South University of Science and Technology of China (yu.hy@sustc.edu.cn)

*An E-mode AlGaN/GaN HEMT*
Morpho Detection Germany develops and sells X-ray diffraction imaging systems (XDi) for screening of cabin- and hold-luggage at airports. The advantage of these systems over conventional transmission X-ray systems, which base their alarm-decision on effective atomic number and density of objects, is the ability to directly probe the molecular structure of substances inside a bag by X-ray diffraction, resulting in good detection at low false alarm-rates. Drawbacks of the initial system XRD3500 used to be size, cost and throughput, but the maturity of energy-resolving detectors based on room-temperature semiconductors together with a multi-focus X-ray source allowed for a complete system-redesign to meet nowadays airport requirements. The XDi system-concept is explained as well as the functionality of our two types of detectors developed for XDi, one based on CdTe the other on CdZnTe. The detectors from our prototype- resp. small-scale production are characterized on the basis of 241Am- and 57Co-spectra. The corresponding performance of the two detector-types will be compared to each other as well as to the multi-segment Germanium-detectors used in our installed airport-systems.
Evolution of Portable X-Ray Equipment for Analysis of Works of Art

Evolution of devices based on energy dispersive X-ray fluorescence for analysis of artefacts:

Transportable device:

From 1971- Radioactive source of Pm-147/Al, or Pu-238, Xe- gas counter with energy resolution at 5.9 keV (ER) of 1000 keV, from 1975 Si(Li)-detector (250 eV E.R.) multi or single-channel analyze (MCA or SCA).

Analysis of Etruscan gold, of bronzes and paintings.

Portable device:


1996 - small X-ray tube (0-30 kV), Si-PIN, MCA card. Analysis of gold alloy from the altar of Volvinius in Milan.

2009 - small X-ray tube (0-40 kV), Si-PIN (200 eV E.R.). Analysis of gold alloys.

2010 - small X-ray tube (0-40 kV), Si-drift detector (140 eV E.R.) including the MCA. Analysis of pre-Columbian gold in Peru.

Battery equipped device:

2011 – small X-ray tube (0-50 kV), Si-drift detector (130 eV E.R.) including the MCA. Analysis of pre-Columbian gold in Peru.

Energy Resolution of Segmented Silicon X-ray Detectors

Segmented silicon detectors of X-rays, like microstrip and pixel detectors, offer several advantages including high spatial resolution, high count rate capability and good energy resolution. In various imaging applications using X-rays good energy resolution is an additional attractive feature that allows one to perform electronic selection of energy instead of using monochromators.

In the paper we will discuss fundamental limitations of energy resolution of silicon microstrip detectors, including the following aspects:
(1) charge sharing effect, (2) electronic noise and optimisation the front-end electronics, (3) sensor geometry and sensor bias.

Selected experimental results will be presented and discussed.
10:00  Eva Vilella-Figueras, University of Liverpool (E.Vilella-Figueras@liverpool.ac.uk)

*Status of HV-CMOS Detectors for High Energy Physics*

Due to their capability to cope with very high rates in very harsh radiation environments, hybrid silicon detectors were until very recently the preferred option to track particles in high energy physics experiments. However, their notable material thickness, together with their complex and costly production process, have motivated the pursuit of a new generation of thin and cost-efficient position sensitive detectors. In this sense, the industry standard High Voltage-CMOS (HV-CMOS) technology is emerging as a very attractive solution. Tracker detectors in HVCMOS technologies combine in the same substrate material a high bias voltage to create a large depleted sensing volume, which enables fast charge collection by drift and high radiation tolerance, and high integration density of CMOS electronics. Novel developments have shown the feasibility of fully monolithic HV-CMOS detectors, which integrate analogue and also digital processing front-end electronics in the same sensor chip thus suppressing the need for bump bonded or glued readout chips. In this talk, representative prototype and large size demonstrator ASICs from different commercial vendors that are currently under study for the Mu3e experiment, ATLAS and CLIC will be reviewed. Details about the sensor and readout structures, together with measured results, will be given.

10:40  COFFEE BREAK (FOYER)

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11:00  Marek Moszyński, National Centre for Nuclear Research (Marek.Moszynski@ncbj.gov.pl)

*Energy Resolution of Scintillation Detectors*

The limitation of energy resolution of scintillation detectors are discussed with a special emphasis on non-proportionality response of scintillators to gamma rays and electrons, which is of crucial importance to an intrinsic energy resolution of the crystals. Examples of the study carried out with different crystals and particularly those of tests of undoped NaI and CsI at liquid nitrogen temperature with the light readout by avalanche photodiodes are presented suggesting strongly that the non-proportionality of the halide crystals are not their intrinsic property. Moreover, the influence of slow components of the light pulses on energy resolution and non-proportionality are discussed.

11:20  Daniel Durini, Jülich Research Centre (d.durini@fz-juelich.de)

with C. Degenhardt, A. Palomino-Razo, S. Kumar, A. Feoktystov, M. Herzkamp, M. Streun, A. Erven and S. van Waasen

*SiPM-based Scintillator Detectors for Small Angle Neutron Scattering Experiments*

Small Angle Neutron Scattering (SANS) technique uses cold or thermal neutrons for investigation of soft and condensed matter. Significant developments in microelectronics enabled scintillation-based pixelated neutron detectors that use Silicon Photomultipliers (SiPM) for detecting the visible light generated within a scintillator. We characterized three different SiPM technologies in terms of their radiation hardness. The results of this first study are presented together with the first preliminary characterization results obtained in a beam of cold neutrons of a demonstrator consisting of a 1 mm thick Ce doped 6Li-glass optically coupled to an 8 x 8 pixel Philips DPC module.
SiPMs in Gamma Spectrometry with Scintillation Detectors

Development of an Advanced 2-D THGEM Detector for Low and High LET Mixed Radiation Fields

Aiming at measuring the spatial distribution of radiation dose for mixed neutron-gamma fields, an advanced two-dimensional (2-D) Thick Gas Electron Multiplier (THGEM) detector was designed and constructed at McMaster University, which will overcome the operational limitation of the traditional tissue equivalent proportional counter (TEPC), particularly for high dose rate fields. Compared to the standard TEPCs, that are commercially available, anode wire electrodes were replaced by a THGEM layer, which not only enhances the gas multiplication gain but also offers a flexible, convenient and low cost fabrication for building 2-D detectors.

The main feature of the device is that it consists of multiple individual TEPCs (array of 3x3 or 5x5 or more gas cavities) within a single chamber, which accordingly requires multiple (9, 25 or more) pulse height analyzers to process each individual signal simultaneously. This requires 9, 25 or more electronic components, such as preamplifier and digital signal processor (DSP) to process each signal in parallel, which is expensive, complex and causes difficulty for the portability of the system. This issue was resolved by developing a custom made multi-input digital signal processing system using modern microcontrollers interfaced with ADC at comparatively low cost.

Using the McMaster Tandetron 7Li(p,n) accelerator neutron source, both fundamental detector performance as well as neutron dosimetric response of the 2-D THGEM TEPC has been extensively investigated. This study proved that the 2D TEPC based on the THGEM technology, together with the cost effective custom made multi-input digital signal processing system can be used as a promising detector for measuring the absorbed dose rate distribution over an area. This small cavity counter opens new possibilities in applications for high-intensity radiation fields as well as in nanodosimetry (simulates smaller tissue sizes). Recent progress including detailed results will be presented.
Photonic Crystal Enhanced Microscopy: A New Tool for Cell-Surface Quantitative Imaging and Digital Resolution Biomolecular Diagnostics

We report a novel biosensor based microscopy approach termed Photonic Crystal Enhanced Microscopy (PCEM) that enables the movement of cellular materials at the plasma membrane of individual live cells to be dynamically monitored and quantitatively imaged. PCEM utilizes a photonic crystal biosensor surface, which can be coated with arbitrary extracellular matrix materials to facilitate cellular interactions, within a modified brightfield microscope with a low intensity non-coherent light source. Benefiting from the high sensitivity, narrow resonance peak, and tight spatial confinement of the evanescent field atop the photonic crystal biosensor, PCEM enables label-free live cell imaging with high sensitivity and high lateral and axial spatial-resolution, thereby allowing dynamic adhesion phenotyping of single cells without the use of fluorescent tags or stains. We apply PCEM to investigate adhesion and the early stage migration of different types of stem cells and cancer cells. By applying image processing algorithms to analyze the complex spatiotemporal information generated by PCEM, we offer insight into how the plasma membrane of anchorage dependent cells is dynamically organized during cell adhesion. The imaging and analysis results presented here provide a new tool for biologists to gain a deeper understanding of the fundamental mechanisms involved with cell adhesion and concurrent or subsequent migration events. Using the same PCEM platform, we also demonstrate the ability to image the surface attachment of individual dielectric or metallic nanoparticles, with signal-to-noise ratio that is substantially enhanced when the nanoparticle absorption spectrum overlaps with the photonic crystal resonant wavelength. Utilizing the ability to detect single surface-attached 30 nm gold nanorods with 14 dB signal-to-noise ratio, we are applying PCEM towards applications in biomolecule detection with digital resolution precision, using plasmonic nanoparticles as tags.

Ultra-thin, Ultra-flexible, Ultra-conformable Electronics for Healthcare and Biomedical Applications

The goal of creating an artificial skin capable of monitoring medical conditions, for instance with electrodes placed directly on patient’s skin or on the heart, requires ultra-thin, flexible, stretchable, conformable and bio-compatible electronics. Furthermore, the biological signals are relatively weak and need further amplification. Organic electronics promises to fulfil all of these constraints. The bending thickness and subsequently the conformity of a thin film is proportional to its thickness cubed. Therefore, reducing the total thickness of the electronics makes the devices much more conformal to the organ’s surface roughness, allowing for more accurate, and more comfortable, monitoring of biological signals. Amplifying a signal closer to the source typically leads to a higher signal-to-noise ratio, necessitating ultra-thin-film amplifiers to be deployed directly on the skin or the brain.

I will review recent achievements of our group, including the fabrication of ~2 μm thin electronics, such as polymer transistors, polymer light emitting diodes, and organic solar cells. I will also present flexible temperature and pressure sensors, as well as photonic e-skin and an organic pulse oximeter. Finally, I will discuss the fabrication of the world’s thinnest, sub-300-nm e-skin, fit with transistors, tactile sensors, organic amplifiers, and biometric sensors.
Stochastic Sensors as Screening Tools for Biomedical Analysis

Early detection of diseases became in the past year a high request from medical doctors. Some diseases like diabetes, cancer, hepatitis, can be reversed, and cured in only one condition; to be detected at a very early stage. Different types of electrochemical sensors were developed for medical analysis to date. The only reliable class of sensors is the one of stochastic sensors.

Different stochastic sensors were designed, characterized and validated for the assay of biomarkers for diabetes, cancer, obesity, neurotransmitters in biological fluids.

The limits of determination obtained as well as the recovery tests performed proved that they can be reliable used for the assay of such biomarkers in biological fluids of adults and children. This is an advantage over the standard methods of analysis that cannot be always applied for analysis of certain biomarkers in biological fluids such as saliva.

The utilization of stochastic sensors increased the reliability of qualitative and quantitative analysis. They can be used for early screening and detection of different diseases.

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Microelectronics for Portable DNA Sequencing

Recent innovations in DNA sequencing have been have astounding, and comparisons are often made to Moore's Law. This relationship is more than superficial; genomics platforms have benefited greatly from semiconductors, as sequencing solutions rely heavily on the high-performance acquisition, signal processing and computational power that has come from four decades of exponential growth in microelectronics. In this talk I will summarize these symbiotic trends, focusing on how future generations of sequencing systems can take advantage of CMOS technology. Nanopore sequencing, in particular, has been making headlines for its low cost, small instrument size, and long single-molecule reads. The signal acquisition strategy for nanopore sensors is quite different from previous generations of sequencers, and these differences have a major impact on the signal-to-noise ratio and the types of errors that can result. This rapidly-moving field has many opportunities for interdisciplinary contributions from biochemistry, electronic hardware design, and scientific computing. I will review some of the fundamental challenges and opportunities, along with some of our recent contributions.
Zbigniew Kolber, Soliense Inc. (zkolber@gmail.com; zkolber@soliense.com)

Remote, Fluorescence-Based Sensing of Photosynthesis in Plants: A Tool for Improving Crop Yields under Conditions of Environmental Change

We have developed a fluorescence-based technique called LIFT (Light Induced Fluorescence Transient) for assessing photosynthetic performance in plants. This technique employs a sequence of sub-microsecond flashes of controlled wavelength, excitation power, and time interval that activate the photosynthetic apparatus and records the fluorescence transients produced in response. Deconvolving the fluorescence response against its associated excitation profile allows for the characterization of light utilization efficiency, quantum yield of photochemistry, kinetics of photosynthetic electron transport, and characterization regulatory pathways that control these properties. Together, they constitute the "photosynthetic signature" of plants, which can be used to identify desirable traits of drought resistance, tolerance to low/high temperature, high/low light regime, and efficient nutrient utilization. These signatures, acquired at a distance of up to 5 meters, can greatly improve the efficiency of plant phenotyping efforts and assist in the practices of intensive agriculture for optimizing water and fertilizer delivery. Wider adoption of the LIFT technique will be determined by the ability to operate with high acquisition rates and a high S/N ratio, under adverse field conditions. We will discuss how these objectives are met with currently-available light sources, optical sensors, data acquisition and signal processing electronics; as well as what further progress will be required to make LIFT a common tool in plant phenotyping and intensive agriculture.

Ana Rusu, KTH Royal Institute of Technology (arusu@kth.se)

Ultra-Low Power Bioelectronics for Healthcare Applications

Research on ultra-low power bioelectronics is motivated by the continuous growth of implantable/wearable biosensors for healthcare applications and their huge impact on Internet of BioThings. Wearable and implantable biosensors are mainly challenged by the power consumption, which is intensified by the extreme constraints on weight and volume. In addition, implantable devices face many cross-disciplinary challenges, such as biocompatibility, integration, reliability, security, privacy, and safety, etc., which require extensive research and innovation.

The focus of this presentation is on ultra-low power electronics for implantable/wearable biosensors, which involves ultra-low power operation and highly-efficient energy harvesting, storage and processing. After a brief overview of the recent development and current trends in bioelectronics technologies, examples of biomedical devices will be given. The limitations and challenges towards their implementation will be discussed and our approaches will be presented. Finally, energy harvesting interfaces, which allow self-powering operation, will be presented. The presentation concludes with an inventory of research still to be done, and some suggestions for how it might be done.

Monika Weber, Fluid-Screen Inc. (monika.weber@fluid-screen.com)

Pathogen Detection in 30 Minutes
11:40 Kohei Soga, Tokyo University of Science (mail@ksoga.com)

*Application of OTN-NIR (NIR II/III) for Transparent Biomedical Photonics*

12:00 Claudio Bruschini, École Polytechnique Fédérale de Lausanne (Claudio.Bruschini@epfl.ch)
with H. Homulle and E. Charbon

*All-Digital, Quantum Biomedical Imaging*

Emerging single-photon detectors in CMOS has enabled massively parallel conversion of photons to digital signals that can be readily processed and/or transported with negligible losses. As a consequence, a new class of imaging sensors is emerging, known collectively as all-digital image sensors, for detection and processing of ultra-fast and complex photonic events, often present in biomedical imaging systems. All-digital image sensors are fast and robust, often enabling unprecedented accuracy in a number of biomedical imaging modalities, including PET, SPECT, NIROT, FLIM, FRET, etc. This talk describes several all-digital image sensors, including SiPMs for all-digital biomedical imaging designed to efficiently process large data volumes, so as to minimize power dissipation, improve flexibility, and shorten overall time-to-market.

12:20 Eliška Trojanová, Advacam (eliska.trojanova@advacam.com)

*The Small Animal Imaging using Energy Sensitive Photon Counting Detector*

The soft tissue X-ray imaging methods gain greater and greater importance in determining anatomical, physiological changes and processes, particularly those specific to various diseases. The standard X-ray radiography is based solely on absorption effects of different tissue. In-line phase contrast method eneable to study microcellular soft tissue structure. However, some microstructers are hard to visualise with required contrast. The proper selection of X-ray spectrum and irradiation geometry allows for great enhancement of the contrast for micro-structures of preselected type. It is possible to reveal presence and distribution of preselected cellular micro structures in soft tissue samples. Individual cells or their agglomerations could be imaged even in large or thick samples. Observation of cellular micro-structure alternations due to pathological changes in inspected tissue should be possible in future. The tissue type resolving X-ray radiography and tomography performed even without contrast agents could gain a great importance in morphology observation of soft tissue. The differences between soft tissue types such as kidney, muscles, fat, liver, brain and spleen were measured based on their spectral response. The Timepix based X-ray imaging detector WidePIX 2x5 and 5x10 with 300 µm thick silicon sensors was used for most of the measurements.

These advertised methods allow acquiring information about the extent, morphological and structural changes of individual organs or tissue structures influenced by disease or therapeutic procedures. The promising results are used for further optimizations of the detector technology and radiographic methods.
Session E4: Advanced Materials

Chairs: Gord Harling, Innotime Technologies (gharling@innotime.ca)

9:00 Bertrand Vilquin, École Centrale de Lyon (bertrand.vilquin@ec-lyon.fr)

Infra-red Characterizations of Metal Oxide Thin Films

Metal-insulator transitions in oxides are of considerable interest already for more than half a century. The phenomenon finds applications in novel electronic and photonic devices, thus stimulating the discovery of new functional materials. In this talk, we will present the characterizations and simulations of VO2 film transition and strained SrTiO3 film properties, performed on the IR and THz beamline at Synchrotron Soleil (AILES) located in France, which give information on the relationship between structure and physical properties of this functional materials.

9:20 Krzysztof Maksymiuk, University of Warsaw (kmaks@chem.uw.edu.pl)

Nanostructural Materials for Ion-selective Electrodes

Nanostructural materials are advantageous for construction of ion-selective electrodes (ISE), particularly of all-solid-state ones (ASS-ISEs), where construction simplification, miniaturization and improvement of analytical parameters can be obtained.

In our studies nanostructural materials were applied: (i) as alternative membrane materials instead of typically used poly(vinyl chloride) or polyacrylates; (ii) as solid contacts with enhanced capacitance resulting in better potential stability; (iii) as addition of a conducting material to classical membrane material resulting in better potential stability.

Selected examples will be presented showing advantages of nanostructural materials for above mentioned applications.

(i) As alternative membrane gold nanoparticles or reduced graphene oxide were applied, modified by appropriate ligands. The obtained analytical parameters were comparable or better than those of classical ISEs.

(ii) Noble metal nanoparticles, carbon nanotubes, reduced graphene oxide or nanoparticles of conducting polymers were applied as solid contacts.

(iii) Addition of nanoparticles of noble metals or conducting polymers to a classical membrane material (poly(vinyl chloride) or polyacrylates) was found beneficial from the point of view of resistance lowering as well as some transducing properties resulting from redox properties of conducting polymers or participance of oxygen in redox processes. These effects were advantageous for higher potential stability and shorter response time.
Yoriko Tominaga, Hiroshima University (ytominag@hiroshima-u.ac.jp)

In Content Dependence on Crystalline Quality of Low-temperature-grown InxGa1-xAs on InP Substrate

The authors report here that In composition dependence on crystalline quality of low-temperature-grown (LTG) InxGa1-xAs on InP substrate towards development of efficient photoconductive antennas for terahertz-wave emission and detection which can be activated by femtosecond fiber lasers. LTG InxGa1-xAs samples with thicknesses of 1.6-2.0 µm were grown on semi-insulating (001)InP substrates using molecular beam epitaxy at a substrate temperature of 240-250°C. After the growth, the sample was annealed at 400-600°C for 1 h in an H2 atmosphere with a cover wafer of GaAs. X-ray diffraction (XRD) spectrum of LTG In0.543Ga0.457As exhibited sharpness being similar to that of InP substrate, while that of LTG In0.45Ga0.55As was very broad. In order to consider this, critical thicknesses of these LTG InxGa1-xAs was calculated on the basis of Matthews' and Blakeslee's model. It revealed that the thickness of LTG In0.45Ga0.55As sample (2.0 µm) was 20 times larger than calculated critical thickness. On the other hand, the thickness of LTG In0.543Ga0.457As (1.6 µm) turned out to be smaller than the critical thickness. This indicates that low-temperature growth itself does not induce degradation of crystalline quality of InxGa1-xAs at the growth temperatures in the range of around 250°C.

10:00 André Ivanov, University of British Columbia (ivanov@ece.ubc.ca)

Modeling of Hydrogen Diffusion in Different Semiconductor Dielectric Materials, Using Molecular Dynamics Simulation Approaches

In this work we have studied various stages of Hydrogen diffusion MOSFET devices using molecular dynamics and reactive forcefields. The diffusion of Hydrogen which is believed to be the cause for NBTI aging in transistors is studied at the dielectric/channel interface, bulk high-k and low-k dielectric material and high-k/low-k interface. Various damage control and aging reversal mechanism based on the mechanical characterizations of the dielectric material have been studied.

10:20 Qiao Zhang, Soochow University (qiaozhang@suda.edu.cn)

Engineering Nanomaterials for Catalysis

In this presentation, I will summarize my recent efforts in the synthesis, stabilization and application of functional nanomaterials. By using silver nanoplates as a model system, we attempt to outline the key components that determine the formation of nanomaterials, clarify the roles of each reagent, provide highly reproducible recipes for synthesis, and therefore take a significant step towards the complete understanding of the mechanism behind the experimental phenomena. We have also focused on core-shell nanostructures - a class of nanoparticles encapsulated and protected by an outer shell that isolates the nanoparticles and prevents their migration and coalescence during the catalytic reactions.

10:40 COFFEE BREAK (FOYER)

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Updated May 22, 2017
11:00  Joerg  Appenzeller, Purdue University (appenzeller@purdue.edu)

*On the Prospect of Tunneling Field-Effect Transistors from 2D Materials*

Over the last years, two-dimensional (2D) materials are attracting an increasing amount of interest for various electronic applications owing in particular to the ideal electrostatics conditions that can be enabled in a three-terminal field-effect transistor (FET) geometry. Transition metal dichalcogenides (TMDs) as MoS2, WSe2, or WS2, to just name a few, or black phosphorus (BP) offer sizable bandgaps at mobilities that cannot be achieved in three-dimensional, bulk type materials that are scaled down to similar dimensions. The key is the absence of dangling bonds at the 2D semiconductor to substrate or gate dielectric interface that allows for highly conductive channels with sub-nm body thicknesses. In my presentation I will discuss the benefits of an ultra-thin body structure for scaled device applications with a particular emphasis on tunneling field-effect transistors (TFETs). I will also elucidate the critical impact of Schottky barrier (SB) contacts in the context of TMD and BP devices and will present an analytical approach that allows extracting materials and device information as the SB height and bandgap of single- and multi-layer FET structures.

11:20  Sumeet  Walia, RMIT University (sumeet.walia@rmit.edu.au)

*Layered Black Phosphorus: An Emerging Material for Electronics*

Few-layer black phosphorus (BP) is an emerging material of interest for applications in electronics. It exhibits exotic semiconducting properties that are highly desirable for electronics applications. However, the ambient instability of BP remains the weakest link in its research progress, as it has to be stored and handled in inert environments, rendering it to be unfavorable for practical implementation. To date, the solution to avoid degradation has been capping BP to minimize its interaction with the ambient environment.

We have conducted a thorough spectroscopic investigation into the origin of degradation right from the point of exfoliation revealing that oxidation due to light causes degradation whereas humidity on its own does not cause any material and acts merely as a facilitator of photo-oxidation. We have also devised strategies to protect the material from environmental degradation using a chemical sequestration strategy whereby we attack the origins of degradation rather than preventing the exposure of BP to the environment. This is an important aspect for creating any practically realisable electronic devices based on BP.

11:40  Christian  Martella, Consiglio Nazionale delle Ricerche (christian.martella@mdm.imm.cnr.it)

with A. Molle

*From Flat to Anisotropic MoS2 Nanosheets*

Here we show that MoS2 nanosheets can be conformally grown on flat and nanostructured substrates by taking benefit from chemical vapor deposition (CVD) based on metal film precursors. This approach enables us to gain a large area synthesis with an atomic thickness control. We also exploit the high degree of conformality of the CVD growth to induce a nanoscale anisotropy in the MoS2 nanosheets using one-directional modulated SiO2/Si substrates. The so-induced morphological anisotropy is reflected in a phononic and electronic anisotropy at the macro- and nano-scale, respectively, thus promising new avenues of multifunctional applications. Being easily extendible to a variety of CVD-grown two-dimensional nanosheets, our study paves the way to a controllable functionalization of the nanosheet properties via engineering of the substrate pattern anisotropy.
12:00  Carl Ventrice, University at Albany-SUNY (cventrice@sunycnse.com)

*Role of Oxygen on the Nucleation and Growth Kinetics of Graphene on Cu Substrates*

Graphene has several unique properties that can be used to enhance the performance of many types of solid-state devices and sensors. For instance, the carrier mobility in graphene has been measured to be as high as 200,000 cm²/Vs for suspended flakes exfoliated from graphite. However, the transport properties of graphene that is produced by scalable processes such as chemical vapor deposition on Cu foil substrates are typically a couple of orders of magnitude lower than for exfoliated graphene flakes. One of the primary reasons for the reduction in transport properties is that CVD graphene grown on Cu foil substrates is typically polycrystalline. One approach for producing graphene films with a lower density of grain boundaries is to reduce the initial nucleation rate of graphene crystallites during the CVD process by predosing the Cu substrate with oxygen. Most of these studies have been performed on Cu foil substrates, so it is difficult to determine if oxygen is primarily reducing adventitious carbon or passivating surface contaminants. In this study, the effect that predosing oxygen on Cu(111) and Cu(100) surfaces has on the nucleation rate and the defect density of the graphene films grown by CVD has been measured.

12:20 Pawel Hawrylak, University of Ottawa (pawel.hawrylak@uottawa.ca)

*Electronic Structure, Optical Properties and Spontaneous Light Polarization by 2D Crystals*

We discuss the electronic and optical properties of monolayer 2D hexagonal crystals, graphene and transition metal dichalcogenites (TMDC) MoS2 and WS2. The ab-initio calculations [1-3] establish TMDCs as direct gap single monolayer semiconductors with valley selective optical transitions. In order to develop a better understanding of the electronic properties a tight binding model involving Mo and W metal d-orbitals and sulfur dimer S2 p orbitals is developed based on input from ab-initio calculations. The role of d- and p-orbitals and nearest and next nearest neighbor hopping is clarified. The effective tight binding model is further reduced to the massive Dirac Fermion model which allows introduction of the magnetic field. The Lande and Zeeman Valley effects and the effect of e-e interactions in the magneto-exciton spectrum are discussed[4]. In the discussion of the exciton spectrum we draw analogies with graphene quantum dots with degenerate top of the valence and bottom of conduction band for which multi-exciton spectrum based on extensive exact diagonalization is known[5]. Finally, we discuss the possibility of broken symmetry ground states of the electron gas, in particular the existence of a Valley Polarized Electron Gas (VPEG), as a ground state of n-type WS2. The Valley Polarized state leads to spontaneous circular polarization of the emitted light, an effect which has been recently observed [3].


E-Health: Where Sensors and Circuits Meet

Electronic-health, or e-health has shown the promise of bettering health management and reducing its costs. At present, several devices and systems exist for both in-house and remote care. Whereas interconnected non-invasive medical devices are already strongly present on the market and embodied in various wearables, sensors that can detect compounds in body fluids can provide new major opportunities in diagnostics and therapy. Moreover, the fusion of sensors with micro/nano-electronic technology can provide us with means of volume production that can lower overall costs. A key factor in reducing non-recurrent engineering costs is the use of modular structures to construct multi-sensor platforms that can be eventually personalized in the last steps or fabrication or as post-processing. Overall, e-health represents an important research and economic opportunity requiring a challenging synergy of technologies.

Towards Dynamic Spectrum Access and 5G, via Television White Spaces

The world has just began taking advantage of the fourth generation (4G) communication technologies, whilst both research and industry communities are already starting with debates around 5G. Besides the antenna based and multiple-input multiple-output (MIMO) technologies and improved coding techniques, the key to faster speeds and longer communication distances is in availability of radio frequency spectrum. This talk will discuss the movement from the present day’s static and long-term spectrum allocations towards sharing the spectrum between different technologies in a dynamic fashion. The key focus will be on the developments in television white space and geolocation spectrum database methods and technologies, with mention of parallels to LTE.

Lab-on-a-Printer Platform Technology for Next Generation 3D Bioprinting
15:30 Tomas Base, Institute of Inorganic Chemistry ASCR (tbase@iic.cas.cz)

Investigating and Exploiting Unique Properties of Boron-hydride Cage Molecules

We are concerned with investigating and exploiting the unique properties of the boron-hydride cage molecules in nanotechnology. One of the main themes that we have been developing, and in which we have gained significant expertise and knowledge, is the modification of surfaces of various metal and semiconductor substrates with mono-molecular layers of boron-rich compounds. Our attention has been paid to metals such as gold, silver and copper, and to semiconductors such as silicon. These are industrially important substrates with many applications that range over many areas (electronics, textiles, photovoltaics, new materials) and our research has led to results applicable in all these fields. Examples of some key substrate properties that we can advantageously influence (work function value, surface stability and corrosion resistance) and new functions that we can introduce to surfaces by the adsorption of our thermally stable molecules with rigid structures will be presented and their further prospects discussed.


16:00 Thomas Webster, Northeastern University (th.webster@neu.edu)

15 Years of Commercializing Nanomedicine, Nano Sensors, and Nano Implants

There is an acute shortage of organs due to disease, trauma, congenital defects, and most importantly, age related maladies. The synthetic materials used in tissue engineering applications today are typically composed of millimeter or micron sized particles and/or fiber dimensions. Although human cells are on the micron scale, their individual components, e.g. proteins, are composed of nanometer features. By modifying only the nanofeatures on material surfaces without changing surface chemistry, it is possible to increase tissue growth of any human tissue by controlling the endogenous adsorption of adhesive proteins onto the material surface. In addition, our group has shown that these same nanofeatures and nano-modifications can reduce bacterial growth without using antibiotics, which may further accelerate the growth of antibiotic resistant microbes. Inflammation can also be decreased through the use of nanomaterials. Finally, nanomedicine has been shown to stimulate the growth and differentiation of stem cells, which may someday be used to treat incurable disorders, such as neural damage. This strategy also accelerates USA FDA approval and commercialization efforts since new chemistries are not proposed, rather chemistries already approved by the FDA with altered nanoscale features. This invited talk will highlight some of the advancements and emphasize current nanomaterials approved by the USA FDA for human implantation.
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