Emerging Technologies

Communications Microsystems Optoelectronics Sensors

2018 Conference Program

May 9 - 11, 2018

Hilton Whistler Resort & Spa

Whistler, Canada

Updated February 16, 2018

May 9, 2018

Session P1: Plenary I 8:30 Mt. Currie North

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

8:30 Mina Rais-Zadeh, University of Michigan (minar@umich.edu)

Microsensors and systems for missions to hot planets

Harsh environments are abundant in the Solar System and the ability of technology to survive in extreme temperatures is limited. Specifically, Venus is a terrestrial planet with similarities to Earth and exploring how climate and geology work on Venus could potentially provide a deeper understanding of the processes at work in our own environment. As such, there is an increasing interest in exploring such hot planets but so far, the missions to these extreme environments have been very limited in scope and duration mainly due to unavailability of sensors and readout electronics that can survive the extreme environments of the planet. To enable low-cost and long-lasting planetary exploration missions to hot planets, we are developing a sensor technology platform that is temperature and radiation tolerant using gallium nitride MEMS technology. In this talk I will discuss our devices in more detail and show our recent results.

9:00 Sorin Voinigescu, University of Toronto (sorinv@ece.utoronto.ca)

Silicon device and circuit scaling to the end of the ITRS 2030 time Horizon and natural Evolution into Si QC at the Atomic Scale

9:30 Matteo Rinaldi, Northeastern University (rinaldi@ece.neu.edu)

Zero-power infrared digitizers based on plasmonically enhanced micromechanical photoswitches

10:00 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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10:30 Drew Evans, University of South Australia (Drew.Evans@unisa.edu.au)

Emergence of organic electronic devices

Organic electronic devices represent a transition in product development, as new materials and manufacturing lead to devices that are lighter in weight, (semi) flexible, and offer new functionality. At the heart of these are new materials such as polymers that conduct electricity. These so called conducting polymers offer several key advantages over their inorganic counterparts, such as mechanical flexibility, transparency, and material abundance, which can enable low-cost fabrication and novel applications such as printed and flexible electronics. The conducting polymer poly(3,4-ethylenedioxythiophene), PEDOT, is one material which displays (among others) high electrical conductivity, enhanced thermal conductivity, good electrocatalytic performance, as well as thermoelectric behaviour. Importantly, conducting polymers such as PEDOT interface the electrical devices with chemical and biological systems. This talk will overview some of the recent advances being made in this area, developing new technology to tackle global challenges.

11:00 Rob Aitken, ARM (Rob.Aitken@arm.com)

What is ahead in 2018?

11:30 Federico Rosei, INRS (rosei@emt.inrs.ca)

Multifunctional materials for emerging technologies

As the age of fossil fuels is coming to an end, now more than ever there is the need for more efficient and sustainable renewable energy technologies. This presentation will give an overview on recent developments in solar technologies that may address, in part the energy challenge. In particular, nanostructured materials synthesized via the bottom–up approach present an opportunity for future generation low cost manufacturing of devices [1]. We demonstrate various multifunctional materials, namely materials that exhibit more than one functionality, and structure/property relationships in such systems, including new strategies for the synthesis of multifunctional nanoscale materials to be used for applications electronics and photovoltaics [2-30].

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Session A1: Devices, Circuits and Systems 13:30 Mt. Currie North

Chairs: Mohammad Darwish, Aplicata Technologies (mdarwish@aplicata.com)
Yushi Zhou, Lakehead University (qiezhys@gmail.com)

13:30 Tetsuo Endoh, Tohoku University (tetsuo.endoh@cies.tohoku.ac.jp)

Impact of nonvolatile brain-inspired VLSIs with CMOS/MTJ hybrid technology

Conventional CMOS type VLSIs face the insurmountable problems on intelligent applications such as image recognition, automotive car control, video surveillance, and so forth.

In this invited talk, it is discussed that CMOS/MTJ hybrid VLSI technology has an impact in brain inspired computing and neuromorphic computing.
We have developed a novel associative processor employing nonvolatile memories base on our IPMA type perpendicular-MTJ and fabricated it under 90nm-CMOS/70nm-p-MTJ hybrid process on 300mm-wafer. An intelligent power-gating technique leveraging the non-volatility, high access speed and unlimited endurance features of p-MTJs is employed to shut down idle circuit blocks during not only standby periods but also full operation periods for autonomously activating currently-accessed memory cells. The measured average operation power of the prototype chip is only 600μW (Conventional CMOS type associative processor's power is over 100W).

Acknowledgment: This work is supported by CIES's Industrial Affiliation on STT-MRAM program, ACCEL under JST, OPERA under JST.

[1] T. Endoh and Y.Ma, MMM2016 (Invited)
[2] T.Endoh, The 9th MRAM Global Innovation Forum 2017 (Invited)

13:50 Carlos Galup Montoro, Universidade Federal de Santa Catarina (carlosgalup@gmail.com)

Ultra low voltage/power LNA and mixers

14:10 Naoya Onizawa, Tohoku University (nonizawa@m.tohoku.ac.jp)

Energy-efficient brainware LSI based on stochastic computation

Stochastic computation has been recently studied for soft-error-resilient hardware and approximate computing, such as image processing, machine learning, and deep neural networks. This talk reviews stochastic computation and discusses the advantages and disadvantages with the recent developments in haredware. In addition, stochastic- computation based brainware LSIs (BLSIs) for vision information processing are introduced and discussed in terms of energy efficiency.

14:30 Arash Sheikholeslam, University of British Columbia (sarashs@ece.ubc.ca)

Proton transport and its effects on transistor aging

Hydrogen is used to passivate silicon dangling bonds at the dielectric/channel interface of metal–oxide–semiconductor field-effect transistors (MOSFETs). The untreated dangling bonds can shift the threshold voltage and as a result decrease the transistor's switching speed. One reliability issue with such transistors is that the passivating hydrogens dissociate from the Si-H bond and diffuse as a proton complex inside the gate dielectric (SiO2). Molecular dynamics with reactive force fields is shown to be an accurate method in understanding and predicting proton diffusion kinetics at the dielectric/channel interface as well as the bulk dielectric material. The model is first validated against experimental data and then used for making predictions wherever experimental data is not available.

14:50 Hassan Maher, Université de Sherbrooke (hassan.maher@Usherbrooke.ca)

Normally-off GaN HEMT transistor for high power applications

In today's fast evolution and expansion of wireless communications, the GaN HEMT is a good candidate taking advantage of its high frequency performance, high breakdown voltage and material robustness. For the next generations of RF power amplifiers, GaN-based technology is the most promising to satisfy the more and more demanding specifications of the market. The standard GaN-HEMT is a depletion mode device (D-mode), which is normally-on. RF circuit designers claim for normally-off devices (E-mode) to reduce circuit complexity and power consumption. On other hand, the normally-off aspect is mandatory for the High power application due to the safety issues. In this presentation we will illustrate the different available technics to fabricate a normally-off GaN-HEMT and the strength and the draw-back of each technic.

15:10 Sarit Dhar, Auburn University (sarit_dhar@auburn.edu)

Silicon carbide MOSFET science and technology

Metal-Oxide-Semiconductor field-effect transistors (MOSFETs) fabricated using 4H-SiC are an enabling technology for various high voltage (>900 V) power convertors and invertors, important in automotive and renewable energy applications. While commercial 4H-SiC MOSFETs offer significantly lower conduction losses compared to conventional Silicon for blocking voltages ≥900 V, the low channel electron mobility (~20 cm2 V-1 s-1) is a critical limitation for competitive penetration into lower voltage (`600 V) discrete electronic markets. In addition, reliable high temperature (>200°C) operation is also a key factor for various, especially for automobile and aircraft applications. At the heart of both these issues lie electronic defects or traps at the oxide (SiO2)/semiconductor (4H-SiC) interfaces and in the near interfacial SiO2. Low inversion channel electron mobility has been a traditional challenge due to a high density of near interfacial electron traps (NIT), energetically located near the conduction band of 4H-SiC and spatially located at or near the gate oxide-4H-SiC interface. In addition to mobility degradation, such traps can negatively impact device stability under bias temperature stress conditions [1]. Introducing about a monolayer (1015 cm-2) of nitrogen atoms at the SiO2/SiC interface [2] reduces the trap densities which improves the channel mobility as well as gate oxide reliability, making commercial 4H-SiC MOSFETs a reality.

In this talk the current status of 4H-SiC MOSFETs will be reviewed highlighting the importance of dielectric/SiC interface optimization. Results demonstrating lower NIT density and higher channel mobility than the state-of-the –art (~120 cm2 V-1 s-1 at room temperature on lightly doped p-SiC) using dielectrics formed by doping of SiO2 with Phosphorus [3,4] and Boron [5] will be presented. In addition, the effect of a very thin (~10 nm) n-type doped layer on p-type SiC surface, formed by the implantation of Sb [6] will also be discussed. The mobility limiting mechanisms in these novel MIS structures will be discussed. The physical nature of interface charges in SiO2 based planar and trench devices analyzed by electrical/ physical measurements and validated by atomistic calculations will be described.

Acknowledgements:
Results to be presented in this talk have been obtained by financial support from the U.S. Army Research Laboratory, the U.S. National Science Foundation, II-VI Foundation Block-Gift Program, DOE NCSU Power America Center and Texas Instruments Inc.

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15:30 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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15:50 Jia Di, University of Arkansas (jdi@uark.edu)

Advantages and applications of asynchronous circuits

Asynchronous circuits do not have clock. Handshaking protocols are used instead to control the circuit operation. Born with a series of advantages, e.g., flexible timing requirement, high energy efficiency, average-case performance, high modularity, and low EMI, asynchronous circuits have not been developing nearly as fast as synchronous counterparts. This is due to the drawbacks of asynchronous circuits (e.g., larger area, slower speed) and the lack of industry-standard EDA tool support. However, for a variety of applications, asynchronous circuits have unique advantages. This talk will introduce the basic concept and advantages of asynchronous circuits and discuss several of such applications suitable for asynchronous circuits with design examples and results.

16:10 Fei Yuan, Ryerson University (fyuan@ryerson.ca)

All-digital time-mode approaches for mixed analog-digital signal processing

CMOS technology scaling has always been geared towards optimizing the performance of digital circuits at the expense of the deteriorating performance of analog circuits with shrinking voltage headroom, worsening device mismatch, and deteriorating linearity the most critical. Scaling-rooted performance deterioration of analog circuits can be compensated using digital means to some degree, however, at the cost of increased silicon area and power consumption. Technology scaling, on the other hand, has greatly improved the switching time of digital circuits. Time-mode signal processing where information is represented by time difference between the occurrence of digital events e.g. the rising or falling edges of digital signals offer a viable and technology friendly means to combat stiff difficulties encountered in mixed analog-digital systems. Time-mode circuits are digital systems capable of performing analog and mixed analog-digital signal processing without using power-greedy and speed-impaired digital signal processors, and therefore possess the inherent characteristics of digital circuits such as technology compatibility, programmability, portability, better immunity to disturbances, and rapid design turnaround time that are not possessed by their analog counterparts. Time-mode approaches have found a broad spectrum of emerging applications in mixed analog-digital systems including vehicle navigation systems, analog-to-digital data converters, finite and infinite impulse response filters, all digital phase-locked loops and frequency synthesizers, and high-speed data links, to name a few. This talk reports the latest research findings in this exciting emerging field with a focus on all-digital time-mode delta-sigma data converters.

16:30 Seung-Tak Ryu, KAIST (stryu@kaist.ac.kr)

with J-H. Jang

Study on various ADC architectures with SAR ADCs

16:50 Amir Masnadi, University of British Columbia (amirms@ece.ubc.ca)

Sub-THz to THz signal generators on CMOS: Techniques for improving DC-to-RF efficiency

Signal sources at mm-wave and (sub-)terahertz frequencies in CMOS can be classified into two broad categories: harmonic oscillators and oscillators that are based on the frequency multiplication of fundamental sources. This presentation shows that frequency-multiplier-based sources potentially have a higher dc-to-RF efficiency than do the popular harmonic oscillators. To improve the power efficiency of CMOS signal sources that operate near or above the cutoff frequency of the device, design factors including the harmonic current efficiency, the effective output conductance, and the passive losses should be carefully tailored. In this talk after showing existing bottlenecks of (sub)THz generation on CMOS, some techniques will be presented to simultaneously generate high output power while achieving superior DC-to-RF efficiency.

17:10 Ramesh Harjani, University of Minnesota (harjani@umn.edu)

with S. Chaubey

Ultra low voltage LDO regulator design

We present the first fully integrated analog low dropout regulator (LDO) for sub-0.5V supply voltages. The LDO can operate from 0.3V-to-1.0V input voltage, and can sustain a load variation of 10mA-to-100mA at 1.0V input and 5mA-to-25mA at 0.3V input. It achieves a peak 99.1% current efficiency for a 100mA load at 0.9V output voltage. We introduce a negative charge pump based adaptive offset for the pass FET which provides gate-source headroom at input operation voltages normally reserved for digital LDOs. The 32 phase charge pump runs at a frequency of 3GHz with a ripple of ~3mV. The prototype was fabricated in TSMC's 65nm GP CMOS.

Session B1: Nanoscale Devices and MEMS 13:30 Mt. Currie South

Chairs: Chair to be Announced

13:30 Maxime Hugues, CNRS-CRHEA (mh@crhea.cnrs.fr)

The development of AlGaN/GaN and ZnMgO/ZnO heterostructures for THz devices

During the last 20 years, wide bandgap materials (GaN and ZnO) have attracted a large interest for electronic and optoelectronic devices. The efforts on nitrides development have successfully allowed the commercialization of efficient blue and white light emitting diodes but also high-frequency and high-power transistors. On the other hand, despite really attractive potential for optoelectronic and sensing applications the development of ZnO devices has been strongly limited by the p-type doping issue.

Unipolar (i.e. only dealing with electrons) emitters and detectors based on quantum cascade structures have been widely developed in "classical" III-V materials. While it allows to fully covering the mid-infrared range, the device performances strongly degrade for the 1-10 Terahertz (THz) spectrum part. Here, we will show how wide bandgap material properties could overcome the intrinsic limitations of the classical material.

First, we will demonstrate that wide bandgap heterostructures fulfill the high control and quality level requirements of quantum cascade devices. This is particularly true for homoepitaxial ZnO since molecular beam epitaxy allows getting defect density, surface roughness, and residual doping, comparable to the state-of-the-art of GaAs. Then, we will give an overview of the main intersubband transition results obtained with these two wide bandgap families.

This work is funded by the French National Agency under "OptoTeraGaN" project (ANR-15-CE24-0002) and by EU commission under the H2020 FET-OPEN program; project "ZOTERAC" FET-OPEN 6655107.

13:50 Ji Ung Lee, SUNY Polytechnic Institute (jlee1@sunypoly.edu)

Reconfigurable logic devices in 2D materials

14:10 Andreas Ruediger, INRS (ruediger@emt.inrs.ca)

CMOS compatible ferroelectric tunnel junctions

14:30 Fabrice Vallee, Université de Lyon (fabrice.vallee@univ-lyon1.fr)
with F. Medeghini, N. Del Fatti, A. Crut and P. Maioli

Control of mechanical energy damping at the nanoscale

Controlling and modeling the mechanical response of nanoscale systems is of central interest for many technological applications. In this size range, breaking of translational invariance leads to appearance of discrete acoustic modes that find application in different domains and also rule many fundamental properties of nano-materials. They have been intensively studied during the last decade as full exploitation of the new potentialities they offer requires identifying and understanding the underlying physical mechanisms at the origin of their specific responses.

The acoustic mode frequencies of nano-objects down to the one nanometer size are well described in the framework of the elasticity model [1,2]. Damping, a key element for applications, mostly originates from vibrational energy transfer from the objects to their environment. It is thus highly sensitive to their mechanical contact, to the presence of interfacial layers, and to the object morphology. This sensitivity makes theoretical description challenging but also opens-up the possibility of altering the damping of a given acoustic mode tailoring the system morphology. These dependencies will be discussed, based on experimental investigations of the acoustic vibration of single supported metal nano-objects.

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14:50 Toshiyuki Tsuchiya, Kyoto University (tutti@me.kyoto-u.ac.jp)

Measurement of energy carrier transportation across fracture fabricated nanogap on MEMS

Energy transportation across narrow gap less than 100nm attracts peoples to develop new nano materials, devices and systems. To investigate and apply the transportation, large (larger than micrometers square) and narrow (less than 100nm) uniform gap is needed but it is difficult to fabricate with conventional micro- and nano-fabrication technologies. We have proposed "fracture fabrication", in which cleavage of single crystal silicon on (111) plane is used. A beam with a notch is fractured by applying a tensile force along longitudinal direction and is separated into two pieces at the notch. The cleavage plane is atomically smooth and corresponding fracture surfaces are identical with each other and conformal gap can be formed. The beam is integrated to a MEMS structure, which may equip various functions, such as an actuator for fracture force generation and gap control after cleavage, a sensor for force, displacement and temperature measurement, and electrodes for current measurement. Using the structure, electron and phonon transportation, as well as attraction force is easily measured just after creating gap. We have succeeded in measuring field emission current through 100nm scale nanogap [1] and its gap-size dependency.

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15:10 Jan Dubowski, Université de Sherbrooke (Jan.J.Dubowski@USherbrooke.ca)

Open circuit potential of digitally photocorroding GaAs/AlGaAs quantum well microstructures

15:30 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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15:50 Victor M. Castaño, Universidad Autónoma de México (vmcastano@unam.mx)

MEMS and NEMS for advanced sensing of re-emerging diseases

16:10 Edmond Cretu, University of British Columbia (edmondc@ece.ubc.ca)

From symmetry breaking to high sensitivity sensing in weakly-coupled resonators

16:30 Matthew Spencer, Harvey Mudd College (mspencer@g.hmc.edu)

Evaluating electromechanical sequential logic

Nanoelectromechanical (NEM) switches have a set of switching characteristics which make them intriguing candidates for low power computing, but which make the design of sequential logic difficult. NEM switches display zero off state leakage, which allows NEM circuits to exhibit very low energy per operation, but NEM logic circuits must be designed to accommodate the long mechanical delay of NEM switches. This is especially apparent in sequential logic, where incorporating NEM flip-flops designed in the same way as CMOS flip-flops triples the delay of a well designed NEM pipeline stage. This talk will re-introduce the rudiments of NEM logic circuit design, discuss the challenges of designing NEM flip-flops, survey the NEM flops in literature, propose NEM sequential logic circuits which are capable of preserving the performance of combinational NEM logic, and demonstrate that proposal in simulation using a Verilog-A model of the NEM switch.

16:50 Raafat Mansour, University of Waterloo (raafat.mansour@ece.uwaterloo.ca)

Integrated atomic force microscope/scanning microwave microscope on a single CMOS-MEMS chip

Session C1: Quantum Computing and Photonics 13:30 Diamond Head

Chairs: Lukas Chrostowski, University of British Columbia (lukasc.ubc@gmail.com)

13:30 Michael Adachi, Simon Fraser University (mmadachi@sfu.ca)

Colloidal quantum dot lasers and solar cells

13:50 Marek Korkusinski, National Research Council (Marek.Korkusinski@nrc-cnrc.gc.ca)

with S. Studenikin, A. Bogan, L. Gaudreau, G. Aers, P. Zawadzki, A. Sachrajda, L. Tracy, J. Reno and T. Hargett

Advances in the coherent control of holes in gated lateral quantum dots

Single holes localized in electrostatically tuneable quantum dot devices are explored as candidates for spin qubits. Here we study single-hole and two-hole hybrid spin-charge qubits in the presence of a strong spin-orbit interaction. For the single-hole regime we present results on the Landau-Zener-Stuckelberg (LZS) interferometry involving spin-conserving and spin-flip processes. LZS patterns evolve with microwave frequency from discrete (often referred to as PAT) at high frequencies to continuous LZS fringes at low frequencies. Taking LZS measurements at different magnetic fields we observe two separate sets of LZS fringes offset by the Zeeman energy.

The magnetic field dependence of the single hole spin relaxation time is measured, taking advantage of the latching technique we originally developed for electron spin qubits [1-2] and which is rapidly being adopted as a standard technique for high fidelity measurements.

Additionally, we extend LZS measurements to the two-hole case near the (02)-(11) transition and present results from LZS interferometry of the singlet-triplet spin qubit states.

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[2] J. D. Mason et al., Phys. Rev. B 92, 125434 (2015).

14:10 Stephanie Simmons, Simon Fraser University (s.simmons@sfu.ca)

A photonic link for donor spin qubits in silicon

Atomically identical donor spin qubits in silicon offer excellent native quantum properties, which match or outperform many qubit rivals. To scale up such systems it would be advantageous to connect silicon donor spin qubits in a cavity-QED architecture. A few proposals in this direction introduce strong electric dipole interactions to the otherwise largely isolated spin qubit ground state in order to couple to superconducting cavities, however these strategies have unknown coherence properties. Here I present an alternative approach, which uses the built-in strong electric dipole (optical) transitions of singly-ionized double donors in silicon. These donors, such as chalcogen donors S+, Se+, and Te+, have the same ground-state spin Hamiltonians as the extensively studied shallow donors, yet offer mid-gap binding energies and mid-IR optical access to excited orbital states. This photonic link is spin-selective which could be harnessed to measure and couple donor qubits using photonic cavity-QED at 4.2K.

14:30 Mark Eriksson, University of Wisconsin-Madison (maeriksson@wisc.edu)

Controlling the coupling of silicon qubits to their noise environments

In order to achieve high-speed operation of semiconductor spin qubits, a strong control knob for qubit manipulation is essential. Increasingly, that control knob is a gate voltage coupling to the spin qubit through spin orbit coupling, which itself is often engineered in silicon through the use of micromagnets and the large magnetic field gradients they produce. I will discuss an alternative approach to coupling gate voltages to spins in silicon: using three electron spins in two quantum dots as a single qubit, a configuration called the quantum dot hybrid qubit (QDHQ) [1,2]. I will show recent results that demonstrate how changing the operating conditions for this qubit enables control of the coupling of the spin state to the noise environment [3]. Such tunability can be used, for example, to turn down the coupling to preserve coherence and to turn up the coupling when desired for qubit manipulation. The time scale for making such changes is very short, so that they can be implemented in real time during qubit operation.

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[3] B. Thorgrimsson, et al.,Ênpj Quant. Inf.Ê3, 32 (2017).

14:50 Paul Barclay, University of Calgary (pbarclay@ucalgary.ca)

Diamond optomechanical devices for quantum nanophotonics

15:10 Benoit Bertrand, CEA (Benoit.BERTRAND@cea.fr)

with L. Hutin, R. Maurand, M. Urdampilleta, B. Jadot, H. Bohuslavskyi, L. Bourdet, Y.-M. Niquet, X. Jehl, S. Barraud, C. Bäuerle, T. Meunier, M. Sanquer, S. De Franceschi and M. Vinet

Using Si CMOS technology as a platform for quantum computing

Spin qubits in silicon nanostructures are promising candidates towards the implementation of quantum information technologies, taking advantage of both their long coherence time – especially in isotopically purified 28Si [1] – and their potential for scalability. We present some recent progress and prospects in the use of fully-depleted silicon-on-insulator (FDSOI) technology to implement hole or electron spin qubits [2, 3]. The demonstration of foundry-compatibility is at the core of our approach as we study the functionality of qubits fabricated following a conventional transistor-like process flow. This is of particular relevance in terms of future up-scaling of qubit architectures as well as for the possibility of co-integration with classical Si CMOS control and readout circuitry.

[1] M. Veldhorst et al., Nature 526, 410 (2015)
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15:30 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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15:50 Jonathan Baugh, University of Waterloo (baugh@uwaterloo.ca)

A network architecture for silicon quantum computing

Several paths to a large scale, universal quantum computer have been proposed, though realization beyond the small scale (~50 qubits) remains a significant challenge. Superconducting qubits, semiconductor quantum dot and donor spin qubits, and topological qubits offer the exciting prospect for quantum analogues of the monolithic computer chip. In particular, quantum dots and donors in silicon have the advantage of a CMOS-compatible platform, which can exploit conventional foundry processes to fabricate the quantum device layer and integrate classical control circuitry via cryo-CMOS. In silicon, electron spin coherence times benefit from isotopic purification and a weak intrinsic spin-orbit coupling. Combining these CMOS-compatible qubits with a surface code architecture has been proposed for quantum dots and donor arrays. I will discuss some of the major challenges of such approaches, including density of wiring, integration of control electronics and multiplexing, noise and cross-talk, device yield and variability, and the need for advanced simulation tools to design and characterize real devices. I will then describe how a network architecture can provide an equivalent surface code functionality while reducing wiring density and isolating the qubits most critical to storing quantum information.

16:10 Philipp Niemann, DFKI (Philipp.Niemann@dfki.de)

Compact representations for the design of quantum logic

For future quantum computers, going well beyond the size of present-day prototypes, the manual design of quantum circuits that realize a given (quantum) functionality on these devices is no longer an option. In order to keep up with the technological advances, methods need to be provided which, similar to the design and synthesis of conventional circuits, automatically generate a circuit description of the desired functionality. To this end, an efficient representation of the desired quantum functionality is of the essence. While straightforward representations are restricted due to their (exponentially) large matrix descriptions, we present a data-structure termed Quantum Multiple-Valued Decision Diagram (QMDD) – a means for compactly and efficiently representing and manipulating quantum logic. QMDDs employ a decomposition scheme that naturally models quantum systems. By this, they are able to take advantage of redundancies, thereby allowing a very compact representation of relevant quantum functionality composed of dozens of qubits. This provides the basis for the development of sophisticated design methods as will be illustrated by means of several exemplary applications in the field of quantum circuit synthesis and verification.

16:30 Edoardo Charbon, EPFL, Technische Universität Delft (e.charbon@tudelft.nl)

From SPADs for quantum sensing to cryo-CMOS interfaces for quantum computing

CMOS SPADs have appeared in 2003 and soon have risen to the status of image sensors with the creation of deep-submicron SPAD technology while the applications have literally exploded in the last three years, with the introduction of proximity sensing and portable telemeters. The current promise is that SPAD based sensors will be in every smartphone by 2018 and in every car by 2022. But SPAD technology was born for scientific applications and in scientific applications it will continue to innovate. For instance, super-resolution microscopy, time-of-flight PET, NIROT, FLIM, FRET are expected to become more and more accurate and less and less expensive thanks to the scalability of CMOS technologies. With the introduction of 3D CMOS IC technologies for SPADs, imagers will be more compact, with more advanced techniques and functionalities. Very recently, SPADs and in general CMOS circuits and systems have been proposed as an interface to quantum processors, due to their sensitivity and the capability of operating normally at cryogenic temperatures (cryo-CMOS). In this context, the emerging cryo-CMOS technology will be presented, with a technical and economic perspective, in view of the creation of scalable quantum computing platforms.

16:50 Ellen Schelew, Lumerical Inc. (eschelew@lumerical.com)

Design, simulation and optimization of photonic components and systems for quantum applications

Photonic quantum technologies are in their infancy, and methodologies for component and system level modeling are still under development. Fortunately, classical integrated photonics and its supporting ecosystem are currently undergoing rapid growth and are leveraged for quantum applications. For component modeling, our shorter term efforts are focused on extracting useful quantum model parameters from purely classical, linear simulations. This approach uses mature numerical techniques for component design and is valid for many useful building blocks. Our longer term efforts involve more explicit coupling of quantum and classical behavior, however more work remains to achieve satisfactory self-consistency. Similarly, for system modeling, our initial efforts involve classical photonic circuit modeling combined with quantum analysis, which is often sufficient as these quantum circuits share many of the same components found in classical photonic circuits. Longer term efforts involve introducing new quantum compact models into classical circuit simulations.

17:10 Jeff Young, University of British Columbia (young@phas.ubc.ca)

Cavity-quantum-electrodynamic-based quantum information processing elements in silicon photonic circuits

Session D1: Thin Film Devices and Electronics 13:30 Sutcliffe A

Chairs: Zhehui (Jeph) Wang, Los Alamos National Laboratory (zwang@lanl.gov)

13:30 Sebastjan Glinsek, LIST (sebastjan.glinsek@list.lu)

Transparent piezoelectric thin films on glass for transducer applications

Piezoelectric thin films on silicon substrates have reached industrial maturity (e.g. pMUTs, TFBARs, etc.), with sputtering and Chemical Solution Deposition (CSD) as the most advanced deposition methods. In the quest for devices with extended functionalities integration of piezoelectrics with non-silicon substrates are needed.

Glass offers capability to combine piezoelectricity and transparency. However, deposition of piezoelectrics on glass is not straightforward due to interface reactions, low glass transition temperature Tg and the difference in thermal expansion coefficients. Therefore quality of the active layer depends strongly on the type of glass substrate and processing conditions.

In this contribution I will present our recent work on Pb(Zr,Ti)O3 (PZT) thin films deposited by CSD on fused silica substrates. Buffer layers have been employed to obtain crack-free and single-phase perovskite films by annealing at 700°C. Transparent Al-doped ZnO (AZO) interdigital electrodes have been designed and deposited by atomic layer deposition, while standard metal electrodes were used for comparison. State-of-the-art electromechanical response, which can be exploited in ultrasonic applications, will be presented and discussed. Strategies to decrease crystallization temperature of the CSD-deposited PZT for integration with low-cost commercial glass substrates will be outlined in the second part of the presentation.

13:50 Sheng Xu, University of California, San Diego (shengxu@ucsd.edu)

A hybridized approach to soft electronics: materials design and advanced microfabrication

Wearable devices that are capable of acquiring multichannel physiological signals from the human body represent an important trend for healthcare monitoring, consumer electronics, and human-machine interface. The resulting search for pliable building blocks calls for approaches to bridge the gap between conventional high performance hard materials and soft biology. Combined strategies of materials design and advanced microfabrication on the system level present unique opportunities. In this presentation, I will discuss a rationally designed "island-bridge" matrix that allows hybridizing hard materials with soft substrates. Specifically, the hard components are integrated on the predefined distributed islands, and the wavy bridges will buckle out of the plane to absorb the externally applied stress. The result is a fully functional system that is rigid locally in the islands, but soft globally that enables conformal integration with the curvilinear human body. Demonstrated prototypes include a multichannel health monitor that can sense local field potentials, temperature, and acceleration, and wirelessly transmit the acquired data to the backend receiver. This is a platform technology, which holds profound implications for integrating a broad range of sensors, actuators, and circuit components, for diagnosing and treating a broad range of health conditions.

14:10 Kyung-In Jang, Daegu Gyeongbuk Institute of Science and Technology (kijang@dgist.ac.kr)

Skin-mountable electronic patches for the human

To establish mechanics and material designs for transdermal biomedical patches in rugged and breathable forms, I proposed materials and composite designs for thin, breathable, soft electronics that can adhere strongly to the skin, with the ability to be applied and removed hundreds of times without damaging the devices or the skin. The figure on the left shows the approach that combines thin, ultralow modulus, cellular silicone materials with elastic, strain-limiting fabrics, to yield a compliant but rugged platform for stretchable electronics. With these unique mechanics and material integrations, new kinds of soft and robust skin-mountable devices have been developed in single or multimodal mode: mechanical, optical, electrical and radio frequency sensors for measuring hydration state, electrophysiological activity, pulse and cerebral oximetry.

14:30 Joachim Burghartz, Institut für Mikroelektronik Stuttgart (burghartz@ims-chips.de)

Hybrid Systems-in-Foil (HySiF) – enabler of flexible electronics

Flexible electronics add mechanical flexibility, adaptivity and stretchability as well as large-area placeability to electronic systems, thus allowing for conquering fundamentally new markets in consumer and commercial applications. Hybrid assembly of large-area devices and ultra-thin silicon chips on flexible substrates is now viewed as an enabler to high-performance and reliable industrial solutions as well as high-end consumer applications of flexible electronics. This talk discusses issues in ultra-thin chip fabrication, device modeling and circuit design, as well as assembly and interconnects for thin chips embedded in foil substrates. Particular attention will be given to the interface of the deep-submicrometer structures on thin, flexible chips to the sup-10-micrometer interconnects in assembly technologies. An interposer technology called ChipFilm Parch (CFP) will be presented and discussed. Various examples of dedicated applications of such HySiF components will be presented and compared.

14:50 Moon J. Kim, University of Texas at Dallas (moonkim@utdallas.edu)

New and emerging 2D materials for nano-electronics

Material dimensionality plays a crucial role in determining material physical properties. In particular, transition metal dichalcogenides (TMDs) exhibit diverse properties that depend on their composition: semiconductors, semimetals, metals, or superconductors. In exploring and developing these emerging materials, correlations between inherent materials characteristics and integrated device properties become ever more important. In this talk, I will present our recent studies on the characterization of 2D layered materials from Graphene to TMDs including MoS_2, WSe_2 and $MoTe_2$, and their integrated hetero-structures for nano-electronic field effect devices. The location and nature of individual atoms, defects, interfaces, and the integrated device characteristics will be presented and discussed in detail.

15:10 Christopher Künneth, Munich University of Applied Sciences (christopher.kuenneth@googlemail.com)

Explaining the ferroelectricity and pyroelectricity in HfO2 and ZrO2 thin films from an interface driven size effect with DFT

Ferroelectricity and pyroelectricity in Hf1-xZrxO2 thin films promise a variety of applications ranging from ferroelectric memories to energy-related applications. The finding of ferroelectric properties in Hf1-xZrxO2 thin films was unexpected and the root cause of the ferroelectric phase formation is still not fully understood. Recently, it was shown that the contribution of the interface and grain boundary energies in a Gibbs energy model can explain the ferroelectric phase formation of Hf1-xZrxO2 in accordance with the experimental measurements. For the calculation of the interface contribution, the surface areas of the grains were determined directly from the measured grain radius distributions of the thin films. Additionally, the unknown interface energies for each crystallographic phase are determined from a fit to experimental measurements. The success of this simple model suggests that the ferroelectric and pyroelectric properties of Hf1-xZrxO2 can be engineered and optimized by controlling the growth of the grains. Aside from interface and grain boundary contributions, doping of Hf1-xZrxO2 thin films is a second mechanism, which significantly alters the present crystallographic phases composition and gives the opportunity to optimize and modify the properties of Hf1-xZrxO2 to the ultimate operating point of the desired device.

15:30 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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15:50 Serge Oktyabrsky, SUNY Polytechnic Institute (soktyabrsky@sunypoly.edu)

with K. Dropiewski, M. Yakimov, V. Tokranov and P. Murat

Ultrafast scintillation detector based on waveguiding nanomaterial

A picosecond-range timing of energetic charged particles and single x-ray photons is a long-standing challenge for many in high-energy and nuclear physics, medical 3D imaging and security applications. Physics and technology of InAs epitaxial quantum dot (QD) scintillator embedded into GaAs waveguiding matrix with integrated photodetector is presented. Due to relatively low bandgap in semiconductors in comparison to traditional solid-state scintillators, and very fast and efficient luminescence in the QDs, this heterostructure is expected to provide exceptional performance surpassing in several parameters the best traditional inorganic scintillators (such as LYSO): about 5x higher light yield (240,000 photons/MeV), and 20x faster decay time, resulting in unsurpassed speed (1-10 ps) and energy resolution in ultra-fast calorimetry (~0.5 % at 1MeV and >100MHz). Self-absorption in the QD waveguides of about 0.3/cm, decay time of 0.6 ns and time resolution of alpha-particles of <80 ps were measured experimentally providing strong evidence of this QD waveguiding nanomaterial being the fastest scintillation medium.

16:10 Hagen Klauk, Max Planck Institute for Solid State Research (h.klauk@fkf.mpg.de)

Submicron-channel-length organic thin-film transistors

Organic thin-film transistors (TFTs) can typically be fabricated at temperatures below 150°C and thus not only on glass, but also on unconventional substrates, such as plastics and paper. This makes organic TFTs potentially useful for flexible, large-area electronics applications, such as rollable or foldable displays and conformable sensor arrays. In some of the more advanced applications envisioned for organic TFTs, the TFTs have to control electrical signals of a few volts at frequencies of several megahertz. The first requirement for achieving high switching frequencies is efficient charge transport in the semiconductor, which can be met by choosing organic semiconductors that provide good molecular ordering and large carrier mobilities. The second and more critical requirement is a small channel length. To meet this requirement, we have developed a process in which the TFTs are patterned using high-resolution silicon stencil masks. With this process, bottom-gate, top-contact organic TFTs with a channel length as small as 300 nm can be fabricated. For 11-stage complementary and unipolar ring oscillators based on TFTs with a channel length of 1 µm, signal propagation delays per stage as short as 6.6 µs and 420 ns have been measured at a supply voltage of 3 V.

16:30 Weng W. Chow, Sandia National Laboratories (wwchow@sandia.gov)

Semiconductor micro- and nano-lasers

16:50 Zhehui (Jeph) Wang, Los Alamos National Laboratory (zwang@lanl.gov)

Thin film detector technology, from ultracold to ultrafast applications

Riding on the advances and traditions in high-energy particle and nuclear physics, accelerator-driven experiments are in the forefront of material science, biology, chemistry and other disciplines. High-intensity X-ray sources from synchrotrons and X-ray free electrons lasers can interrogate materials with unprecedented temporal and spatial resolutions, opening up new frontiers in ultrafast material science, ultrafast biology and others. Meanwhile, accelerators have also been used to produce the highest intensity neutrons at sub-mK temperatures, opening doors to ultracold neutron science and applications. In this talk, we discuss the scientific motivations behind the ultrafast material and ultracold neutron sciences, and the roles and needs for thin film detector technology. We then highlight some recent progress in using thin film technology for ultrafast X-ray and ultracold neutron measurements. We conclude the discussions with some promising directions for thin-film detector technology development related to ultrafast X-rays and ultracold neutrons.

Session E1: Advanced Materials 13:30 Sutcliffe B

Chairs: Yi-Hwa Liu, Yale University (yi-hwa.liu@yale.edu)

13:30 Rehan Kapadia, University of Southern California (rkapadia@usc.edu)

Compound semiconductors on anything

13:50 Giuseppe Greco, National Research Council, Italy (giuseppe.greco@imm.cnr.it)

with E. Schilirò, R. Lo Nigro, I. Deretzis, A. La Magna, G. Nicotra, F. Roccaforte, F. Iucolano, S. Ravesi, P. Prystawko, P. Kruszewski, M. Leszczyński, R. Dagher, E. Frayssinet, A. Michon, Y. Cordier, and F. Giannazzo

2D materials integration with nitrides for high frequency applications

Graphene (Gr) integration with Al(Ga)N/GaN heterostructures has been recently proposed to implement a Hot Electron Transistor (HET), with Gr working as the ultrathin base and the Al(Ga)N/GaN 2DEG as the emitter [1,2]. Although THz operation has been predicted for Gr base HETs, achieving the targeted performances ultimately depends on the structural and electrical properties of the interfaces. Here, two approaches were explored to fabricate Gr/Nitrides heterostructures: the transfer of Gr grown by chemical vapour deposition (CVD) on catalytic metals (Cu) [3], and the direct CVD growth of Gr on AlN and AlGaN/GaN templates on Si, SiC or sapphire substrates, as well as on bulk AlN [1,2]. Furthermore, different strategies were considered to obtain a base-collector barrier with optimal hot electrons transmission, i.e. the atomic layer deposition of ultra-thin dielectrics (Al_2O_3, HfO_2) or the transfer of thin MoS_2 films onto Gr [4]. Finally, arrays of HETs were fabricated by integration of these elementary building blocks.

Vertical current transport across the heterostructures was studied by electrical measurements on device test structures and by local CAFM analyses [2,5,6]. In addition, XRD, STEM/EELS, XPS, LEED, Raman and AFM analyses were used to investigate the heterostructures structural/chemical properties. These experimental information were compared with ab-initio DFT calculations of the Gr/Nitride interfacial properties.

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14:10 Guangrui (Maggie) Xia, University of British Columbia (gxia@mail.ubc.ca)

Thermal thinning and Raman spectroscopy in the study of 2D black phosphorus

2D black phosphorus (BP) is a promising material for ultra-thin and flexible electronic and photonic applications. So far, there have not been an effective method in depositing uniform and high quality 2D BP samples, which have been fabricated by thinning from bulk BP. We report a new controllable and scalable approach to prepare high-quality few-layer black phosphorus, which is thermal sublimation. Uniform and crystalline 2 to 4-layer BP with an area from 10 to 1,000µm2 was prepared with this method. No micron scale defects were observed. The uniformity and crystallinity of BP samples after thermal thinning were confirmed by Raman spectra and Raman mapping. The sublimation rate of BP was around 0.18 nm / min at 500 K and 1.5 nm / min at 550 K. Both room and high temperature Raman peak intensity ratio Si/A2g as functions of BP thickness were established for in-situ thickness determination and control. A fast method to determine the BP crystal orientation by angle-resolved Raman spectroscopy with 442 nm excitation will also be presented.

14:30 Antoine Fleurence, Japan Advanced Institute of Science and Technology (antoine@jaist.ac.jp)

Epitaxial silicene on ZrB2(0001): a 2D allotrope of silicon

Two-dimensional materials are of great interest for the miniaturization of the electronic devices and the realization of new functionalities. In this perspective, silicene, a graphene-like two-dimensional honeycomb structure made of Si atoms, offers new opportunities to scale down the Si-based nanotechnologies. The analogy of silicene with graphene is reflected by the existence of Dirac cones in the calculated band structure of free-standing silicene. However, in contrast to graphene, silicene was only fabricated in epitaxial forms with electronic and structural properties deviating from those of the free-standing form. Among the few substrates on which silicene has been experimentally observed, (0001)-oriented zirconium diboride (ZrB2) thin films grown on Si(111) have the unique capability of promoting the spontaneous and self-terminating growth of a silicene sheet made of atoms segregating from the Si substrate. In this talk, I will present the structural, electronic and chemical properties of epitaxial silicene, which are stemming from the particular sp2/sp3 hybridization of the orbitals in the two-dimensional allotrope of silicon.

14:50 Feng Xiong, University of Pittsburgh (f.xiong@pitt.edu)

Tuning electrical and thermal transport in two-dimensional materials via electrochemical intercalation

Layered two-dimensional (2D) transition-metal dichalcogenides (TMDs) such as MoS2 have shown great promise for nano- and opto-electronics. The interlayer separation in MoS2 (~0.65 nm) provides perfect sites to accommodate guest species such as alkali metal ions (Li+) through a process known as intercalation. Recently, intercalation has been shown to be an effective technique to reversibly tune material properties of layered 2D films.

In this work, we report an in-situ platform to electrochemically intercalate Li ions into the interlayer spacing of ultrathin MoS2 nanosheets, controllably tuning their electrical and thermal properties. Our in-situ optical and Raman illustrate the dynamics of the electrochemical intercalation process and reveal a reversible 2H to 1T phase transitions in MoS2 upon Li intercalation and de-intercalation. Through Hall measurement, we notice a 100x increase in carrier concentration in Li-intercalated MoS2 due to charge transfer.

We also study cross-plane thermal transport in MoS2 upon intercalation using time-domain thermoreflectance (TDTR). We find that the thermal conductance decreases by a factor of ~7-9x upon lithiation, and is fully reversible upon de-intercalation.

This capability to reversibly engineer the physical and chemical properties of nanomaterials through intercalation is promising and could enable exciting opportunities in optoelectronics, transparent electrodes, energy harvesting and storage.

15:10 Byron Gates, Simon Fraser University (bgates@sfu.ca)

Extending the strategies for modifying the surfaces of semiconductor materials and devices

The interfaces of semiconducting materials and their oxides are integral to the design of fabrication routes for preparing freestanding semiconductor materials, such as components in microelectromechanical systems, or the preparation of interfaces for electronic devices that serve as electronic, mechanical or other types of chemical and biochemical sensors. A variety of strategies are used to modify the surfaces of these materials either during or following fabrication processes. The properties that are desired from these interfaces include tuning their ability to repel or retain water, to overcome stiction during fabrication processes or subsequent applications, to resist fouling from biochemical species, to tune the electronic and/or electrochemical properties of their interfaces, and to improve the durability of the underlying materials. A strategy for modifying these materials is introduced in this contribution that are enabling a new approach to tuning the properties and uses of semiconductor materials. These surface modifications are demonstrated for a variety of applications and surface chemistries.

15:30 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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15:50 Faisal Mohd-Yasin, Griffith University (f.mohd-yasin@griffith.edu.au)

Sputtered AlN and ZnO thin films on 3C-SiC/Si substrates for piezoelectric applications

Aluminum Nitride (AlN) and Zinc Oxide (ZnO) thin films have been deposited on a variety of substrates such as silicon, glass, sapphire etc. In this talk, I present the DC and RF sputtering of the said films on epitaxial cubic-silicon carbide-on-silicon substrates. The later were fabricated in-house at Queensland Micro- and Nanotechnology Centre. The effects of the sputtering parameters towards growing highly c-axis structures will be elucidated. The sputtered AlN and ZnO films are suitable for piezoelectric applications. This conclusion is supported by the values of the structural, morphological and mechanical parameters of these materials.

16:10 Hasina Huq, University of Texas Rio Grande Valley (hasina.huq@utrgv.edu)
with H. Orta and J. Castillo

Investigation of gallium-based thin films for bio-sensor applications

GaN is a wide energy band gap semiconductor material which shows chemical and mechanical stability, and high tolerance temperature behavior. It is an appropriate candidate to monitor the harmful gases such as methanol, nitrogen and hydrogen. Thermochemical stable high temperature gas sensors using GaN nanostructures are fabricated by physical vapor deposition (PVD) method. Using the magnetron sputtering system GaN thin films are deposited on Sapphire (Al2O3) and silicon (Si) substrates. During the annealing process, the thin films are heated to a specific temperature (up to 850°C) where recrystallization can occur. The samples are held at that temperature for a fixed period, then cooled down to room temperature. The process is done very slowly to produce a refined microstructure; thus the crystallinity of the grown thin films is improved. It exhibits superior performance due to better uniformity of the surface. sapphire (Al2O3) substrates. The electrical characteristics and the surface morphology of the thin films are investigated by using a X-ray photo electron spectroscopy (XPS), a scanning electron microscopy (SEM) and an atomic force microscopy (AFM). The methodology to fabricate the wide band gap (WBG) semiconductor thin films at lower pressure and lower temperature with better crystal quality is still challenging.

16:30 Marco Rahm, Technische Universität Kaiserslautern (marco.rahm@eit.uni-kl.de)
with J. Kappa, K.M. Schmitt and D. Sokoluk

Grating modulators for terahertz coded aperture imaging

In terahertz science, imaging technologies display the highest technological potential, although they currently lack of data acquisition speed which bars them from a number of key applications on the commercial market. A promising step to overcome these limitations was the introduction of coded aperture imaging techniques into the terahertz frequency domain. Pursuing the ultimate goal to develop imaging terahertz spectroscopes over a wide frequency range, the key challenge is the implementation of spatial light modulators with wide spectral modulation bandwidth and sufficient modulation contrast.

Here, we present a spectrally broadband modulator concept based on a switchable grating in Littrow configuration [1]. We demonstrate that such a modulator can potentially modulate terahertz waves in a frequency range from 1.7 THz to 3 THz at a modulation depth of more than 0.6. Furthermore, we numerically study coded aperture imaging of a binary image and its reconstruction. As a great advantage, the approach allows to dynamically alter the pixel size of the modulator by adjusting the number of micromirrors that define a pixel. By this means, also aperiodic grating structures can be implemented.

1. J. Kappa, K. M. Schmitt, and M. Rahm, Opt. Express 25, 20850 (2017).

16:50 Toru Aoki, Shizuoka University (rtaoki@ipc.shizuoka.ac.jp)
with K. Takagi, T. Takagi, T. Okunoyama and A. Koike

High count rate CdTe photon counting imaging sensor

We have reported the photon counting imaging sensors by using CdTe compound semiconductor with energy discrimination function. It has good image quality for hard X-ray imaging, but the dynamic range is so low because of its low count late limitation. The pulse width of each pulse generated from each X-ray photon is around several hundred nano-second from 1mm thick of CdTe diode sensor. But the conventional signal processing using charge sensitive amplifier and pulse shaper is so slow around 1µs or more. The dead time is so high in X-ray imaging fluxion condition, it is very difficult to apply X-ray imaging and CT. We developed new count method for high count rate using pulse analysis of rise part by fully high speed digital pulse processor. In this paper, we will report the detail of this method and signal processing LSI. We developed direct current – digital converter by using charge injection method from CdTe X-ray sensor diode. The ASIC include this CD convertors and other digital functions.We will demonstrate X-ray imaging and CT by using this sensor.

17:10 Yvon Cordier, Centre National de la Recherche Scientifique (Yvon.Cordier@crhea.cnrs.fr)
with Y. Cordier, R. Comyn, E. Frayssinet, M. Lesecq, N. Defrance and J-C. DeJaeger

On the advantages of a lower growth temperature for GaN HEMTs on Silicon

Lower growth temperature is generally considered as a drawback for achieving high crystal quality heteroepitaxial III-Nitrides, but in the case of GaN on Silicon, the necessity to reduce the nucleation temperature of AlN gives molecular beam epitaxy (MBE) the opportunity to demonstrate high performance high frequency devices like Al(Ga)N/GaN high electron mobility transistors (HEMTs). Compared to metal organic vapor phase epitaxy (MOVPE), the control of the interface between the AlN nucleation layer and the substrate is easier and the reduced growth temperature allows to obtain a more electrically resistive interface while keeping good crystal quality. Furthermore, thanks to the high purity of ammonia-MBE, compensation doping is not necessary to achieve resistive buffer layers and we have shown that further reducing the growth temperature of AlN within the nucleation and stress mitigating layers has a noticeable impact on the lateral and vertical buffer leakage currents with resulting vertical breakdown voltage up to 740V in 2 µm thick structures. As a consequence, the buffers of MBE grown HEMT structures exhibit low RF propagation losses (below 0.5 dB/mm up to 70 GHz) while structures regrown by MOVPE on MBE AlN-on-Si templates confirm that the thermal budget is critical for achieving a high resistivity.

May 10, 2018

Session A2: Memories and Computing 9:00 Mt. Currie North

Chairs: Mohammad Darwish, Aplicata Technologies (mdarwish@aplicata.com)

9:00 Kerem Camsari, Purdue University (kcamsari@purdue.edu)

Stochastic p-bits for invertible logic

Digital electronics is based on deterministic bits that are either a "0" or "1". In this talk, I will outline our recent work on "Probabilistic Spin Logic (PSL)", that is based on probabilistic bits (p-bits) that fluctuate randomly between "0" and "1" in a controllable manner. We have shown that "p-circuits" built out of p-bits can be a viable hardware framework for a wide range of applications including Bayesian Networks, problems of Optimization and a new kind of Boolean logic that is "invertible". Not only does a Boolean p-circuit provide outputs specified by inputs, but also all inputs consistent with a given output. I will illustrate how this remarkable property can be exploited with different examples. I will describe how the basic equations of PSL can be naturally mapped to the physics of existing spintronic devices, such as the commercially developed embedded MRAM, but I will also talk about non-magnetic representations of p-bits and p-circuits.

9:20 Tosiron Adegbija, University of Arizona (tosiron@email.arizona.edu)

Potentials of microarchitecture adaptability for performance, energy, and security optimizations

Emerging embedded systems execute memory- and compute-intensive applications with vast data streams and dynamic execution characteristics. In order to achieve optimization goals (e.g., performance, energy, and security), system resources must be dynamically adapted to support dynamic data complexity and execution variability. This talk will explore some of the benefits of, and techniques for, enabling adaptability as an inherent feature of emerging microarchitectures, in order to improve energy efficiency, performance, and security. We will first discuss recent work on leveraging configurability as a low-overhead defense against cache side channel attacks. We will then discuss new techniques for improving the energy efficiency of emerging non-volatile memory-based caches through logical retention time adaptability.

9:40 Ajay Joshi, Boston University (joshi@bu.edu)

Electro-photonic NoC designs for kilocore systems

The increasing core count in manycore systems requires a corresponding large Network-on-chip (NoC) bandwidth to support the overlying applications. However, it is not possible to provide this large bandwidth in an energy-efficient manner using electrical link technology. To overcome this issue, photonic link technology has been proposed as a replacement. In this talk, I will discuss the limits and opportunities for using electrical and photonic links to design the NoC architectures for a future Kilocore systems. We explored three different NoC designs: ElecNoC, an electrical concentrated two-dimensional- (2D) mesh NoC; HybNoC, an electrical concentrated 2D mesh with a photonic multi-crossbar NoC; and PhotoNoC, a photonic multi-bus NoC. We considered both private and shared cache architectures, and to leverage the large bandwidth density of photonic links we investigated the use of prefetching and aggressive non-blocking caches. Our analysis using contemporary Big Data workloads shows that the non-blocking caches with a shared last-level cache can best leverage the large bandwidth of the photonic links in the Kilocore system. Compared to ElecNoC-based and HybNoC-based Kilocore systems, a PhotoNoC-based Kilocore system achieves up to 2.5x and 1.5x better performance, respectively, and can support up to 2.1x and 1.1x higher bandwidth, respectively, while dissipating comparable power in the overall system.

10:00 Massimiliano Di Ventra, University of California, San Diego (diventra@physics.ucsd.edu)

Memcomputing: a brain-inspired efficient computing paradigm

Which features make the brain such a powerful and energy-efficient computing machine? Can we reproduce them in the solid state, and if so, what type of computing paradigm would we obtain? I will show that a machine that processes information directly in memory, like our brain, and is endowed with intrinsic parallelism and information overhead - namely takes advantage, via its collective state, of the network topology related to the problem - has a computational power far beyond our standard digital computers. We have named this novel computing paradigm "memcomputing". As examples, I will show the polynomial-time solution of prime factorization, the search version of the subset-sum problem, and approximations to the Max-SAT beyond the inapproximability limit using polynomial resources and self-organizing logic gates, namely gates that self-organize to satisfy their logical proposition. I will also demonstrate that these machines are described by a topological field theory, and they compute via an instantonic phase, implying that they are robust against noise and disorder. The digital memcomputing machines that we propose can be efficiently simulated, are scalable and can be easily realized with available nanotechnology components.

10:20 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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10:40 Bastien Giraud, CEA (bastien.giraud@cea.fr)

Smart memory solutions for emerging technologies

This talk presents our recent research activities about memory design solutions to address new emerging markets.

We have studied advanced memory solutions on different technologies such as monolithic 3D CoolCubeTM, Tunnel-FET (TFET) and Resistive RAM.
Firstly, the presented 4T SRAM bitcell in 3D CoolCube shows 30% area reduction with respect to a standard planar 6T bitcell and a strengthened stability thanks to data dependent dynamic back bias. Secondly, a reconfigurable CAM/SRAM circuit outperforms the state of the art, with operations at 1.56GHz and 0.13fJ/bit energy per search. Furthermore, the proposed TFET-based designs are competitive in terms of area and performance, while reducing significantly the leakage currents. Thirdly, the proposed compensation techniques for crosspoint memory architecture enable large memory arrays, while reducing the impact of temporal and spatial variations. Finally, our software platform to implement the proposed in-memory computing concept will be exposed.

For the sake of clarity, the talk will focus on a subset of these activities.

11:00 Alessandro Paccagnella, Università degli Studi di Padova (alessandro.paccagnella@dei.unipd.it)

Non-volatile memories for space applications: from planar to 3D devices

This talk will introduce ionizing radiation effects affecting non-volatile floating gate memories, with a specific focus on the space environment. We will explore in particular the single event effects - SEE, and how they are changing with the continuous technological scaling of the minimum feature size. As a guideline for such exploration, we will follow the single event effects occurring in the NAND Flash cell arrays. We will also present some recent results obtained in 3D components, where a sophisticated vertical integration process gives rise to unexpected SEE results and may shine new light on the interpretation of SEE phenomena observed in planar components. In fact, the cell circular shape and the fact that the tunnel oxide and interpoly dielectric blocking layers are perpendicular to the semiconductor substrate, make it possible to gain insight into the underlying upset mechanism.

11:20 Zhengya Zhang, University of Michigan (zhengya@umich.edu)

Spiking neural net accelerators for embedded computer vision applications

Session B2: Next-Generation Wireless 9:00 Mt. Currie South

Chairs: Chair to be Announced

9:00 Masum Hossain, University of Alberta (masum@ualberta.ca)

Affordable digital beam forming techniques for 5G wireless

9:20 Morris Repeta, Huawei (Morris.Repeta@huawei.com)

5G mm-wave ultra-large-scale-array integration technology

This paper reports an E-band ultra-large-scale phased array radio for 5G communications. The antenna was implemented in LTCC technology. In order to reduce system/circuit complexity, 8-element sub-arrays are used. These sub-arrays are randomly tiled to disrupt the periodicity in the array in order to keep side lobe level (SLL) and grating lobe level (GLL) low. Limited field of view (LFOV) of ±15o in both Azimuth and Elevation planes is achieved with < -10dBc SLL and 60% efficiency. A boresight and a +15o θo, φo beam steered 256-element E-band phased arrays were prototyped with LTCC technology to validate the concept, and a 1024-element design was completed. Measured results are presented and compared with simulations. This design is also scalable if higher antenna gain is required making this proposed phased array a good candidate for next generation high speed 5G communications.

Implemented in 55nm SiGe BiCMOS, two ASICs were designed to be mounted into the LTCC substrate; 1) the Active Antenna which includes 8 TRX and 2) Up/Down Conversion ASIC that will the feed TX and RX signals to an array of Active Antenna ASICs . On-wafer measurements will be presented across multiple samples.

9:40 Suraj Prakash, Texas A&M University (prakash.suraj1111@gmail.com)

Energy-efficient envelope tracking in RF power amplifier for demanding wireless standard

In our day-to-day life, low battery run-time of portable devices is an instrumental issue with huge growth in functional density. Due to the significant consumption of battery power, a power amplifier is always a bottleneck in enhancing battery run-time. In order to reduce power consumption of a power amplifier, several techniques are used in present portable devices. In these techniques, envelope tracking technique is a ubiquitous approach. An envelope tracking solution needs to be faster enough to accommodate fast-moving envelope signal; at the same time, it needs to be power efficient. However, due to a continuous movement to demanding wideband wireless standards with a high peak-to-average ratio, these aspects are becoming challenging. In this talk, we will see the challenges for an envelope tracking solution due to demanding wireless standards and way to overcome these challenges. Furthermore, we will also see an approach of envelope tracking that helps the technique to be faster and power efficient at the same time.

10:00 Joy Laskar, Maja Systems (joylaskar@gmail.com)
with R. Pelard and J. Sevic

mmW CMOS products for terabit connectivity

Since the first demonstration of mmW wireless connectivity in 1895, there has been much interest and promise in the future of mmW gigabit wireless technology. It has been only recently, with the emergence of CMOS based technology and its capacity for low-cost monolithic single-chip integration that one can envision a new class of systems and applications for low delay and high throughput connectivity, which forms the foundation for the 5G revolution. In this presentation, we focus on recent breakthroughs at Maja Systems enabling Terabit wireless connectivity. These products are enabled with highly integrated CMOS radios combined with novel surface mount antenna.

10:20 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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10:40 Yahya Tousi, University of Minnesota (ymtousi@umn.edu)

Integrated phased arrays for next-generation mm-wave and sub-mm-wave wireless systems

Millimeter and sub-millimeter wireless systems bring the promise of a new generation of applications capable of wide bandwidth, low latency, and line-of-sight spatial multiplexing. Phased array transceiver architectures that can support a large number of elements while providing accurate phase and amplitude control are fundamental to the realization of such systems. In this talk, we discuss current limitations in scaling the size of a millimeter-wave phased array as well as challenges in accurate control of the beam. Next, we present a distributed approach in designing phased arrays and phase shifters that allow significant improvement in the size of the array as well as the conceivable accuracy of the beam pattern, demonstrating phased array prototypes with better scalability and accuracy than the state-of-the-art.

11:00 Syed Kamrul Islam, University of Tennessee, Knoxville (sislam@utk.edu)
with I. Mahbub

Low-power wireless wearable sensors: past trends and future directions

In recent years, low-power wearable sensors have become a promising choice for advanced healthcare monitoring. Advancement of sensing technology fueled by prolific growth of wireless technologies facilitates continuous health monitoring of patients to detect disorders in the early stages of their progression. The next generation healthcare technologies will require continuous monitoring of vital information via wireless medium which will facilitate in-home care services preventing potential life-threatening events for the patient without requiring hospitalization. Wireless devices for monitoring of vital signs and other physiological parameters play a significant role in advancing the modern home-based healthcare applications. In general, biomedical signals have low frequency and thus require a low-data-rate transmitter for transmitting the data wirelessly. Unlike the traditional radios for cellular application, biomedical wireless devices do not require to transmit the data with high emission power as they are designed primarily for short-range communication. Most of these radios are either powered by the energy harvested from the ambient sources or tiny Li-polymer batteries. For such an energy constrained environment, the challenges lie in the design of a low-power radio which can sustain the short-range communication (~1-2 m) link for a long period of time without compromising the bit-error-rate (BER) requirement. The talk will include a discussion on various low-power circuit design techniques for biomedical sensors as well as recently published low-power radio architectures and approaches for wearable low-data-rate biomedical sensing applications. The current trend of smart cognitive radio that can sense the spectrum and transmit and receive the signal through the unoccupied channels by hopping into different frequencies will be elaborated in the talk. Finally, the talk will conclude with the discussion of future research directions towards the implementations of energy-efficient and spectrum efficient low-power radio modules suitable for various wearable sensing applications.

11:20 Farhana Sheikh, Intel (engenia@gmail.com)

Adaptive and multi-mode baseband systems for next generation wireless communication

System adaptivity has been studied since the mid-60s and recently there has been a surge in interest in self-adaptive systems, especially in the software engineering community, with its main application to cybernetics. In this work, we apply self-adaptivity to multi-mode baseband processing systems for 5G wireless communications to exploit channel characteristics to modify the computation of digital baseband processing subsystems for energy savings. The gains from self-adaptivity are exemplified in the design of lattice reduction aided MIMO detection and extended out to other baseband subsystems such as multi-mode FIR filters, and multi-point FFT computation.

11:40 Eran Socher, Tel-Aviv University (socher@eng.tau.ac.il)

THz CMOS radiating transceivers and arrays for future connectivity and sensing

Session C2: Sensors 9:00 Diamond Head

Chairs: Fabio Di Francesco, Università di Pisa (fabio.difrancesco@unipi.it)

9:00 How-Foo Chen, National Yang Ming University (howfoochen@gmail.com)
with C-Ha. Chen and P-B. Wang

Designing and fabricating a medical surface plasmon resonance biosensor: application on antimicrobial susceptibility test of E. Coli

9:20 Sigurd Wagner, Princeton University (wagner@princeton.edu)
with T. Moy, Y. Afsar, L. Aygun, Y. Mehlman, J.C. Sturm and N. Verma

Thin-film circuits for interfacing large-area sensor arrays and CMOS circuits

We have been demonstrating sensor systems that combine large-area arrays of sensors, made in thin-film technology, with CMOS ICs [1]. We foresee that such systems will become unobtrusive components of the built environment, with the purpose of augmenting human sensing. Systems for sensing mechanical strain [2], gestures [3], images [4], sound [5], and electrophysiology (EEG) [6] have been demonstrated. Our goals are (i) to understand the optimal distribution of functions between the large-area thin-film and CMOS domains, and (ii) to explore the application space for large-area sensor systems made with this hybrid technology. A priority has been to reduce the number of electrical interfaces between the thin-film and the CMOS domains. Interfaces have been reduced by using purely circuit-based approaches, and also by introducing algorithmic techniques. We will describe several of the thin-film circuits developed for this purpose.

[1] N. Verma et al., Proc. IEEE 103, 690 (2015).
[2] B. Glisic et al., Proc. IEEE 104, 1513 (2016).
[3] Y. Hu et al., IEEE Custom Integrated Circuits Conf., 2014.
[4] W. Rieutort-Louis et al., IEEE J. Solid-State Circuits 51, 281 (2016).
[5] J. Sanz-Robinson et al., IEEE JSSC 51, 979 (2016).
[6] T. Moy et al., IEEE JSSC 52, 309 (2017).

9:40 Lado Filipovic, Technische Universität Wien (filipovic@iue.tuwien.ac.at)

CMOS-compatible semiconductor-based gas sensors

Recently, there has been an ever-increasing demand for functional integration in a single device. Connecting multiple technologies using bond wires can negatively impact performance due to the associated increase in circuit resistances. The highest efficiency is reached when all functionalities are fabricated on a single substrate, deemed System-on-Chip. Fabrication on silicon allows for the efficient integration of sensors and CMOS structures into a truly monolithic device.

The integration of a metal-oxide (MOX) based gas sensing device into silicon technology is a particular challenge. The sensing layer, which can be a nanowire, nanosheet, or a thin film, must be heated to temperatures between 300°C and 500°C to operate as a sensor. For this reason, a microheater is implemented underneath the sensing element. The heater is the main power dissipater and its design determines the total power consumption of the device.

Our work is focused on understanding the consequences of the complex microheater structure on the mechanical stability of the sensor and the optimized operation of the MOX layer. We will describe how the reliability and gas-MOX interaction can be modeled and optimized for low-power operation. Furthermore, we will present some 2D semiconductor alternatives, which go beyond the limitations of MOX-based sensors.

10:00 Yves-Alain Peter, École Polytechnique de Montréal (yves-alain.peter@polymtl.ca)

Gas sensing with optical microresonators

We present an optical nose on chip made of a matrix of optical gas sensors. Optical noses integrated on chip present numerous advantages over electronic noses such as low power requirements, robustness, and immunity to electromagnetic fields, remote sensing and lower price. Miniaturized on-chip sensor, designed to detect air-borne compounds, are essential for inexpensive monitoring systems that are portable and deployable on a large scale. The optical sensing device is based on a reversible absorption of a gas with a dedicated polymer matrix. The sensor is integrated on chip and is therefore small, compact, and can be distributed in a network enabling low power consumption. We demonstrated that it can monitor several volatile organic compounds (VOCs), such as alcohols, aldehydes, ketones, carboxylic acids, amines and aromatics, that it operates in a reversible fashion, under different environmental conditions
(temperature and humidity), and that it detects concentrations in the order of parts per million (ppm).

10:20 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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10:40 Chi Xiong, IBM (cxiong@us.ibm.com)

Monolithically integrated silicon photonic gas sensors

11:00 Justin Caram, University of California, Los Angeles (jcaram@chem.ucla.edu)

Probing new chemistry in the shortwave infrared using superconducting nanowire single photon detectors

The short-wave infrared (SWIR or NIR II), is the sparse spectral region from 1-2 microns (0.6-1.2 eV), red of most electronic transitions, yet blue of many infrared active molecular vibrations (except C-H and O-H overtone combination bands). While the primary use of the SWIR has been in fiber-optic communications, recent research has realized its potential in deep tissue imaging, biometric identification, satellite telemetry for weather and plant cover, and pedestrian imaging for self-driving cars. However, there has been limited work combining SWIR with high temporal and spatial resolution methods such as confocal fluorescence imaging and TCSPC, commonly used in chemistry and biological questions. My group uses superconducting nanowire single photon detectors (SNSPDs), to extend a suite of powerful photon correlation methods from the visible into the SWIR. This research enables unique measurements of weakly emissive states critical to the development of optoelectronic materials and devices. We explore the photophysics of a broad range device-relevant inorganic and organic semiconductors, whose dynamics depend strongly on the properties of states that emit in the SWIR, including triplets, charge-transfer states and defects.

11:20 Seiji Kajihara, Kyushu Institute of Technology (kajihara@cse.kyutech.ac.jp)

A full digital temperature and voltage sensor for field testing

In this talk we present a novel digital sensor to measure temperature and voltage on a VLSI chip simultaneously. The sensor is composed of ring oscillator based logic circuits, and all computations are done with fully digital process. Compared with the conventional analog sensors, the proposed sensor has several technical merits which are small chip area, quick response time, low power dissipation and no need to prepare A/D convertor and reference current/voltage. Therefore, more than one sensor can be placed at various locations on a chip. In addition, the sensor can have an aging-tolerant structure for electro-migration, BTI and HCI. In order to reduce the influence of process variations on measurement accuracy, a calibration method that uses an initial measurement value of each sensor is adopted. In order to estimate measurement accuracy of the sensor, experimental results using circuit simulation and a fabricated test chip are also presented where we investigates effectiveness of the sensor derived from reduction of temporal and spatial variations. The comprehensive evaluations show that the total measurement error is smaller than the analog sensors, and it implies the importance of real time and contiguous measurement.

11:40 Bhaskar Choubey, University of Oxford (bhaskar.choubey@eng.ox.ac.uk)

Increasing the M/NEMS Sensors population per chip

Micro/nano sensors designers have generally avoided placing more than a few sensing devices on the same chip fearing coupling and other undesired effects. The aim has typically been to improve the sensitivity, functionality, manufacturability and often size of single or few devices per chip or die. Often, the contacts are significantly larger than the actual device being built, wasting precious microfabrication area. On the other hand, we have always preached that our devices will end up costing the same as silicon VLSI devices, as we make them in similar foundries. However, having just one or few devices per chip reduces the potential functionality and does not align with VLSI philosophy. More importantly, most of our devices follow the philosophy of "one design, one fab and one product", which is not in line with VLSI industry wherein one foundry caters to a large number of designs. This means that the cost per device of a MEMS sensor is still very high. In VLSI domain, more than one device are placed on a single chip, by providing suitable interconnects and thereby limiting the needs of electrical external contact pads. Providing several M/NEMS devices on a chip leads to generally undesirable collective behaviour. However, if we can utilize this undesirable behaviour, we can potentially provide for several M/NEMS sensors on the same chip. In this presentation, we will present mathematical techniques, physical realisations and applications of utilizing such collective behavior leading to large number of M/NEMS sensors on a chip, yet with limited contact counts or increase in

Session D2: Digital Revolution and IoT 9:00 Sutcliffe A

Chairs: Chair to be Announced

9:00 Bob Merritt, Convergent Semiconductors (bobm@convergentsemiconductors.com)

The digital revolution goes world wide

9:20 Aatmesh Shrivastava, Northeastern University (aatmesh@ece.neu.edu)

Computing at the edge: Analog Signal Processing for IoT Using High Precision Analog

Internet-of-Things (IoT) envisions a large-scale deployment of ultra-low power (ULP) electronic devices integrated in our environment to perform meaningful sensing and communication. To reduce the power consumption needed for communication, the amount of data must be reduced which can be done by incorporating computing at the edge in IoT. A conventional digital system that can perform computing at the edge, typically requires a micro-controller and a large amount of memory for storing data which is a significant overhead. Analog computing and processing can achieve both lower power and lower area. This talk presents a high precision analog building blocks which are needed for signal processing for the real-world analog signals. We present structures which can achieve very low power consumption and very low PVT variations. The stable and precise outputs for various fundamental analog circuits can be obtained using sub-threshold operation with switched capacitor resistors (SCR). This biasing scheme is then used for the biasing of a differential amplifier and a second order biquad filter to demonstrate proof of concept. Simulation results show that we can achieve a temperature stability of 50 ppm/oC for gain of a single stage differential amplifier realization and multi-stage filters. These structures can then be used to realize high precision analog computing structures to enable lower area, ultra-low power computing at the edge.

9:40 Subhanshu Gupta, Washington State University (sgupta@eecs.wsu.edu)

Energy-efficient information-aware sampling in Edge Computing devices

Projections of multi-trillion node sensor networks in the future are giving rise to deeply interconnected systems that anticipate, adapt, and control, while being autonomous and dependable. Yet these systems are unsettled in important ways. Transmitting large amounts of raw data, for example, is inefficient, clogs the network, and requires charging batteries frequently. Many of these systems lack any signal-aware capabilities, making them oblivious to changes and characteristics of the input signal which can be used to alter the amount of data that is sampled and transmitted. This talk will describe innovations in recent state-of-the-art analog-to-information converters with emphasis on information-aware sampling architectures that benefit from the ultra-low-power mixed-signal design paradigms to overcome the fundamental trade-offs between energy-quality based on feature-based metrics. These metrics will help in development of hardware models towards a decentralized network with local intelligence helping in reduce the network overhead and the data center processing workload.

10:00 Ajit Khosla, Concordia University (khosla@gmail.com)

Ubiquitous sensors and systems for Internet of Things

10:20 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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10:40 Manos Tentzeris, Georgia Tech (etentze@ece.gatech.edu)

3D/4D-printed smart wireless packages, energy harvesters, sensors and modules up to mmW

In this seminar, numerous inkjet-/3D-printed flexible antennas, "smart" packages, RF electronics and sensors fabricated on a variety of substrates are introduced as a system-level solution for ultra-low-cost mass production of Millimeter-Wave Modules for Communication, Energy Harvesting and Sensing applications. Prof. Tentzeris will briefly touch up the state-of-the-art area of 3D/inkjet-printed fully-integrated wireless sensor modules on flexible or 3D multilayer substrates and demonstrate the unique capabilities of additive manufacturing for the fully 3D integration of arbitrary-shape wireless sensors with RF systems on virtually every substrate (glass, paper, plastic, ...) as well as for the first realizations of 4D (morphing/shape changing/origami) multilayer RF/microwave structures, that could potentially set the foundation for the truly convergent wireless sensor ad-hoc networks of the future with enhanced cognitive intelligence and "rugged" packaging. Prof. Tentzeris will discuss issues concerning the power sources of "near-perpetual" RF modules, including flexible energy harvesting approaches involving thermal, EM, vibration and solar energy forms. The final step of the paper will involve examples from mmW conformal/stretchable (e.g. structural health monitoring) antennas and RF modules, as well as the first examples of the integration of inkjet-printed nanotechnology-based (e.g.CNT) sensors on paper and organic substrates for IoT, smart skin and autonomous vehicle applications. Special focus will be paid on newly developed fully printed 3D ramp interconnects and IC embedding approaches as well as on-chip/on-package printed RF components for further miniaturization and enhanced package intelligence and reliability.

11:00 Satinder Singh, Cogknit (Satinder.singh@cogknit.com)

Multi processor System On Chip (MPSoC) design challenges in the era of Artificial Intelligence (AI) , ML (Machine Learning), Deep Learning (DL) and Blockchain (BC) applications

11:20 Alvaro Pena-Quevedo, University of Puerto Rico (alvarojpena@gmail.com)

Hurricanes Irma and Maria: total digital collapse at the Caribbean. Rethinking for the future communication systems

The Global Climate Changes brought a very active season on the Atlantic Ocean in 2018. Several strong hurricanes (over class 4) affected the US, such as Harvey, Irma and Maria. In the Caribbean, where digital technology had grown at a great pace, the unexpected happened: a collapse in Advanced Telecommunications. During weeks, the Island of Puerto Rico, holding thousands of cellular antennas, advanced Doppler radars, AM and FM radio stations, and other systems, was silenced by the destruction of over 24-h of winds and water. Even the recovery for telecommunications has become slow due Puerto Rico geography and the placement of the more important antennae on the top of the mountains.

This study not only presents the vulnerability of digital systems to environmental effects, but also it is interested in proposing options and alternatives to overcome future climate events with active technologies and novel constructions. Most of the digital infrastructure was affected by electricity problems, but also antennae requires changes for future events.

Session E2: Nanotechnology 9:00 Sutcliffe B

Chairs: Peter Wilson, Alpha & Omega Semiconductor (peterhwilson@msn.com)

9:00 Gord Harling, Innotime Technologies (gharling@innotime.ca)

TBA

9:20 Jaydeep Kulkarni, University of Texas (jaydeep@austin.utexas.edu)

Materials and electronic systems based on 2D atomic layers

9:40 Guihua Yu, University of Texas (ghyu@austin.utexas.edu)

Functional nanostructured polymers for energy storage and environmental technologies

This talk will present a novel class of polymeric materials we developed recently: nanostructured conductive polymer hydrogels (CPHs) that are hierarchically porous, and structurally tunable in size, shape, porosity and chemical interfaces. Given advantageous features such as intrinsic 3D nanostructured conducting framework, excellent electronic and electrochemical properties, and scalable processability, they have been demonstrated useful for a number of applications in energy, bioelectronics, and environmental technologies. Several examples on developing high-performance energy storage devices and multifunctional superhydrophobic coatings for environmental cleanup will be discussed to illustrate "structure-derived functions" of this special class of materials.

10:00 Gary Leach, Simon Fraser University (gleach@sfu.ca)

New strategies for single crystal plasmonic nanostructures and plasmon-based solar energy harvesting

Plasmon-based solar energy conversion relies on absorption and charge separation at rectifying, metal/dielectric interfaces. Plasmon decay into hot electrons can undergo internal photoemission (IPE) and injection into an adjacent dielectric material, generating useful photocurrent and voltage determined by the metal/dielectric material pair. Here, we describe our work to optimize plasmonic photovoltaic devices on smooth and nanostructured Ag/ZnO interfaces and identify the requirements for high quantum efficiency structures. We have (i) modelled the capture of solar radiation by plasmonic metal/dielectric structures using finite difference time domain (FDTD) simulation methods, (ii) fabricated test devices, (iii) evaluated their optical, rectifying, and photovoltaic response, and (iv) characterized their materials properties using electron microscopy, spectroscopy and x-ray diffraction methods. We describe the challenges and opportunities of this and related technologies and introduce a new bottom-up approach to deposit single crystal epitaxial metal films and nanostructures from solution. While this chemistry allows for the subtractive manufacture of nanostructure through ion beam milling, it also enables additive crystalline nanostructure using lithographic methods such as electron beam lithography to enable novel, large area, metamaterial arrays and high aspect ratio crystalline nanostructure. We anticipate that this new approach will have significant impact on this and other new plasmon-based nanotechnologies.

10:20 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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10:40 Swastik Kar, Northeastern University (S.Kar@neu.edu)

Tailoring functionality at the interface between dissimilar 2D materials

Vertically-stacked heterostructures of 2D materials can lead to novel properties that result in new electronic phenomena originating from their superlattices. Since the relative rotation between the lattices leads to Moiré superlattices of varying degrees, controlling their rotational alignment constitutes an important approach for obtaining tunable functionalities in 2D Heterostructures. We discuss heterostructures of atomically-thin transition metal dichalcogenides and bismuth selenide, whose crystallographic orientation can be controlled, in situ, using low-energy lasers and electron beams. Samples prefer to grow rotationally aligned despite the large lattice mismatch between the two layers, and can be rotated in-situ, resulting in widely and controllably tunable electronic and optical properties. Density functional Theory suggests that the formation of superlattices (including rotated Moiré superlattices) lead to dramatic changes including direct to indirect band gap evolution, reduction of gap magnitudes, and sizable growth of electronic states near the band edges, in agreement with the observed spectral behaviors in these systems. The changes are reversible, and can be potentially used for developing low-cost optical memory devices and other optoelectronic applications.

Reference: Vargas, A. et al., Science Advances 3(7), p.e1601741 (2017)

11:00 D. Keith Roper, University of Arkansas (dkroper@uark.edu)

Nanoantenna augment carrier dynamics and wavelength mixing in two dimensional semiconductor nanocrystals

11:20 Jim Booth, British Columbia Institute of Technology (James_Booth@bcit.ca)
with P. Shen and K. Madison

Defining pressure -- cold atom technology for high- and ultra-high vacuum pressure metrology

The ability to localize and to control the quantum states of atoms with high precision through laser cooling and trapping methods has revolutionized technology. Cold atom-based clocks are the standard for time supporting the GPS network. This talk will describe our work which aims at creating the first primary pressure standard for the high- and ultra-high vacuum regime: Cold, trapped "sensor" atoms are confined to a small volume in space and monitored by light scattering. When a background particle passes through the collision cross-section of a sensor atom, it imparts some momentum to it. If this momentum is sufficient to liberate the atom from the trap, the collision event is detected via the reduction in the scattered light signal from the trap. Thus, the flux of background particles through the trapping volume (pressure) is registered as a loss rate of sensor atoms (time). This pressure standard is based on fundamental, immutable atomic properties and particle interactions, and tied directly to the base SI unit of seconds.

11:40 Shamik Das, Mitre Corporation (sdas@mitre.org)

Performance assessment of gapless graphene logic circuit designs

We present models, designs, and simulation results for logic circuits based upon graphene ballistic deflection transistors (GBDTs). The use of graphene in conventional semiconductor circuits has proved difficult due to its negligible bandgap. GBDTs might avoid this deficiency by electrostatically steering currents through a two-dimensional charge transport medium. Simulation results are presented for a GBDT-based inverter and full adder that are projected to operate twice as fast as conventional CMOS circuits, at the cost of much lower transistor density. The GBDT-based circuits presented in this paper would be well suited for high-speed, high-duty-cycle applications, including high-throughput networking and high-performance computing.

Session A3: Energy Harvesting and Storage 13:30 Mt. Currie North

Chairs: Chair to be Announced

13:30 Terry J. Hendricks, NASA (terry.j.hendricks@jpl.nasa.gov)

A universe of energy: emerging technologies to expand our energy "toolbox" for planet earth, our solar system, and beyond

Spacecraft power technologies surround our daily lives. Piezoelectrics in our shoes; thermoelectrics (TE) in the ground, industry, automobiles, and spacecraft; concentrated solar photovoltaics and solar thermal systems to power our homes and industries are prevalent as never before. Thermoelectric and solar technologies have key benefits and strengths in many terrestrial and military energy recovery applications, such as potential modularity, high reliability, and solid state performance requiring little or no operational maintenance.

New TE materials are being developed at smaller length-scales and with new nano-composite materials (including Ni/La3Te4, Ca9Zn4.6Sb9, and NiSb2Sn) to support next-generation energy harvesting and next-generation RTG power system opportunities. The latest advanced and demonstrated TE materials (skutterudites, La3-xTe4, Zintls) will be discussed to show new trends, requirements, and remaining challenges. Jet Propulsion Laboratory (JPL) has developed high-efficiency, high-power-flux thermoelectric (TE) modules using skutterudite materials and nano-scale and micro-scale design techniques for high-specific-power thermoelectric generators (TEG) critical for terrestrial waste energy recovery (WER) applications. These new skutterudite-based TE modules with small cross-sectional footprints (i.e., area) and high packing factor have demonstrated high power levels (>11 W), uniquely high module-level power fluxes greater than 3 W/cm2, and high efficiency (>9%) at working temperature differentials of approximately Th = 440°C to Tc = 15°C. JPL is also developing new advanced minichannel heat exchangers and micro-scale evaporators to integrate with the new TE systems in advanced energy recovery systems enhancing energy management and efficiency in terrestrial applications. This presentation will examine current and potential future use of thermoelectric technology and systems based on nano-scale material advancements for proposed NASA deep-space missions to Mars, Jupiter, Saturn, Europa, Titan, and Enceladus and beyond, and transitioning to Earth-based applications in automotive, industrial processing, and aircraft.

NASA JPL is also developing the latest high-temperature solar photovoltaic (PV) technology for potential future Venus missions. These high-temperature solar photovoltaic cells are being developed to operate continuously at >300°C for 6 months and survive at 465°C for up to 1 month, while converting the red-shifted solar spectrum of Venus into useful electrical power. Researchers expect these PV cells will be compatible with Venus' sulphuric acid environments.

These technologies demonstrate how NASA-driven technology development is flowing down to a wide-spectrum of Earth-based power system applications, such as thermoelectric-driven energy recovery systems and high-temperature solar PV cells applicable to concentrate solar power systems.

13:50 Ji-Hyun Jang, Ulsan National Institute of Science and Technology (clau@unist.ac.kr)
with K-H, Kim and S-Y. Yu

Mesoporous graphene for efficient clean water supply

The fundamental and serious problem of solar desalination is poor efficiency to be broadly applied. In order to improve the poor solar-to-vapor conversion efficiency, mesoporous three-dimensional graphene networks (3DGNs) with a high solar absorption property has been introduced in the solar desalination device. The device contains 3DGN-photoabsorbers and a wood post that serves as a water transporter and thermal insulator. It has shown greatly enhanced solar-to-vapor conversion efficiency of about 91.8% under one sun illumination and excellent desalination efficiency of five orders salinity decrement. Since this highly efficient solar desalination device is made by mass-producible 3DGNs and the earth-abundant wood piece, it provides a straightforward way to efficiently supply worldwide clean water.

14:10 Adam Duong, Université du Québec à Trois Rivières (Adam.Duong@uqtr.ca)

Materials design for the development of energy and nanotechnology

With the depletion of non-renewable energy sources, effective methods for storing and converting renewable energies into usable energy are the prior attention for researchers. In this context, the need for new materials capable of efficiently storing and converting renewable energies is essential. Coordination polymers are one of the advanced classes of materials for such applications due to their versatile structures and properties depending on organic and inorganic moieties. In this study, we have designed a series of isostructural two-dimensional Metal-Organic Polymers (MOP) using a rich N-polyaromatic ligand with various metals to produce materials that are valuable for solar cells, batteries, sensors and optoelectronic applications. MOPs prepared with our approach display reversible chromic behaviours confirmed by single-crystal and powder X-ray diffraction, Fourier transform infrared spectroscopy and solid-state UV-Vis spectroscopy. They also show interesting bandgaps for light harvesting as determined by theoretical calculations. To explore the isostructurality of MOPs, we incorporated two different metals into a structure to create Mixed Metal-Organic Polymers (MMOPs). The addition of various metals in the same structures allows us to tune and improve the properties of materials.

14:30 Karin Hinzer, University of Ottawa (khinzer@uottawa.ca)

High efficiency photovoltaics

Photovoltaic devices that are connected in series can become efficient DC-DC power converters for numerous applications. Using tailored materials, 5-24 V electromagnetic free interference devices with up to 70% conversion efficiency can be obtained. I will present results on the III-V semiconductor material properties required for these devices and the role nanostructures play in increasing their maximum efficiencies. I will compare the design and operation of these devices with multijunction solar cell designs and how luminescent coupling is important for their optimized operation. Performance within a photonic power system has been emulated experimentally by illumination via a multi-mode optical fiber, controlling the distance between the fiber tip and the phototransducer while centering the beam over the active area. Lasers from 808-850 nm wavelengths have been studied. To predict performance of new designs, a fully-parameterized 3D distributed circuit model was developed to enable calculation of N-junction phototransducers or solar cells. I will compare measurements and simulations, and present analysis of losses across limiting layers of the structure under nonuniform illumination conditions relevant for both power-over-fiber and concentrated photovoltaic optical systems.

14:50 Antonio Agresti, Università degli Studi di Roma "Tor Vergata" (antonio.agresti@uniroma2.it)

Perovskite and 2D materials: a winning paradigm for new generation photovoltaics

15:10 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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15:30 Darren Frew, BC Bioenergy Network (frew.darren@gmail.com)

Stop wasting waste

The volume of organic by-products produced by Agriculture, Forestry and Municipalities is growing dramatically every year. These materials are usually considered as "waste" and are dumped in piles or burned. However, these unused leftovers can be an important source of high-value products, including bioenergy and many advanced materials. As well, the present method for disposing of these "wastes" creates substantial, harmful greenhouse gas emissions.

The volume of these materials in B.C., Canada and worldwide is growing exponentially. The negative impacts on the economy and our environment are becoming dire.

Fortunately, there are many Emerging Technologies that effectively address this problem and will play a key role to help the world stop wasting waste. This presentation will highlight specific, successful examples of these emerging technologies.

15:50 Cengiz Ozkan, University of California, Riverside (cozkan@engr.ucr.edu)

Design of materials for advanced energy storage

The global electrochemical energy storage market ranging from electric vehicles and personal electronics to physical grid storage and defense applications demands the development of new classes of materials for fabricating high performance batteries and supercapacitors. I will describe innovative approaches for the design and synthesis of nanostructured materials towards enhanced reversible capacity; superior rate performance and cycling stability; superior gravimetric capacitance; and enhanced energy density and power density. Hierarchical three dimensional graphene hybrid materials which possess characteristics including ultra large surface area, tunability, mechanical durability and high conductivity are appealing to diverse energy storage systems. Integration of nanostructured pseudocapacitive metal oxides received a lot of attention recently due to their superior electrochemical performance. In order to realize high energy density supercapacitors, we developed a scalable method to fabricate MGM (graphene/MWNT/MnO2) and RGM (graphene/MWNT/RuO2) hybrid systems. The high specific/areal capacitance and extended operational voltage window of 1.5 V lead to an exceptionally high energy density of 39.28 Whkg-1 and power density of 128 kWkg-1. Next, I will talk about three-dimensional cone-shaped carbon nanotube clusters decorated with amorphous silicon for lithium ion battery anodes. Innovative silicon decorated cone-shaped CNT clusters on graphene (SCCC) are prepared by chemical vapor deposition (CVD) with subsequent inductively coupled plasma (ICP) treatment, followed by depositing amorphous silicon onto the carbon nanotube-graphene templates via magnetron sputtering. The seamless connection between silicon decorated CNT cones and the graphene substrate facilitates charge transfer in the system and provides a binder-free technique for preparing lithium ion battery (LIB) anodes. Lithium ion batteries based on this novel 3D SCCC architecture demonstrated fast charging, a high reversible capacity of 1954 mAhg-1 and excellent cycling stability.

16:10 Abderraouf Boucherif, Canada-3IT (abderraouf.boucherif@usherbrooke.ca)

Graphene – porous semiconductor nanocomposites for energy applications

16:30 Mihri Ozkan, University of California, Riverside (mihri@ece.ucr.edu)

Sulfur cathode materials for lithium-sulfur batteries

In this study, silica-coated sulfur particles (SCSPs) were synthesized and characterized as a cathode material for Li–S batteries. The novel core–shell structure was fabricated in a facile 2-step wet chemical synthesis. The SCSP cathode showed superior cycling stability when coupled with mrGO (mildly reduced Graphene Oxide) as an additive, improving the capacity retention after 50 cycles from 440.8 mAh/g without mrGO to 763.2 mAh/g with mrGO. The electrochemical data also shows reduced capacity fading over 50 cycles, from 12.2 mAh/g per cycle without mrGO to 8.6 mAh/g per cycle with mrGO. During cycling, SCSPs are understood to fracture and release active material (S8), and mrGO helps to contain the ruptured particles, thereby improving cycling stability. By the 50th cycle, SCSPs experienced a 318.8 mAh/g boost in specific discharge capacity with the addition of mrGO. These improvements are attributed to the polysulfide inhibiting effects of SiO2 as well as the host of benefits provided by mrGO, similar to other work. Thus, SCSPs with the addition of mrGO show great promise in the application of low-cost, high energy density battery systems for portable electronics and electric vehicles.

16:50 Stefano Gregori, University of Guelph (sgregori@uoguelph.ca)

Energy conversion and harvesting in low-power systems

This talk will introduce a discrete-time circuit analysis technique tailored to the implementation of energy conversion and harvesting in low-power systems.

A new approach based on two-port equivalent models and z-domain analysis will be presented. Such approach easily allows to study the dynamic response and the energy consumption during transient. Both capacitor-based and inductor-based power converters will be considered and the results will be compared to conventional circuit simulations.

Energy harvesters based on force-sensitive mechanically-variable capacitors will be also introduced. A prototype electrostatic harvester for low-power wearable devices will be shown. The device is based on flexible and biodegradable nanocellulose films and is designed to operate without startup battery.

Session B3: Wireless Technologies 13:30 Mt. Currie South

Chairs: Mohammad-Reza Nezhad-Ahmadi, University of Waterloo (mrnezhad@uwaterloo.ca)

13:30 Andreia Cathelin, ST Microelectronics (andreia.cathelin@st.com)

Analog RF mmw design in FD-SOI and new features enabled by body biasing techniques

13:50 Shuhei Amakawa, Hiroshima University (amakawa@hiroshima-u.ac.jp)

Feedback network design for transistor operating near its performance limit

The growing demand for faster wireless communications is pushing radio frequencies in use higher up. Miniaturization of MOS transistors is still ongoing but their high-frequency performance has started to fall. Need is expected to arise to operate transistors near their performance limit. This talk will give an overview of recent progress in boosting transistor performance by circuit techniques, namely feedback. A design theory developed recently allows the designer to formulate equations for quickly finding a good initial design.

14:10 Arun Natarajan, Oregon State University (nataraja@eecs.oregonstate.edu)

Reconfigurable code/frequency/spatial filtering for full-duplex and frequency-domain duplex MIMO arrays

14:30 Tanbir Haque, InterDigital (tanbir.haque@interdigital.com)

Developing flexible architectures for wideband data reception and rapid interference detection for cognitive radio type applications

A reconfigurable RF frontend (RFFE) architecture for signal reception and compressed-sampling (CS) wideband signal detection is presented. A cognitive radio (CR) dynamic shared spectrum access usecase where CR terminals rapidly gain awareness of their environments and opportunistically access unused blocks in the frequency-time resource space is used to motivate the proposed RFFE architecture. Evolution of the CS RFFE for sparse multi-band signal detection is presented. The Modulated Wideband Converter is briefly reviewed. The Quadrature Analog-to-Information Converter (QAIC) is then introduced and an approach for frequency domain analysis of the QAIC RFFE with linear impairments is developed. Building upon the direct-conversion RF chain, typically preferred for signal reception, and combining it with a flexible LO modulator and CS signal processing, the Direct RF-to-Information Converter (DRF2IC) unifying high-sensitivity signal reception, swept narrowband detection and CS wideband detection into a compact reconfigurable architecture is then introduced. Key frontend circuit blocks of the DRF2IC implemented on 65nm CMOS are described. Measurement results demonstrating the energy, speed and flexibility advantages of the proposed DRF2IC architecture is presented and benefits of the DRF2IC are contrasted with exiting conventional and other CS detection approaches.

14:50 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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15:30 Rouzbeh Kananizadeh, University of California, Davis (rkanani@ucdavis.edu)

Harmonic boosting in solid state circuits using harmonic positive feedback

In my talk I will introduce a new concept for harmonic boosting based on linear time invariant behavior of nonlinear devices. Based on a new perspective on nonlinear electronics, I will expain how different harmonics translate to each other. By trapping the translations in a loop, second harmonic power is boosted dramatically in an oscillator, yielding high second harmonic output power and state-of-the-art phase noise performance at high millimeter wave frequencies.

15:50 Christian Schlegel, Dalhousie University (Christian.Schlegel@Dal.ca)
with K. El-Sankary and T. Sandhu

Ultra-low power acoustic receiver with wake-mode

16:10 Antonio Liscidini, University of Toronto (antonio.liscidini@utoronto.ca)

Complex poles with passive switched capacitor filters

Session C3: Optics and Photonics 13:30 Diamond Head

Chairs: Sudip Shekhar, University of British Columbia (sudip@ece.ubc.ca)

13:30 Lukas Chrostowski, University of British Columbia (lukasc.ubc@gmail.com)

Sub-wavelength silicon photonics and applications

13:50 Jonathan Bradley, McMaster University (jbradley@mcmaster.ca)

Rare-earth-doped light-emitting thin films and photonic devices on silicon

Since the 1990s, compact and low cost rare earth integrated amplifiers and lasers have received much attention, particularly for high speed telecommunications applications. Nevertheless, despite many advances, the technology has yet to see widespread application. The primary reason is that fiber-based devices, although bulkier, are very well established, offer good performance and can meet the requirements of larger telecom systems. Recently, however, with the rise of silicon photonics and scaling of transceiver technology in data centers, the demand for compact optical amplifier and light emitter solutions is high. In this talk I will discuss our recent progress in silicon-based rare earth amplifiers and lasers. I will focus on the rare-earth host material aluminum oxide (Al_2O_3), which exhibits high thermal stability, broad emission spectra, and reduced rare-earth clustering and higher refractive index than other common rare earth host materials such as silica, thus enables smaller devices. We have demonstrated compact erbium-doped waveguide amplifiers and a number of on-chip near-infrared lasers, including distributed feedback, distributed Bragg reflector and microcavity devices. I will discuss the potential for integration of such devices in silicon photonic microsystems.

14:10 Rusli, Nanyang Technological University (erusli@ntu.edu.sg)

Si/MoOx heterojunction hybrid solar cell

14:30 Harry van der Graaf, National Institute for Subatomic Physics (vdgraaf@nikhef.nl)

New developments in the detection of single soft photons

In a single soft photon detector two essential processes occur: photoelectric absorption, converting the photon into a free photoelectron, and the multiplication of this electron, resulting in a detectable charge pulse. In the photomultiplier, amplification-by-multiplication occurs at a dynode, where a multiple of secondary electrons is reflected after the impact of an incoming energetic primary electron. We have developed the transmission dynode "tynode", in the form of a thin layer where secondary electrons are emitted at the bottom side after the impact of a primary electron at the top side. Using Atomic Layer Deposition (ALD) MgO at the emission side, a transmission secondary electron yield of 5.5 has been reached. A stack of 5 - 8 tynodes should produce a charge pulse sufficient to drive (digital) electronics after the impact of a single primary electron. Thanks to the short and identical straight line paths of the electrons crossing the gap between a tynode and the next one, the transient time is in the order of 50 ps, while all secondary electrons arrive within one ps on the readout anode below the tynode stack. By pixelising the anode in the form of a CMOS pixel chip, the required multiplication is minimised, and 2D spatial resolution is realised.

A stack of tynodes could be an alternative for Micro Channel Plates (MCPs), which have been improved significantly during the last decade. The time resolution of a tynode-based detector may potentially be better.

At present, photon detector development is focused on SiPMs because they are cheap, fast and efficient. Their dark noise, however, cannot be suppressed. An MCP or a tynode stack is a noise-free amplifier, but these are always combined with a photocathode with a limited quantum efficiency (QE). The efficiency of a SiPM could be unity in theory, but the ultimate photon detector could be an assembly of a tynode stack or MCP (ultra fast, free of noise) and a high QE photocathode. With new MEMS technology, an active photocathode may be feasible with a QE much larger than the state-of-the-art value of 0.4.

14:50 Douglas M. Gill, IBM (dmgill@us.ibm.com)

Making short reach link transmitter Figure of Merits cognizant of transmission format

The traditional Mach-Zehnder modulator (MZM) figure of merit (FOM) is defined as (V^2)/(Freq_3dBe), and works effectively for LiNbO3 long haul modulators. However, this FOM is inappropriate for plasma dispersion based electro-optic modulators, or any modulator with an inherent relationship between bandwidth, required drive voltage, and optical insertion loss/gain. This FOM is even less relevant for such modulators when used in short reach links with no optical amplification. I will present a newly proposed modulator FOM (M-FOM) based on device metrics that are essential for assessing short-reach link performance, such as peak-to-peak drive voltage, modulator rise-fall time, and relative optical modulation amplitude. In addition, I will discuss how the M-FOM can essentially be made "transmission format aware" by appropriately scaling its value with these essential performance metrics. Furthermore, I will present a novel application protocol for our M-FOM that provides direct insight into the impact that modulator performance has on required optical power for unamplified data links. Finally, I will show that our new M-FOM construct allows, for the first time, a direct comparison between ring and Mach-Zehnder modulators.

15:10 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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15:30 Tohru Ishihara, Kyoto University (ishihara@i.kyoto-u.ac.jp)

Nanophotonic arithmetic and logic circuits toward optical in-network computation

15:50 Pablo Bianucci, Concordia University (pablo.bianucci@concordia.ca)

A topological nanobeam microcavity

Photonic crystals in a waveguide can give rise to nanobeam microcavities, where the lateral confinement is given by the waveguide mode, and axial confinement is created by introducing a trivial defect in the photonic crystal. These cavities tend to have small mode volumes and reasonably high quality factors, limited mostly by surface roughness introduced during the fabrication.By moving to a dimerized photonic crystal waveguide, we can create a topological defect in the waveguide that will introduce axial confinement. This topology-induced confinement is robust agains disorder and fabrication-induced roughness. We will discuss the tradeoffs involved in the design of these topological microcavities, and their implementation in a silicon-on-insulator platform.

16:10 Andy Knights, McMaster University (aknight@mcmaster.ca)

with Z. Wang

Resonance control of a silicon micro-ring resonator modulator without the requirement for heterogeneous integration

A method to stabilize the resonance wavelength of a depletion-type silicon micro-ring resonator modulator during high-speed operation will be presented. The method utilizes the intrinsic defect-mediated photo-absorption of a silicon waveguide and results in a modulator chip fabrication process that is free of heterogeneous integration. The residual defects present after p-n junction formation are found to produce an adequate photocurrent for use as a feedback signal, while an integrated heater is used to compensate for thermal drift via closed-loop control. This feedback control method is experimentally demonstrated. The resonance locking is validated for a 10 Gb/s intensity modulation in a back-to-back bit-error-rate measurement, while extension to 28Gb/s is described. The use of intrinsic defects present after standard fabrication insures that no excess loss is associated with this stabilization method.

16:30 James A. Lott, Technische Universität Berlin (lott@mailbox.tu-berlin.de)
with G. Larisch and D. Bimberg

Surface emitting lasers for a green internet

The energy required to transmit information as encoded optical and electrical data bits within and between electronic and photonic integrated circuits, within and between computer servers, within and between data centers, and ultimately nearly instantly across the earth from any one point to another clearly must be minimized. This energy spans between typically tens of picojoules-per-bit to well over tens of millijoules-per-bit for the intercontinental distances. We seek to meet the exploding demand for information within the terrestrial resources available but more importantly as a common sense measure to reduce costs and to become stewards of a perpetual Green Internet. The concept of a Green Internet implies a collection of highly energy-efficient, independent, and ubiquitous information systems operating with minimal impact on the environment via natural or sustainable energy sources. A key enabling optical component for the Green Internet is the vertical-cavity surface-emitting laser (VCSEL). We review our research work on energy-efficient VCSELs for application as light-sources for optical interconnects and optical fiber data communications. We present VCSEL designs, design principles, and operating methods that enable data communication systems capable of error-free operation at bit rates exceeding 50 gigabits-per-second with energy efficiencies approaching 100 femtojoules-per-bit

16:50 Hengky Chandrahalim, Air Force Institute of Technology (Hengky.Chandrahalim@afit.edu)

Sustainable whispering-gallery ring laser sensors

We present the recent developments of mechanically, thermally, and chemically robust, sustainable whispering-gallery ring lasers for various sensing applications, fabricated by ultrafast laser inscription and standard lithography processes. Our research group have developed highly versatile optofluidic and solid microring laser systems built on fused-silica substrates. They offer a plethora of advantages over existing integrated microring laser systems, including well-defined ring resonator geometries (shape and size), inherent mechanical and chemical robustness, and regeneration capability. We also report our unique fabrication process to integrate photolithographically fabricated ring lasers and optical waveguides inscribed by ultrashort laser pulses on the same photonic chip. The manufacturing procedure of our optofluidic laser is unique and compelling for various applications as it offers maskless and flexible fabrication process, easy assembly, excellent device robustness, no post-fabrication processes, quick prototyping, and low cost. The successful integration of renewable and wavelength-agile microring lasers with laser inscribed photonic waveguides is expected to enable future on-chip optical sensing and signal processing with much higher complexity. We are currently progressing in our research to use the integrated microring cavity systems to perform temperature, pH, and refractive index sensing, broadband acoustic detection, and photoacoustic imaging.

Session D3: Medical Technologies 13:30 Sutcliffe A

Chairs: William Barber, DxRay, Inc. (william.barber@dxray.com)

13:30 Thomas Webster, Northeastern University (th.webster@neu.edu)

Design, fabricating, and commercializing in-the-body nano sensors: the future of health

Synthetic materials used in medical devices today are typically composed of micron sized particles, grains, 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. 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. However, in moving beyond tissue engineering and medical devices, it is clear that for many diseases, we need real time monitoring of body health. In this manner, some of the same materials utilized above are being used to develop implantable sensors that can both monitor and heal diseased cells. This invited talk will highlight some of these advancements, particularly those approved by the FDA.

13:50 Fabio Di Francesco, Università di Pisa (fabio.difrancesco@unipi.it)

with D. Biagini, S. Ghimenti, T. Lomonaco, F. Bellagambi, A. Bonini, P. Salvo, F. Vivaldi and R. Fuoco

Minimally invasive health monitoring

Blood analysis is a pillar in modern medicine, but sample collection has drawbacks such as the reluctance of patients to undergo invasive procedures involving needles, the need of certified health professionals operating in a controlled clinical environment, the creation of potentially infectious wastes and the increased risk of infection.
In the last few decades, an increasing effort has been spent for the development of analytical methods able to detect and quantify chemicals of clinical interest in easily accessible body fluids such as breath, saliva and sweat, but these procedures have failed so far to bridge the gap existing between research and application in the clinical practice.

There are multiple reasons to explain such flop, but the lack of standardized sampling procedures and the effects of sampling on sample composition have certainly made it difficult to compare results obtained from different groups and slowed research. However, in the last few years the development of sensor and telecommunication technologies has brought new enthusiasm in the field. A major advantage of breath, saliva and sweat analysis is that the composition of these fluids mirrors almost in real time processes happening inside the body, so that portable devices might be used for the remote monitoring of patients, athletes or people in a working environment.

We report here results obtained from our research group in analysing the effect of sampling procedures on the composition of breath and saliva samples, illustrative applications of breath and saliva analysis to non-invasive diagnostics and patients monitoring as well as the perspectives of sensing technologies in this field.

14:10 Syed Anas Imitiaz, Imperial College London (anas.imtiaz@imperial.ac.uk)

An ultra-low power system wearable sleep monitoring and diagnosis

It is estimated that more than 3.5 million people in the United Kingdom and more than 70 million people in United States suffer from some form of sleep disorder. These may manifest in the form of sleep deprivation, disruptive sleep, excessive sleepiness and other sleeprelated abnormalities and can be fatal if left untreated. Diagnosis of sleep disorders is an expensive and time-consuming procedure that requires performing a sleep study to monitor multiple parameters including neural activity (EEG), eye movements (EOG), and muscle activity (EMG), amongst others. Due to increasing healthcare costs and limited resources, access to PSG is severely limited and often requires long waiting periods.

Intelligent wearable devices can be used for monitoring and diagnosis of sleep disorders if they can automatically detect sleep abnormalities. This requires designing low-complexity algorithms and low-power systems capable of operating for extended periods of time. This work explores the development of a low-complexity algorithm, for automatic sleep staging, and its subsequent implementation as an ultra-low power system-on-chip. The system integrates an analog front end for EEG data acquisition and a digital processor to extract spectral features from these data and classify them into one of the sleep stages. The digital processor consists of multiple blocks implementing an automatic sleep staging algorithm that uses a set of contextual decision trees controlled by a state machine. The SoC is implemented in an AMS 0.18-μm CMOS technology and is powered using a single 1.25-V supply. Its power consumption is measured to be 575 μW, while its classification accuracy using real EEG data is 98.7%.

14:30 Bonnie Gray, Simon Fraser University (bgray@sfu.ca)

Flexible and reconfigurable microfluidic platforms for applications in biology and medicine

The field of microfluidics continues to show promise for applications in medical screening and diagnostics, and the study of human health and disease. Microfluidics has the potential to miniaturize instrumentation usually limited to the laboratory table top, offering the possibility of highly portable and wearable instruments for medical screening and diagnostics including the monitoring of biomarkers in real time. Microfluidics also offers unique devices and methods that enable scientists to study health and disease in new ways, from studying individual and monolayers of biological cells to mimicking organs on a chip. In order to fully develop these applications, new microfluidic platforms are required that incorporate the results of ongoing research in fields such as materials, biology, microfabrication, electronics, and computer engineering. This presentation discusses several platforms for the development of microfluidic systems for applications in biomedicine and biology. These platforms employ multiple recent advances in conductive and magnetic nanocomposite polymers, polymer microfabrication, printed circuit board technology, reconfigurable systems, and flexible electronics. These platforms are employed toward the development of new microfluidic instruments, including a reconfigurable microfluidic diagnostic unit; inexpensive, flexible, and wearable biomedical screening devices; and biological cell research platforms.

14:50 Francois Rivet, Université de Bordeaux (francois.rivet@ims-bordeaux.fr)

Intra-body communications - why not use ultrasounds instead of radio frequency

Intra-body area network will enable healthcare applications. Sensors and actuators are supposed to be interconnected thanks to wireless communications. But radio frequency (RF) are limited when intra body communications are concerned. This presentation investigates ultrasonic waves as an alternative wireless carrier of information. Indeed, many studies have shown that water and biological environments are most suited to propagating ultrasonic waves. Our goal is to characterize how ultrasonic waves propagate in the human body for intra-body communications. We present trade off in terms of frequency and dimensions of the transmitter based on theory, simulations and experimental setup demonstration.

15:10 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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15:30 Soojin Lee, University of British Columbia (soojin.lee.e@gmail.com)

Engineering approaches to non-invasive electrical stimulation of the brain: application to Parkinson's disease

Parkinson's disease (PD) affects up to 1-2% of the population over 65 years. Treatments include medication and deep brain stimulation (DBS). The latter, by modulating ongoing brain oscillations, is highly effective, but is necessarily invasive and expensive.

More recently, non-invasive electrical neuromodulatory methods such as galvanic vestibular stimulation (GVS) and transcranial alternating current stimulation (tACS) are under active investigation for PD treatment as safe, potentially portable therapies. We (and others) have previously demonstrated that stochastic GVS improves motor symptoms in PD, motivating us to investigate the effects of different stimuli on brain activity and motor function. We examined the GVS effects on EEG recordings and reaction time in PD and age-matched healthy control groups. We demonstrate that GVS had a significant non-linear effect on EEG rhythms, increasing abnormally-suppressed beta and gamma activities seen in PD regardless of the stimulus type, and suppressing excessive theta and alpha activity depending upon on the frequency of stimulation. Furthermore, reaction time was reduced by high-frequency GVS, suggesting a causal relationship between the changes in neural activity and task performance. We suggest that GVS may provide a new way to ameliorate some of the motor symptoms of PD.

15:50 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.

16:10 Ross Walker, University of Utah (ross.walker@utah.edu)

Direct neural interfaces for medical and non-medical applications

Implantable devices that interface with the nervous system are used to treat disease and disorders including Parkinson's, essential tremor, deafness, and blindness. Neural interfaces are also critical tools for neuroscience, allowing high resolution sensing of brain activity as well as actuation of neural circuits. Core technologies for interfacing with the brain and peripheral nervous system are receiving an unprecedented amount of attention both in the academic research community as well as in the entrepreneurial space. This talk will discuss the future of fully implantable neural interfaces and the fundamental technologies they are based on. State of the art devices and systems will be discussed and key technical challenges will be highlighted in the context of enabling advanced human applications of neural interfaces including prosthetic devices and brain computer interfaces.

16:30 Shiva Abbaszadeh, University of Illinois at Urbana-Champaign (sabbasza@illinois.edu)

Improving count rate and sensitivity in cross-strip cadmium zinc telluride detectors

The detector readout bandwidth is of paramount importance to achieve a high-count rate and thus a high sensitivity. For detectors with the number of readout channels larger than that of the application-specific integrated circuit (ASIC), multiple ASICs are required. In systems with such a readout scheme, it is important to consider the load balance to achieve the highest count rate. In this work, a Monte Carlo simulation was performed to investigate the bandwidths of different load balancing configurations between two ASICs in a cross-strip cadmium zinc telluride detector. It is found that for anode strips, allocating each ASIC to half of the detector area provides a higher bandwidth when compared to allocating ASIC channels to alternate anode channels. Cathodes that are closer to the field of view will trigger more often and require a more complex load balancing scheme. Charge sharing and scattering play a role in the different bandwidths, and the bandwidth of the half-half configuration is 2.82% higher than that of the alternate configuration.

16:50 Mirza Faisal Beg, Simon Fraser University (mfbeg@sfu.ca)

Measuring structure and function from medical images

Session E3: Nanomaterials and Smart Materials 13:30 Sutcliffe B

Chairs: Guangrui (Maggie) Xia, University of British Columbia (gxia@mail.ubc.ca)
John Madden, University of British Columbia (jmadden@ece.ubc.ca)

13:30 Peyman Servati, University of British Columbia (peymans@ece.ubc.ca)

Smart textile innovations for technology connected health (STITCH)

13:50 John Madden, University of British Columbia (jmadden@ece.ubc.ca)

Ionic skin--towards smart, compliant and active skin for robots and wearables

14:10 Karen Kavanagh, Simon Fraser University (kavanagh@sfu.ca)

Transmission He ion microscopy

We will describe experiments with a modified He+ ion microscope to monitor milling rates, channeling, beam steering, and diffraction through thin semiconducting materials.

14:30 Andrzej Moscicki, Amepox Microelectronics Ltd. (amepox@amepox.com.pl)
with A. Kinart and M. Abo Ras

New thermal management solution with sinterable TIM materials

Formulations contained mixture of micro and nano size filler start to be new way for improving its technical parameters. At this way is possible to improve electrical, mechanical as well as thermal properties of polymer composites for electronic packaging purpose. Especially the last one (thermally conductive) is one of the largest problems connected with actual electronic and microelectronics systems. The very important is removing of heat generated by active elements, particularly by the power elements. The most so far widespread technical solutions in the range of high thermally conductive layers (Thermal Interface Material - TIM), are compositions on the base of organic adhesives containing as a fillers the particle of silver in the powder or flake shapes with the reason that silver has very high thermally coefficient (ov. 420 W/mK). In the frame of research and development work Amepox prepared TIM compositions based on silver flakes, nanosilver and epoxy resin with a very high thermal conductivity even close 100 W/mK. All information about samples and results of our measurement will be present in the conference paper.

14:50 Krishna Saraswat, Stanford University (saraswat@stanford.edu)

Emerging interconnect technologies for nanoelectronics

15:10 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)
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15:30 Shankar Rananavare, Portland State University (ranavas@pdx.edu)
with S.R. Darmakkolla

Prospects of copper nanowire self-assembly for interconnect applications

In the mid-nineties, researchers at IBM pioneered fabrication of copper-based interconnects that are currently in wide use. This electroplating method employs patterned carbon doped oxide (CDO) covered in copper diffusion barrier that is necessary to prevent migration of copper in silicon. As the scaling of transistor continues, the thickness of the diffusion barrier is becoming comparable to the copper film deposited, thereby significantly increasing undesirable high impedance and electromigration effects.

In this talk, we will explore a hybrid method (bottom-up and top-down) to self-assemble copper nanowires for potential interconnect applications. It exploits magnetic Ni-coated copper nanowires to provide orientational/positional control and allows end-to-end connections between nanowires, anchored to a thiol-derivatized CDO surface. The solution phase deposition of these magnetic NWs in the presences of 2500 G magnetic field allows their placement and anchoring in interconnect channels patterned in CDO. Compared to randomly deposited NWs these assemblies show enhanced conductivity and may even find applications as transparent conductors.

15:50 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

16:10 Heike Riel, IBM Zurich (hei@zurich.ibm.com)

From III-V integration towards ballistic nanowire quantum networks

16:30 Jeffry Kelber, University of North Texas (kelber@unt.edu)
with T. Cheng, W.A. Goddard III, M. Randle, J. Bird and P.A. Dowben

Graphene by MBE on incommensurate polar oxides: Graphene Oxide/Buckled Graphene /Graphene Heterostructures.

The direct growth of graphene by industrially scalable methods on dielectric substrates is a critical step towards practical graphene-based devices. Growth on incommensurate substrates potentially affords a broad array of oxides for different device applications. We report theoretical and experimental results demonstrating that C MBE at 850 K on MgO(111) yields first a non-planar graphene oxide layer, then a buckled graphene layer, and finally a third layer of "normal" graphene—all in azimuthal registry. The graphene oxide is the means by which these heterostructures are accommodated to an incommensurate substrate. Raman, photoemission, electron energy loss spectroscopy and low energy electron diffraction are in agreement with DFT calculations supporting the layer-by-layer growth of the graphene oxide/buckled graphene/graphene heterostructure. The substantial sp3, non-planar character of this heterostructure strongly suggest the presence of spin-orbit coupling and a room temperature spin Hall effect, while the graphene oxide layer has an experimental band gap of ~0.5 eV, in agreement with DFT calculations. Similar behavior has been observed on other polar oxides, such as Co3O4(111), but not on Cr2O3(0001), and a predictive factor for the growth of such heterostructures appears to be whether the C/oxide interface will support C-->oxide charge transfer.

Acknowledgements: Work at UNT was supported by was supported by the NSF under grant no. ECCS-1508991, and in part by C-SPIN, a funded center of STARnet, a Semiconductor Research Corporation (SRC) program sponsored by MARCO and DARPA under task IDs 2381.001 and 2381.006. Work at Buffalo was supported by the NSF under the grant. No. ECCS-1509221. Work at UNL was supported by the NSF under grant No. ECCS-1508541. Work at Caltech was supported as part of the Computational Materials Sciences Program funded by the U.S. Department of Energy, Office of Science, Basic Energy Sciences, under Award Number DE-SC00014607. This work used the Extreme Science and Engineering Discovery Environment (XSEDE), which is supported by National Science Foundation grant number ACI-1548562.

Session N1: Networking Reception 19:00 Mt. Currie North

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

: No Speaker

May 11, 2018

Session A4: Circuits and Systems Design and Manufacture 9:00 Mt. Currie North

Chairs: Peter Wilson, Alpha & Omega Semiconductor (peterhwilson@msn.com)

9:00 Laleh Behjat, University of Calgary (laleh@ucalgary.ca)

From extremely large to super small scale: how optimization is used in the electronic design automation

The Integrated Circuits (IC) industry has been able to double the number of the transistors, the switching elements, in a computer chip every 18 months. This is done by reducing the size of the transistors. Currently, transistor sizes range between14 to 7 nm. This growth in technology has on one hand forced the engineers to solve very large scale problems, while on the other hand, they have to deal with unavoidable uncertainties that exist because of the small sizes of the transistors. In this talk, we will discuss case studies in IC physical design where large scale problems or problems that include uncertainties are solved using convex optimization methods, and how convex optimization methods can be integrated with heuristics to find reasonably good solutions in low runtime.

9:20 Gene A. Frantz, Octavo Systems LLC (gene.frantz@octavosystems.com)
with M. Murtuza

The next frontier of integration: the system in a package

We have enjoyed the technical advancements of integrated circuits for a half of a century. It began with a simple concept of putting more than one device on a substrate. Our drive has been to increase performance while reducing cost and power dissipation. The goal was a System on a Chip (SoC). But there is a complication. As we took on the task of driving the three vectors of performance (clock, cost and power) the manufacturing processes began to diverge. What started as a drive to the SoC found the drive diverging into four different directions and we found ourselves with SubSystems on a Chip rather than a complete System on a Chip. This paper will take a look at the underlying issues we are facing and then discussing what might be a good solution to the drive towards system integration.

9:40 Jayna Sheats, Terecircuits (sheats@terecircuits.com)

Process technology for heterogeneous integration

10:00 Salvador Pinillos Gimenez, Centro Universitário da FEI (sgimenez@fei.edu.br)

Layout techniques for MOSFETs

10:20 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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10:40 Jacques C. Rudell, University of Washington (jcrudell@u.washington.edu)

Integrated CMOS transceivers design towards flexible full duplex (FD) and half duplex (HD) wireless systems

This paper surveys the challenges and the current state-of-the-art in the areas of full duplex (FD) and frequency division duplex (FDD) integrated transceivers. Implementation hurdles in the form of the linearity, noise, bandwidth (BW) and power consumption of transmitter (TX) self-interference (SI) cancellation circuitry are explored. The difficulty of performing SI cancellation is heavily influenced by the modulation method, the maximum TX power output and the receiver (RX) channel BW. These issues are discussed using several recent publications as implementation examples of single-chip FD radios that range in performance from low-power cancellation techniques, to transceivers which target broad channel bandwidths using high-output-power Power Amplifiers, thus requiring deep SI cancellation. While an attempt is made to highlight works across the community, a more in-depth look at several 40-nm CMOS devices which range in performance from a narrowband Bluetooth low-energy (BLE) transceiver to analog-front-ends which integrate a +24dBm power amplifier (PA) with a dual-point feedforward cancellation architecture for broadband (>40MHz) and deep SI suppression (>50dB) are discussed.

11:00 Sidney Tsai, IBM (htsai@us.ibm.com)

Neuromorphic hardware acceleration of neural network training using analog memory

Deep neural networks (DNNs) are a family of neuromorphic computing architectures that have recently made significant advances in difficult machine learning problems such as image/object recognition, speech recognition, and machine language translation. Analog non-volatile memories (NVM) can efficiently accelerate inference and training with back-propagation of DNNs by performing parallelized multiply-accumulate operations in the analog domain, at the location of weight data, using underlying physics.

In this talk, I will briefly review our previous work towards achieving competitive performance (classification accuracies) for such DNNs with Phase-Change Memory (PCM) and show ways to improve accuracy further by improving dynamic range and excessive weight-update asymmetry of the memory element. Circuit approximations that improve network parallelism without significantly degrading classification accuracy and Power/speed advantages of such approach over conventional Von-Neumann processors, e.g. today's CPU and GPUs, will also be discussed.

11:20 Alex James, Nazarbayev University (apj@ieee.org)

Large-scale simulation of memristive neural systems

In the last decade, memristor has found its use in sensory processing systems for neuromorphic applications, cognitive algorithms, intelligent memory arrays and hierarchical temporal memories. The small size, ease of programmability, low leakage currents, ability to maintain resistance states and CMOS compatibility make the memristor a useful device for neurochip implementations. The possibility of using memristors to mimic neural circuits as well as to implement learning memory for various Spatio-temporal pattern recognition and neuromorphic computing applications makes it further a versatile device. However, in this early stages of development and exploration, the practical realisation of computational intelligence applications requires the development of in-depth theory, modelling, simulation and implementation of the memristors in large scale arrays and networks. The area of the large-scale network is explored and the advancement in this emerging field summarised for different computational intelligence applications such as artificial life, artificial cellular networks, bio-inspired networks, and intelligence over the internet of things.

11:40 Maciej Ogorzalek, Uniwersytet Jagiellonski Krakow (maciej.ogorzalek@uj.edu.pl)
with K. Grzesiak-Kopec

Behavior-oriented 3D IC layout design

Collective behavior and self-organization are common phenomena in biological systems that have been successfully applied to many different domains, including economics, social science, game programming or mobile robotics. They are often modeled and analyzed by means of physical systems, where individuals are treated as particles that interact locally and collective behavior emerges without any global control. We have proposed an agent-based flocking model to solve the 3D chip volume minimization. Design goals and constraints were defined by the means of steering behaviors, namely cohesion, separation and alignment. Now, we investigate the influence of neighbor preferences on the spatial sorting of chip module agents in terms of shape and packing. Different individual movement strategies are presented that are strongly correlated to the agent spatial position in a group. In such a way, various IC layout design requirements may be fulfilled, such as the total wire-length minimization or the hot-spot problem reduction. The approach is illustrated by the example application implemented using Godot that is an advanced open source game engine.

12:00 Takashi Matsukawa, National Institute of Advanced Industrial Science and Technology (t-matsu@aist.go.jp)

Process challenges for further scaling of FinFETs

Further scaling of FinFETs as an advanced CMOS platform needs reduction of the fin thickness and suppression of the characteristics variability. A dominant origin of the characteristics variability for the FinFETs with an undoped channel is work function variation (WFV) of the gate electrode due to granularity of the gate material. An effective technology to suppress the WFV is utilization of amorphous metals. The FinFETs with the amorphous metal gate exhibit significant suppression of the variability. The use of the amorphous metal gate can also suppress the flicker noise which has been a critical obstacle to reduction of the analog component size in SoCs. The fin thickness reduction to suppress the short channel effect causes difficulty in doping the fin by ion implantation. Consequently, the residual damage due to the ion implantation causes significant increase in the parasitic S/D resistance, its fluctuation and anomalous off-leakage known as gate induced drain leakage. Our experimental study reveals that the use of lighter ion species, i.e., P instead of As, can lighten the impacts of the residual damage. Furthermore, we have implemented damageless doping by the use of spin-coated phosphorus doped silica.

Session C4: Radiation Detection and Imaging 9:00 Diamond Head

Chairs: Toby Astill, Redlen (Toby.Astill@Redlen.com)
Jan Iwanczyk, DxRay, Inc. (jan.iwanczyk@dxray.com)

9:00 Paul Lecoq, CERN-European Organization for Nuclear Research (paul.lecoq@cern.ch)

A metamaterial approach to reach 10 ps timing resolution with a scintillator-based detector

The future generation of radiation detectors is more and more demanding on timing performance for a wide range of applications, such as time of flight (TOF) techniques for PET cameras, precise event time tagging in high luminosity accelerators and a number of photonic applications based on single photon detection.

There is a consensus for gathering Europe's multidisciplinary academic and industrial excellence around the ambitious challenge to develop a 10ps TOF PET scanner (TOFPET). The goal is to reduce the radiation dose, scan time, and costs per patient, all by an order of magnitude.

To achieve this ambitious goal it is essential to improve the performance of each component of the detection chain: light production, light transport, photodetection, readout electronics.

This talk will concentrate on the light production and light transport. It will be shown that the introduction of a number of disruptive technologies, such as multifunctional heterostructures combining the high stopping power of well know scintillators with the ultrafast photon emission resulting from the 1D, 2D or 3D quantum confinement of the excitons in nanocrystals, as well as photonic crystals and photonic fibers, open the way to new radiation detector concepts with unprecedented performance.

9:20 Maurice Garcia-Sciveres, Lawrence Berkeley National Laboratory (mgarcia-sciveres@lbl.gov)

Challenges of high rate and radiation "imaging" in particle physics

Reconstructing patterns of radiation emerging from subatomic particle collisions is related to conventional imaging, but presents unique challenges. While similar to pixellated imagers, the detectors used must sample the position and timing of subatomic particles shooting through them instead of capturing intensity maps. By precisely positioning a large number of detector elements, the samples collected allow high fidelity reconstruction of the trajectories of many particles simultaneously, thus producing 3-dimensional "images" of sprays of particles from energetic collisions. Science goals push towards larger detector assemblies and at the same time higher rate of collisions, leading to a number of unique challenges not found in imaging applications. These include operating for years without access in a radiation environment of hundreds of krad/hr, tens of MHz frame rate with sparse readout, custom power distribution and readout solutions to achieve very low mass and radiation resistance, and micron level mechanical stability of large assemblies cooled to low temperature. This presentation will introduce the challenges and focus on the present state of the art readout integrated circuit solutions for particle detectors.

9:40 Daniela Muenzel, Technische Universität München (muenzel@tum.de)

Clinical potential of spectral photon-counting computed tomography

10:00 Jan Dudak, Czech Technical University in Prague (jan.dudak@cvut.cz)
with J. Karch and J. Zemlicka

Sub-micron resolution X-ray imaging using large-area photon counting detector Timepix

X-ray micro-CT is nowadays a widely accessible imaging tool as a number of compact and high-quality X-ray imaging systems have become available on the market. The state-of-the-art micro-CT systems are capable to routinely perform scans with spatial resolution at level of several micrometers. Nevertheless, data acquisition with sub-micron precision remains a sophisticated task. Challenges come mostly from prolongation of the acquisition time inevitably connected with use of nano-focus sources providing low photon flux compared to widely used micro-focus X-ray tubes. That usually results in decreased signal-to-noise ratio of projection images. Furthermore, even effects like thermal expansion of the setup components or source spot drift become important and can induce severe artifacts to the reconstructed CT data.

The use of photon counting detector (PCD) technology can efficiently overcome the SNR issue. Prolongation of acquisition time does not compromise the image quality since PCDs operation is dark-current-free.

This contribution evaluates performance of a custom-built laboratory micro-CT system equipped with a nano-focus X-ray tube and a large-area PCD Timepix for CT scans with effective pixel size bellow one micrometer. Both SNR and mechanical stability during scans are addressed and quality of CT reconstructions is demonstrated.

10:20 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)
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10:40 Yi-Hwa Liu, Yale University (yi-hwa.liu@yale.edu)

Near-field coded aperture imaging: potential for high-sensitivity and high-resolution SPECT

Imaging distributed sources with near-field coded aperture (CA) collimation remains extremely challenging and is customarily considered next to impossible for single-photon emission computerized tomography (SPECT) due to the intricate multiplexing (overlapping) counts acquired via CA. We proposed novel CA planar and SPECT reconstruction approaches and evaluated feasibilities of imaging and reconstructing distributed hot sources and cold lesions using near-field CA and iterative image reconstruction. A series of 2-D digital and 3-D physical phantoms were used for method valuations. Ex vivo rat heart with myocardial infarction was imaged using a micro-SPECT system equipped with a custom-made CA module and a commercial 5-pinhole collimator. Rat CA images were reconstructed via the 3-D maximum likelihood expectation maximization algorithm, and 5-pinhole images were reconstructed using the commercial software provided by the micro-SPECT system. Results from the 2-D digital phantom, 3-D physical phantom and small-animal study demonstrated that our proposed 2-D and 3-D CA SPECT imaging and reconstruction approaches worked reasonably well, indicating the potential of high-sensitivity and high-resolution near-field CA SPECT. Future work remains to be done would be (1) improvement of coded aperture mask designs, (2) incorporation with solid state gamma detectors, and (3) development of new demultiplexing algorithms for CA image reconstructions.

11:00 William Barber, DxRay, Inc. (william.barber@dxray.com)

Edge illuminated direct conversion semiconductor X-ray imaging detectors

Direct conversion semiconductor x-ray imaging based on edge illuminated pixelated arrays can provide better energy resolution compared to scintillation detectors, while also providing higher dynamic range and output count rate (OCR) compared to front or back side illuminated semiconductor detectors. Direct conversion provides a more efficient energy transfer as compared to scintillators and edge illumination provides for rapid charge collection independent of the depth of interaction in semiconductors. We have developed room temperature x-ray imaging detectors for medical and security imaging applications using this approach. The imaging detectors are made using direct conversion Silicon (Si) or Cadmium Telluride (CdTe) integrated with mixed signal application specific integrated circuits (ASICs). The use of energy information in medical and security x-ray imaging applications, 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. Fast energy dispersive detectors of this type could outperform these methods by providing the energy information in a single scan with a single energy level on the x-ray tube. We demonstrate the tiling of modules to achieve the required OCR, lp/mm, and kVp for 2D and 3D x-ray imaging.

11:20 Vesna Sossi, University of British Columbia (vesna@phas.ubc.ca)

Advances in PET/MR multimodality imaging: relevance to the study of brain function

Recent understanding of brain function stresses the importance of the interaction between brain connectivity and underlying neurochemistry and metabolism, both in terms of energy cost of brain function as well as in terms of understanding of pathogenic processes. Indeed, the network degeneration hypothesis states that initiation and progression of disease-specific pathological changes occur within specific brain structural and functional networks (best investigated with MRI) and are mediated by abnormal protein aggregation, inflammation and impaired cellular energetics coupled to abnormal neurotransmission (best investigated with PET).

In order to best study brain function in the above described context it is important that PET and MRI imaging is performed simultaneously, that the time and spatial resolutions of PET and MRI-based imaging are optimally matched and that relevant information can be extracted from multi-parameter data by identifying task-specific most informative combinations of imaging metrics. This talk will describe the development in PET and MRI imaging techniques that was spurred by these requirements, including improvements in imaging instrumentation/performance, introduction of novel image reconstruction approaches, image denoising, data and process modeling, as well as application of data fusion and machine learning approaches to data analysis.

11:40 Chin-Tu Chen, University of Chicago (chintuchen@gmail.com)

with C. Kao, L. Leoni, H. Zhang, S. Cheng, M. Bhuiyan, N. Chen, N. Eclov, H. Kim, J. George, B. Quigley, H. Tsai, A. Kucharski, J. Souris, C. Pelizzari, R. Freifelder, I. Balyasnikova, L. Meng, P. La Riviere and L. Lo

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.

12:00 Krzysztof (Kris) Iniewski, Redlen (kris.iniewski@redlen.com)

with C. Siu

Readout ASICs for CdTe/CZT sensors: architecture, performance and design characteristics

Session D4: Biotechnology 9:00 Sutcliffe A

Chairs: Chair to be Announced

9:00 Paul Li, Simon Fraser University (paulli@sfu.ca)

Microfluidic nanotechnology for analyzing proteins, nucleic acids and cells in biological samples

9:20 Michael Canva, Université de Sherbrooke (Michael.Canva@USherbrooke.ca)

Plasmonic imaging systems using nanostructured substrates for enhanced biosensing

Plasmonic imaging systems have become popular instruments for biochips imaging, in particular thanks to their ability to characterize biomolecular surface interactions and associated kinetics without requiring any prior labelling of the targets under investigations.

Most systems make use of a 50 nm gold film as a plasmonic substrate as it support propagating plasmon modes at visible and infrared wavelength with near optimal bulk and biofilm sensitivities; in this case the electromagnetic evanescent field typically extends a few hundred nanometers within the dielectric it probes and the associated propagation length is about ten microns, sufficient for many applications but severely limiting the actual detailed imaging capabilities.

We recently demonstrated that coupling the classical propagating modes with the conventional localized modes obtained using nanoparticles resulted in new plasmonic hybrid modes that could get the best properties of both individual modes (i.e. spectral dispersion of the propagating ones and field enhancement of the localized ones) providing substrates with superior properties, in particular higher field enhancement potentially leading to higher sensitivities (orders of magnitude in Surface Enhanced Raman Spectroscopy), without significant loss of Surface Plasmonic Resonance sensing capabilities, as well as a significant decrease of propagation length leading to important increases in imaging performances.

9:40 Edmond W.K. Young, University of Toronto (eyoung@mie.utoronto.ca)

Transitioning biomicrofluidic systems from PDMS to plastics

Cell-based microfluidic systems have emerged as important experimental tools in cell biology research because of their ability to mimic various aspects of the in vivo tissue microenvironments and be employed as different functional cell-based assays. Poly(dimethylsiloxane) (PDMS) is the most commonly used material for fabricating microfluidic devices, but it has previously been shown to absorb hydrophobic molecules and leach uncrosslinked oligomers. In contrast, thermoplastics are widely used in laboratory cultureware, but have faced challenges in being widely adopted for microfluidics because of a lack of simple methods to fabricate thermoplastic devices.

To address this challenge, our research group has developed a selection of simple and accessible methods for fabricating cell-based microfluidic devices in thermoplastics. Methods include micromilling, hot embossing, and liquid-phase solvent bonding that are effective for various plastics commonly used for microfluidic devices such as polystyrene, acrylic, and cyclo-olefin polymers (COPs). Here, we describe the development of these thermoplastic microfabrication methods, compare and contrast the functional differences between plastic and PDMS devices in a cell biology context, and demonstrate advantages of plastic microfluidic systems in two separate biomedical applications, one for drug sensitivity testing in multiple myeloma, and one for studying biology of lung airways. These applications will offer concrete examples of how certain microfluidics applications can benefit from a transition away from PDMS and towards plastics.

10:00 Takashi Tokuda, NAIST (tokuda@ms.naist.jp)

with M. Haruta, T. Noda, K. Sasagawa and J. Ohta

CMOS-based implantable optogenetic neural interfacing devices

A flexible optoelectronic neural stimulation / measurement device with integrated CMOS technology is presented. The device is equipped with multiple blue LEDs for optical stimulation and neural electrodes for electric neural stimulation / measurement. The device is designed based on multi-chip architecture in which we integrate multiple CMOS chips that cooperatively control multiple LEDs and electrodes with small number of I/O lines. We realized two-dimensional signal distribution with the multiple CMOS chips. This architecture is advantageous not only to reduce the I/O lines, but also the for the physical flexibility of the device. Combination of small-sized rigid neural stimulators equipped with CMOS chips and flexible bridge structures, we can realize various configuration to fit specific applications.

10:20 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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10:40 Fabio Cicoira, École Polytechnique de Montréal (fabio.cicoira@polymtl.ca)

Conducting polymers for flexible, stretchable and healable electronics

Organic electronics, based on semiconducting and conducting polymers, have been extensively investigated in the past two decades and have found commercial applications in lighting panels, smartphone screens, and TV screens using organic light emitting diodes technology. Many other applications are foreseen to reach the commercial maturity in future in areas such as transistors, sensors and photovoltaics.

Organic electronic devices, apart from consumer applications, are paving the path for key applications at the interface between electronics and biology. In such applications, organic polymers are very attractive candidates, due to their distinct properties of mechanical flexibility, self-healing and mixed conduction, i.e the ability to transport both electron/holes and ionic species.

My group investigated the processing conditions leading to high electrical conductivity, long-term stability in aqueous media as well as robust mechanical properties of the conducting polymer poly(3,4-ethylenedioxythiophene) doped with polystyrenesulfonate (PEDOT:PSS), on rigid, flexible and stretchable substrates [1-3]. We have demonstrated that stretchable PEDOT:PSS films can be achieved by adding a fluorosurfactant to the film processing mixture and by pre-stretching the substrate during film deposition. We have achieved patterning of organic materials on a wide range of substrates, using orthogonal lithography, parylene patterning and pattern transfer [4-5]. Recently we have discovered that PEDOT:PSS films can be rapidly healed with water drops after being damaged with a sharp blade [6].

My talk will deal with processing, characterization and patterning of conducting polymer films and devices for flexible, stretchable and healable electronics. I will particularly focus on the strategies to achieve films with optimized electrical conductivity and mechanical properties, on unconventional micro patterning on flexible and stretchable substrates, on the different routes to achieve films stretchability and self-healing.

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11:00 Massimo De Vittorio, Università del Salento (massimo.devittorio@unisalento.it)

Thin flexible piezoelectrics for health and energy

11:20 Clara Santato, École Polytechnique de Montréal (clara.santato@polymtl.ca)

Biodegradable materials and devices for electronics and energy storage

Session E4: Optical Materials and Devices 9:00 Sutcliffe B

Chairs: Guangrui (Maggie) Xia, University of British Columbia (gxia@mail.ubc.ca)

9:00 Magnus Borgström, Lund University (magnus.borgstrom@ftf.lth.se)

Nanowires for tandem junction solar cells

Semiconducting nanowires are promising materials for high-performance electronics and optics for which optical and electrical properties can be tuned individually. The nanowires are suggested for future high efficiency solar cells due to excellent light absorbing properties. Using nanowires covering only about 12 % of the surface, record efficiencies of VLS grown nanowires has been reported for InP nanowires of 13.8 % and for GaAs nanowires of 15.3%. Recently 17.8 % efficiency was reported for top down fabricated nanowires.
In order to further optimize the performance of nanowire photovoltaics, 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 large area patterning of catalytic metal particles with a diameter of 200 nm in a hexagonal pitch of 500 nm. We found that 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 these grown nanowires to a Si platform either by direct growth on Si PV, or by nanowire peel off in polymer, followed by transfer and electrical contacting, or by aerotaxy and alignment for transfer to Si.
This work was performed within NanoLund and supported by the Swedish Research Council, the Swedish Foundation for Strategic Research (SSF), the Knut and Alice Wallenberg Foundation and the Swedish Energy Agency. This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 641023 (Nano-Tandem) and the European Union’s FP7 programme under grant agreement No 608153 (PhD4Energy). This publication reflects only the author's views and the funding agency is not responsible for any use that may be made of the information it contains.

9:20 Yukio Kawano, Tokyo Institute of Technology (kawano@pe.titech.ac.jp)

Multi-view terahertz imaging with nano-carbon flexible scanners

9:40 François Léonard, Sandia National Laboratories (fleonar@sandia.gov)

Inkjet printed terahertz detector

Terahertz waves have shown promise for a number of applications but challenges in developing sources and detectors in this frequency range have prevented broader adoption of the technology. On the detector side, recent work has focused on developing imaging arrays and in improving their performance, which often requires cooling of devices made by photolithography on rigid substrates. Here we present a different approach that focuses on room-temperature detection using inkjet-printed carbon nanotube (CNT) devices. The inkjet printing approach allows for facile, on-the-fly design and printing of devices, including in array format. The structural flexibility of the devices opens new avenues for imaging in non-planar geometries. In this presentation, I will discuss the challenges in developing and printing CNT inks for this particular application, and their properties in the THz. Results of THz detection of CNT pixel arrays will be presented, as well as the factors that impact performance.

10:00 Peter Bermel, Purdue University (pbermel@purdue.edu)

Toward an integrated system for compact solar thermophotovoltaic generation

Solar thermophotovoltaics (STPV) can convert solar heat into electricity via solar heating, followed by thermal radiation illuminating a photovoltaic diode. STPV can operate with high power densities, no moving parts, and can potentially exceed the standard photovoltaic efficiency limit of ~31%, because of spectral squeezing. However, state-of-the-art STPV demonstrations are still well below theoretical limits, because of losses from collecting solar thermal power, as well as generating and efficiently converting thermal radiation. In response, we present the following experimental demonstrations of key components needed for improved performance: (1) a thin-film Si-based selective solar thermal absorber and emitter, stable up to ~700 degrees C; and (2) a passive radiative cooler to reduce the operating temperature and thus increase the operating voltage of low-bandgap photovoltaic diodes. Finally, we will examine how these components can be integrated into a full STPV demonstration that includes selective solar absorbers, thermal emitters and all-passive, radiatively-enhanced cooling. This work may help pave the way to demonstrating reliable, quiet, light-weight, and sustainable STPV power generation.

10:20 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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10:40 Nathaniel Kinsey, Virginia Commonwealth University (nkinsey@vcu.edu)

Applications for emerging materials in nonlinear optics and integrated photonics

The recent flurry of research in fields such as nanophotonics, metamaterials, and parity time symmetry have spurred a large effort to develop tailorable, durable, and cost-effective optical materials. Through this research, several material classes with unique collections of properties have been identified, capable of impacting broader alcoves of optics research. In this presentation, we will discuss the recent advances of two particularly powerful material classes, the transparent conducting oxides, and the transition metal nitrides. These material classes are shown to provide exceptional linear and nonlinear optical responses, demonstrating a nonlinear refractive index change which exceeds the linear contribution and hot-electron relaxation more than two orders of magnitude slower than comparable materials. Together, these properties are poised to enhance applications in fields such as all-optical signal processing, energy harvesting, and on-chip integrated systems.

11:00 Cun-Zheng Ning, Arizona State University (cning@asu.edu)

Nanolasers based on integrated silicon cavity and 2D monolayer gain material

11:20 Han Yun, University of British Columbia (hany@ece.ubc.ca)
with N. Jaeger

Broadband optical power splitters for integrated photonic circuits using Si metamaterial on an SOI platform

Adiabatic 3-dB couplers are 2x2 optical power splitters that are used in photonic integrated circuits for splitting/combining light. In them, light injected into one port of the coupler is split evenly between the two output ports. Due to the high-index-contrast, silicon-on-insulator (SOI) adiabatic 3-dB couplers usually suffer from large footprints. Si metamaterial based structures, e.g., sub-wavelength-grating-based (SWG-based) structures, provide the flexibility to engineer both the refractive index and the dispersion properties of SOI devices and can be used in adiabatic 3-dB couplers to achieve compact sizes.

Here, we summarize our recent work done towards achieving compact broadband 2x2 adiabatic 3-dB couplers using Si metamaterial based waveguides. First, we present work towards a 3-dB coupler having two parallel 20 µm long conventional SWG waveguides for adiabatic mode evolution of transverse electric modes to achieve 3-dB power splitting over an operating bandwidth of 130 nm with a splitting imbalance of <0.3 dB. Then, we present work towards an adiabatic 3-dB coupler using two parallel 15 µm long SWG-assisted strip waveguides having a theoretically predicted operating bandwidth of 500 nm.

11:40 Boris Mizaikoff, Universität Ulm (boris.mizaikoff@me.com)

Mid-infrared photonics: towards IR-lab-on-chip systems

Session P2: Plenary II 13:30 Mt. Currie North

Chairs: Chair to be Announced

13:30 Kourosh Kalantar-Zadeh, RMIT University (kourosh.kalantar@rmit.edu.au)

Outcomes of first human trial on ingestible gas sensing capsules

Ingestible sensors have been hailed as the next influential tools in monitoring human health, providing invaluable information regarding chemical components of the gut. Prof Kalantar-Zadeh and his group have developed a novel low-cost and non-invasive medical device called human gas sensing capsule which has applications in diagnostics of gut disorders and assessing dietary effects on the gut. The product is a capsule size indigestible electronic device that leaves the body after normal bowel transient. This electronic based capsule allows accurate concentration measurement of vital gases of O2, H2 of CO2 and also temperature. Intestinal gas profiles are then transmitted to an external small handheld device that communicates with a smart-phone for real-time data display and analysis. The first phase of human trial has been successfully finished and the outcomes will be presented in the talk. They show some extraordinary phenomena that can potentially revolutionize fields of gastroenterology and food sciences.

14:00 Purang Abolmaesumi, University of British Columbia (purang@ece.ubc.ca)

Advanced machine learning for ultrasound guided diagnosis and intervention

In this talk, I present the development of advanced machine learning approaches for ultrasound-guided interventions and diagnosis. I will highlight three of the projects we are currently working on: 1) For the spine interventions, we have developed techniques that can automatically detect anatomical landmarks in ultrasound, and fuse ultrasound with a statistical model of the spine for guiding needle injections. 2) For prostate cancer diagnosis and treatment, we have demonstrated that automatic techniques can used for identifying cancer maps. Furthermore, we have developed techniques for automatic planning of prostate brachytherapy procedures. 3) For echocardiography, I will present the framework we have developed for automatic analysis of this data.

14:30 Gregory Snider, University of Notre Dame (snider.7@nd.edu)

Adiabatic reversible computation for ultra-low power

Power dissipation is the most severe limiter of progress in computation today, and the heat generated can be enormous. For example, the waste heat generated by computers in data centers can provide all the heating necessary for their buildings, and excess heat is in some cases used to heat nearby towns. Data centers now consume a significant fraction of the electrical power produced, and this fraction is projected to continue increasing in the future. This dissipation is also an issue for small-scale computing, as evidenced by the heat produced by laptop computers, and the short battery life in mobile devices.

The Landauer principle states that energy in computation must necessarily be dissipated only when information is destroyed. However, current CMOS technologies are very wasteful in energy because all information 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 in computational systems. 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 the challenges facing adiabatic reversible computation. Long dismissed because it requires reduced performance to save energy, adiabatic computing can offer compelling advantages. Today constraints of cooling, which sets a maximum power density, requires performance trade-offs such as multi-core, voltage scaling, and dark silicon. This presentation will explore the circumstances when the adiabatic reversible approach makes sense vs. the more established multi-core and dark-silicon methods. Devices and approaches needed for beyond CMOS implementations will also be examined.

15:00 COFFEE BREAK (Mt. Curie Foyer, Sutcliffe Foyer)

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15:30 Juan Rey, Mentor Graphics (juan_rey@mentor.com)

We are glad "you people" did not hear Moore's Law is dead

16:00 Mark Johnson, D-Wave Systems (mwjohnson@dwavesys.com)

Quantum annealing: a practical approach to quantum computing

Last year D-Wave Systems announced general commercial availability and the first system order of its D-Wave 2000Q quantum computer. This system
is D-Wave's fourth generation quantum annealing processor, and is based on a superconducting integrated circuit chip implementing 2000 qubits. I will review quantum annealing (QA) as well as recent enhancements in the ability to control the QA algorithm. These include a new capability called "reverse annealing". I will discuss how these new features are being used to help develop potential applications.

16:30 Ricardo Reis, Universidade Federal do Rio Grande do Sul (reis@inf.ufrgs.br)

Low-power issues in IoE

The increasing number of devices connected to the internet is providing the concept of Internet of Things, that together with Internet of Health, Internet of People and Internet of Something is constructing the Internet of Everything (IoE). There is also an overlapping between IoT and CPS (Cyber Physical Systems) that have as components not only electronic ones, but also mechanical components, optical components, organic components, chemical components, etc. A keyword in IoT is optimization, mainly power optimization. Power optimization must be done in all levels of design abstraction, and at physical level is related to the number of transistors. Also, many systems are critical ones, like in Internet of Heath, where reliability is a major issue. Most of the circuits designed nowadays use much more transistors than it is needed. The increasing leakage power and routing issues are an important reason to optimize the number of transistors, as leakage power is related to the number of transistors. Also, the replacement of a set of basic gates by a complex gate reduces the number of connections to be implemented using metal layers as well the number of vias. The reduction of the number of connections to be implemented using metal layers helps to improve routing and also helps to improve reliability. To cope with this goal, it is needed to provide tools to automatically generate the layout of any transistor network.

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