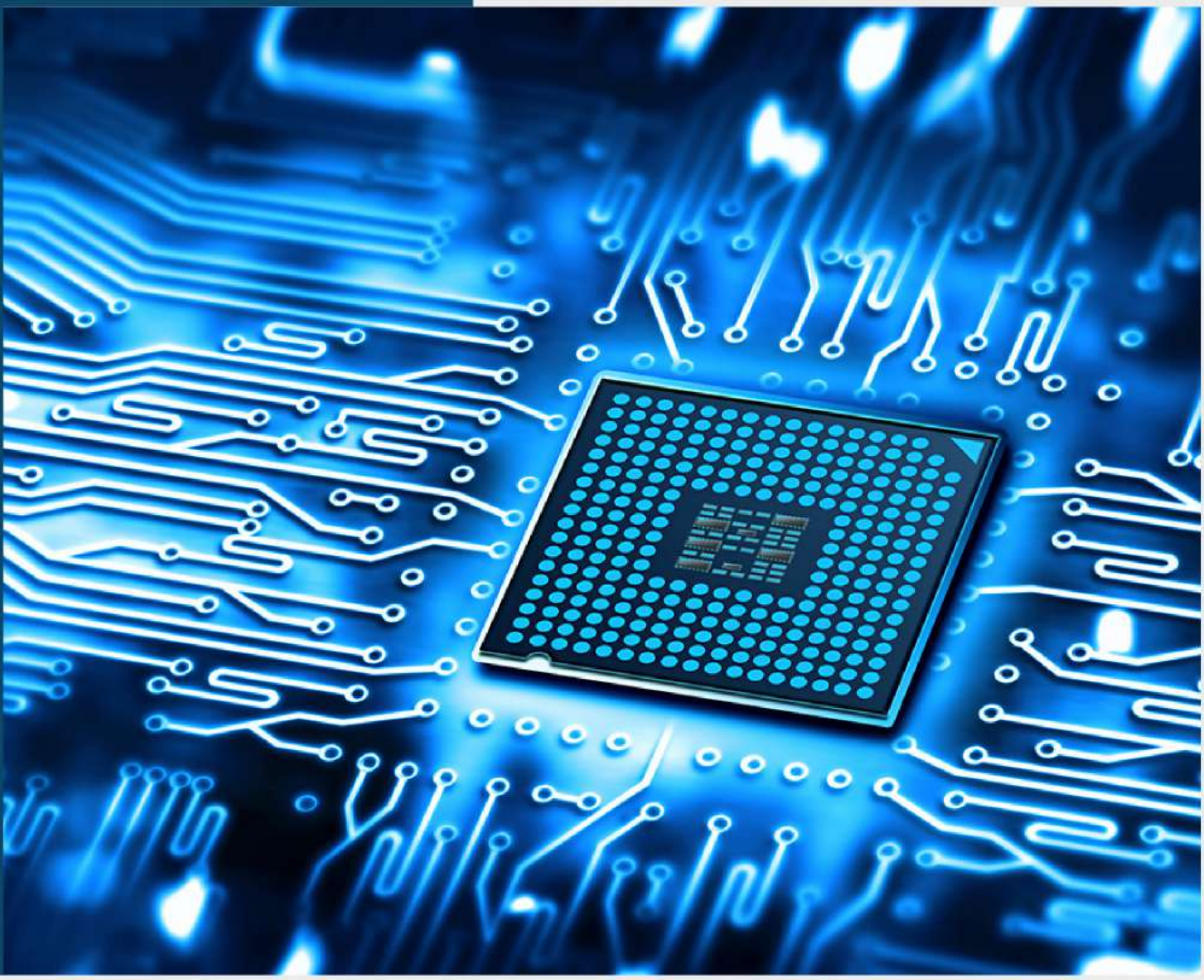
Abstract Book

ISSON2024



International Summit on

Semiconductors, Optoelectronics and Nanostructures

Dates: May 29, 2024

Venue: Prague, Czech Republic

FOREWORD

Dear Colleagues,

It is our pleasure to invite all scientists, academicians, young researchers, business delegates and students from all over the world to attend the International Summit on Semiconductors, Optoelectronics and Nanostructures will be held in Prague, Czech Republic during May 29, 2024.

ISSON2024 shares an insight into the recent research and cutting edge technologies, which gains immense interest with the colossal and exuberant presence of young and brilliant researchers, business, delegates and talented student communities.

ISSON2024 goal is to bring together, a multi-disciplinary group of scientists and engineers from all over the world to present and exchange break-through ideas relating to the Semiconductors, Optoelectronics and Nanostructures. It promotes top level research and to globalize the quality research in general, thus makes discussions, presentations more internationally competitive and focusing attention on the recent outstanding achievements in the field of Semiconductors, Optoelectronics and Nanostructures.

We're looking forward to an excellent meeting with scientists from different countries around the world and sharing new and exciting results in Semiconductors, Optoelectronics and Nanostructures.

COMMITTEE

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Conductometric Biosensors: Semiconductor Technology for Precise Measurements of Molecules

Sharath Sriram
Functional Materials and Microsystems Research Group and the ARC Centre of Excellence for Transformative Meta-Optical Systems, RMIT University, Melbourne, Australia

Abstract:

Semiconducting substrates are chemically and environmentally stable, especially silicon. Here, high resistivity float zone silicon is used as a semiconducting substrate for the design and implementation of novel biosensors. With an electrode pair arrangement at the micro-scale, surface silanisation to create binding sites, and target-specific functionalisation a new category of precise conductometric biosensors is demonstrated. With high sensitivity down to picomolar concentrations and high specificity in complex mixtures, the sensors are demonstrated for targets that encompass biomarkers (inflammatory, heart failure, fertility, and neurological), viral targets (SARS-CoV-2), and DNA fragments (cancer gene sequences for melanoma, liver, stomach, and oral cancers). Integration of the micro-scale sensors with wireless electronics, to allow real-time data acquisition is demonstrated. The technology results in a semiconductor-based remote point-of-care diagnostic platform for early screening of diseases, improving healthcare accessibility and personalised medicine.

Keywords: Float Zone Silicon; Conductometric Sensing; Biosensor

Biography:

Professor Sharath Sriram is a science and research leader creating and delivering breakthrough technologies in nanoelectronics, sensors, and medical technologies. He jointly leads the Functional Materials and Microsystems Research Group at RMIT University, Melbourne, Australia. The team are focussed on translating technology for healthcare, to bring science fiction to reality. Sharath led and coordinated a $60 million multi-user, inter-disciplinary research facility for micro- and nano-fabrication. He is currently leading medical device prototyping and scale-up manufacturing initiatives, as Director of the Discovery to Device Facility. He is the President-Elect of Science & Technology Australia and an active contributor to science policy with a focus on innovation and long-term strategy, early- and mid-career researchers, and diversity and inclusion.

Nonequilibrium Many-Body Interactions in 3D and Quasi-2D Semiconductors

Jerome V Moloney
Wyant College of Optical Sciences, University of Arizona, Tucson, Arizona 85721 USA

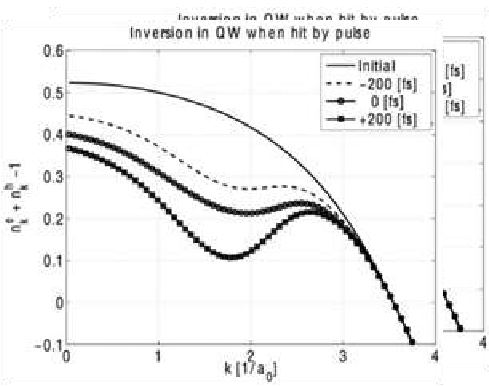
Abstract:

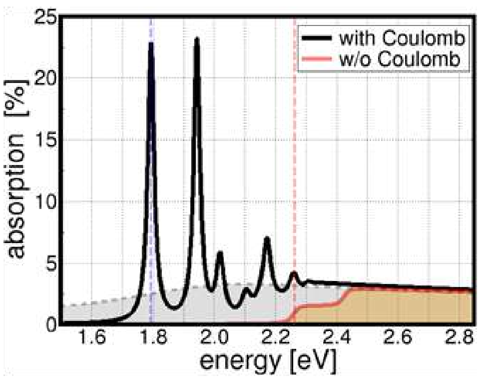
When driven resonantly (near-IR) or non-resonantly (THz) with few cycle extreme laser pulses, both 3D and quasi-2D semiconducting materials, undergo strong deviations from equilibrium/quasi-equilibrium Fermi distributions. Carriers (electrons and holes) can be driven across the 3D Brillouin zone. Mode-locked "conventional" 3D (Quantum Well (QW) stacked) surface emitting Semiconductor Disk Lasers exhibit extreme nonlinear behaviour with the transient pulse burning deep kinetic holes in initial quasi-equilibrium Fermi distributions near the I-point [see Figure]. After the pulse exits the semiconductor QW stack, higher order second Boltzmann quantum many-body scattering interactions refill the holes returning the system eventually to its original state at the lattice temperature. I will review the basic microscopic Semiconductor Bloch theory of these materials, show how this theory removes ad hoc parametrization and illustrate with experimental results how microscopically all designed structures provide tuneable room temperature THz, offset free mid-IR frequency combs and act as sources for GHz multi-contrast biological imaging.

When driving 3D semiconductors with extreme few cycle THz off-resonant pulses, internal excitations are driven by direct band-band polarizations and intra-band currents with the latter driving carriers through the 3D Brillouin zone. The latter interactions strongly influence non-perturbative higher harmonic generation in these crystals and are ideal candidates as compact sources of broadband supercontinuum generation.

Quasi-2D materials are more akin to graphene (2D hexagonal carbon lattice). However, whereas graphene has zero bandgap, these transition metal dichalcogenides (TMDCs) exhibit widely tuneable bandgaps spanning the visible region. 2D Coulomb confinement, enhanced by two orders of magnitude relative to 3D semiconductors, dramatically alters the optical response of these materials. Prominent exciton features emerge at room temperature [see Figure] –

the latter are only observed in conventional semiconductor crystals at a few degrees Kelvin. The huge in-plane Coulomb interactions that create the room temperature excitons and much weaker out of plane Van der Waals forces, makes these materials extremely sensitive to environmental influences. The latter includes sensitivity to substrates (dielectric/metal), or external atoms/molecules making them ideal candidates for gas, biological sensing etc. Monolayers of these materials exhibit a direct band gap at the so-called triply degenerate K and K' valleys and have been shown to exhibit lasing. Bi-layers through to bulk heterostructures are indirect bandgap materials but exhibit high conductivity electronic transport. The microscopic physics of these materials is governed by the Semiconductor Dirac Bloch equations, a many-body system that is orders of magnitude more complicated than the above SBE model. I will highlight the sensitivity of monolayers to external influences and fully nonequilibrium dynamics simulations that show few fs relaxation of excited carriers to the bottoms of the band.





Keywords: Semiconductor, Nonequilibrium, Excitons, Many-Body

Biography:

Jerome V Moloney is a Professor of Mathematics and Optical Sciences at the University of Arizona and is Director of the Arizona Center for Mathematical Sciences, an internationally recognized research center in applied mathematics. He is a fellow of the Optical Society of America and a recipient of the Alexander von Humboldt Prize in physics. His research interests include developing fundamental theories and supercomputer simulation of, high energy ultrashort pulse interactions with gases and solids at wavelengths spanning near-IR , MWIR and LWIR wavelengths. He has led multi-million-dollar JTO MRI projects, an AFOSR MURI and is currently actively involved in an AFOSR mid-IR MURI and a long wavelength ONR MURI. He is actively funded through AFOSR grants on the investigation of highly nonequilibrium processes coupled with laser interactions in gases and solids. He has authored more than 500 papers in peer reviewed journals, has an h-index of 87 and more than 29000 citations.

Xenes, an Extraordinary 2D Family

Guy Le Lay
PIIM-CNRS, Campus de Saint Jerôme, F-13013, France

Abstract:

The birth of Silicene [1], that is, synthetic graphenelike silicon by quantum design, has opened in 2012 a new frontier of materials science and technology by revolutionizing the field of low dimensional materials. Before, such materials were only obtained by peeling existing natural lamellar crystals like graphene and molybdenum disulfide. Typically, nobody believed that sp2-like hybridization of silicon to create an atom thin artificial honeycomb lattice could be possible. However, Silicene was obtained in Marseille upon silicon deposition onto the (111) surface of a silver single crystal under Ultra-High Vacuum, by the reversed way of the usual Molecular beam Epitaxy process of Schottky barrier formation [2]. This breakthrough has given birth to a large and extraordinary family of new artificial low dimensional Xenes with outstanding emergent properties, from the lightest Beryllene and Borophene to the heaviest Plumbene and Bismuthene with strong Spin Orbit Coupling [3,4]. As early as 2015, a first Field Effect Transistor with a Silicene channel was fabricated; it displayed ambipolar character and encouraging mobilities in air [5]. Recently, further reducing the dimensionality, we have theoretically demonstrated that artificially achieved single strand Pentasilicene nanoribbons [6,7], proximitized with a standard superconductor, might host Majorana Zero Modes at their extremities, thus opening enticing prospects for Majorana physics and for topological quantum computing [8].

Biography:

Guy Le Lay, Professor Emeritus at Aix-Marseille University, is the 2021 laureate of the international Fernand Holweck Medal and Grand Prize jointly awarded by the Institute of Physics in the UK and the SociÃ©tÃ© FranÃ§aise de Physique in France, for his pioneering works on Xenes, the artificial counterparts of graphene, from silicene synthesized in 2012 to plumbene realized in 2019. He is an expert in NanoScience and Synchrotron Radiation, serving for eight years as a member of the European Round Table on Synchrotron Radiation and Free Electron

Lasers. He has also collaborated with the ESA and the NASA as co-PI of the Mercuric Iodide Crystal Growth experiment inside the First International Microgravity Laboratory (IML-1) on-board the Discovery shuttle, in January 1992. During his career, he has chaired and organized a large number of international Schools, Workshops and Conferences and served in many UNESCO, NATO, EC, international, national and regional panels and expert committees.

Lead Oxide X-Ray Photoconductor for Application in Direct Conversion Medical Imaging Detectors

Alla Reznik
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Abstract:

X-ray imaging detectors rely on either indirect or direct conversion of X-ray quanta to an electrical signal, with the indirect method most commonly used in commercial systems. In the indirect scheme, the multi-stage conversion process begins with a scintillator converting X-ray quanta into optical photons. The optical photons in turn diffuse through a phosphor and then are converted to electrons by an array of photodiodes. In the direct method, the X-ray quanta are absorbed in a photoconductor that directly creates electron-hole pairs. The electrons and holes are then separated by a bias electric field to generate an electrical signal in the imaging array. With the right photoconductor, the direct conversion scheme offers high spatial resolution, limited only by the pixel size of the imaging array and improved dose efficiency down to the lowest required radiation exposure. Here we present the results of materials science research into new X-ray photoconductive structures based on two different polymorphs of Lead Oxide (PbO) photoconductors for application in direct conversion X-ray detectors, namely, polycrystalline Lead Oxide (poly-PbO) and amorphous Lead Oxide (a-PbO). Optimization of PbO technology was focused on improving the collection of the X-ray–generated charge and solving the problem of signal lag, that is, the residual signal after the end of X-ray exposure. The latter is one of the main obstacles to the use of disordered semiconductors as X-ray–to–charge transducers since the presence of signal lag limits the application of direct conversion detectors to static imaging only and obscures the full potential of this detection method in diagnostic imaging. The approaches we have taken to improve the X-ray performance of PbO-based photoconductive structures can be applied to other promising materials to solve the problems common to disordered photoconductors, paving a way for their use in practical detectors.

Keywords: Polycrystalline Lead Oxide, Amorphous Lead Oxide, Direct Conversion Medical Imaging Detectors.

Biography:

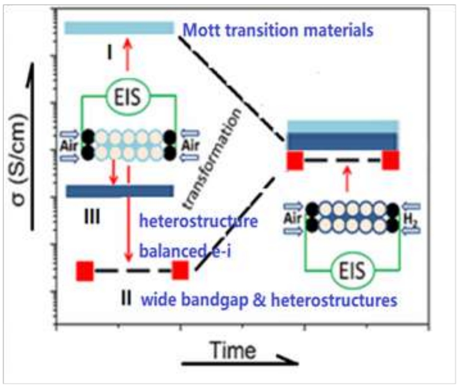
Dr. Alla Reznik is a Tier 1 Canada Research Chair in Physics of Radiation Imaging and a Full Professor in the Physics Department, Faculty of Science and Environmental Studies, Lakehead University. She is also affiliated as a Senior Scientist in the Thunder Bay Regional Health Research Institute (TBRHRI). She is a specialist in photoconductive materials and technologies for radiation medical imaging. The focus of her work is on advanced low-dose direct conversion x-ray imaging detectors based on novel x-ray-to-charge transducers. Another focus of her work is on solid-state technology for organ-targeted Positron Emission Tomography (PET).

Semiconductor Ionics and Materials for Emerging Fuel Cell Applications

Bin Zhu
Jiangsu Provincial Key Laboratory of Solar Energy Science and Technology/ Energy Storage Joint Research Center, Southeast University, China/Loughborough University, UK

Abstract:

Recent research and development on semiconductor-ionic materials (SIMs) with superionic conduction as alternative electrolytes lead to a new trend in low-temperature solid oxide fuel cell (SOFC) and proton ceramic fuel cell (PCFC). This can be traced from a radical new invention of the single-layer fuel cell (SLFC) or electrolyte-free fuel cell (EFFC), i.e. one semiconductor-ionic component instead of anode/electrolyte/cathode three components can realize fuel cell technology [1, 2]. Such SIMs can integrate the functionalities of fuel cells' anode, electrolyte, and cathode into one component. This could represent major progress and breakthrough in fuel cell science and technology and lay grounds for a new era of fuel cell R&D and commercialization. The SOFC and PCFC technologies depends on the electrolyte, yttrium stabilized zirconium (YSZ) fluorite oxide and $BaZrO_3$ (BZO) or $BaCeO_3$ (BCO)-based perovskite oxides, but these materials require a temperature over 700 °C to operate properly due to the requirement of sufficient ionic conductivity. The situation could now be improved if replacing YSZ/BZO/BCO with a SIM with high ionic conductivity to develop semiconductor-ionic fuel cells (SIFCs). The SIFC may demonstrate high performance at temperatures well below 550°C [3, 4]. Current SIMs may be classified into three types as schematically presented in Figure 1: I) Single-phase semiconductors, e.g. perovskite and layered structured oxides, $SmNiO_3$, $LiCoAlO_2$, $LiNiFeO_2$, etc. [5-7] These semiconductors have shown metal or high electronic (hole) conductivity with narrow or zero bandgaps to experience a transition to ionic conduction by proton insertion from fuel cell operation; II) Wide bandgap materials, typically, oxygen deficit oxides, e.g. fluorite structure CeO_{2-d}. The CeO_{2-d} can change from insulating or electronic conduction to a proton conductor in the fuel cell operation [8]; III) Both semiconductor and ionic conduction form a two-phase heterostructural nanocomposite, where percolation of both electron and ion conducting paths result in comparable or balanced electronic and ionic conduction [3, 4, 9].



Biography:

Zhu received M.Sc., in 1987 from the University of Sci. & Tech. of China and PhD in 1995 from Chalmers University of Technology, Physics and Engineering Physics, Sweden and 10/95-12/97, Postdoc. in Uppsala University (Ã…ngstrÃ¶m Lab). Since 1998, Dr. Zhu moved to KTH and in 1999 became associate professor /PhD supervisor until 2018. He is visiting professor in Aalto University and Nanyang Technological University and Loughborough University.as well as in several Chinese universities to co-supervise research projects and PhD students. Zhu has H-index 66 (@ Google scholar) and citations above 15000. He is one of the Most Cited scholars in China (Energy sector, Elsevier) continuously every year since 2014-. Zhu has entered the latest Stanford University released the “worldâ€™s top 2% scientists list” 2% Scientists 2020)”. Zhu is co-editor-in chief for Energy Materials

Nonlinear Charge Transport in Semiconductor Super Lattices and Excitability: Devices and Applications

Luis L. Bonilla

Director-G. Millan Institute of Fluid Dynamics, Nanoscience & Industrial Mathematics, Spain

Abstract:

Semiconductor superlattices are periodic nanaostructures consisting of epitaxially grown quantum wells and barriers. For thick barriers, the quantum wells are weakly coupled and the main transport mechanism is sequential resonant tunneling of electrons between wells. Depending on doping density, voltage bias and other parameters, these superlattices behave as excitable systems and can respond to abrupt dc bias changes by large transients involving charge density waves before arriving at a stationary state. At room temperature, they can also exhibit self-sustained current oscillations, which can be periodic in time, quasiperiodic and chaotic. These properties can be exploited to design and build many devices. Here, we describe detectors of weak signals by using coherence and stochastic resonance and fast generators of true random sequences useful for safe communications and storage.

Biography:

Luis L. Bonilla is a Professor of Applied Mathematics at Universidad Carlos III de Madrid, Spain, and Director of the G. Millan Institute of Fluid Dynamics, Nanoscience and Industrial Mathematics. Previous positions in Theoretical Physics and Condensed Matter Physics at Sevilla and Barcelona universities, visiting positions at Duke and UC Irvine, visiting scholar at Stanford, Harvard and New York Universities. His research interests lie in modeling and analysis of nonlinear problems in condensed and active matter physics including charge transport in semiconductor nanostructures, mechanical defects, and biological physics. He is author and coauthor of more than 280 research papers in international scientific journals and conference proceedings. Coauthored one monograph and edited six books and supervised 24 PhD students.

Boron Arsenide, a Potentially New Powerful Semiconductor for High Power Electronics

Zhifeng Ren
University of Houston

Abstract:

Boron arsenide (BAs) was predicted to have thermal conductivity of about 2000 W m-1 K-1 at room temperature considering 3 phonons scattering only by David Broido et al. in 2013, as high as that of diamond, and it was later revised to be 1300 W m-1 K-1 when 4 phonons scattering was taken into account. Soon after, micrometer size single crystals of BAs were grown and reported to have thermal conductivity of 200 W m-1 K-1 due to high density of defects in 2015 and millimeter size single crystals with 1300 W m-1 K-1 in 2018. In 2020, very weak effect of isotope on thermal conductivity was demonstrated. Further studies found that carrier mobility of both electrons and holes are higher than 1400 cm2 s-1 V-1, a very unique property in any good semiconductors. The combination of ultrahigh thermal conductivity, carrier mobility of both electrons and holes, and large band gap makes BAs an unprecedented semiconductor, which paves the way to push BAs to the future semiconductor industry. The prediction was based on defect-free single crystals, however the grown crystals are still full of defects, when the measured properties in defect-containing crystals match with the predicted value based on defect-free crystals, theory has to be further studied, which leads to a big question: what are the intrinsic thermal conductivity and carrier mobility. In this talk I will present the development on BAs over the last ten years and forecast the future of BAs.

Biography:

Zhifeng Ren is the Paul C. W. Chu and May P. Chern Endowed Chair in Condensed Matter Physics, Department of Physics, and the Director of the Texas Center for Superconductivity at the University of Houston (TcSUH). He received his BS in 1984 from Xihua University, MS in 1987 from Huazhong University of Science and Technology, and PhD in 1990 from the Institute of Physics, Chinese Academy of Sciences. His research focuses on thermoelectrics with high ZT and power factor, boron arsenide single crystals for high thermal conductivity, enhanced oil recovery, water splitting for H2 generation, heated filters for catching and killing SARS-CoV-2 causing COVID-19 pandemic, superconductors levitated super fast vehicles, spent battery recycling, etc.

GaSb-based SESAMs, VECSELs and MIXSELs in the Short-Wave Infrared (SWIR)

Ursula Keller
Department of Physics, ETH Zurich, Zürich, Switzerland

Abstract:

We present the key milestone results required to demonstrate the first dual-comb MIXSEL (Modelocked Integrated eXternal-cavity Surface-Emitting Laser) operating at a center wavelength of 2 µm published early this year [Opt. Express 32, 1, 26-39 (2024)]. The MIXSEL is an optically pumped semiconductor thin disk laser, for which both the the InGaSb quantum well gain and saturable absorber layers are integrated within a highly reflective mirror, enabling fundamental modelocking in the short-wave infrared (SWIR) regime. For this first demonstration we had to achieve key milestone results, such as (1) a fast InGaSb SESAM (Semiconductor Saturable Absorber Mirror); (2) an optically pumped GaSb-based back-side cooled cw VECSEL (Vertical-External-Cavity Surface-Emitting Semiconductor Laser); (3) SESAM modelocking with the same cavity mode size on SESAM and VECSEL chip; and (4) a cw VECSEL with an integrated pump DBR. We generated fundamentally modelocked pulses in single-comb operation, confirming the laser's capacity to produce high-quality, ultrafast pulses. For dual-comb generation, we employed a spatial multiplexing approach using an inverted biprism in Brewster configuration for transmission. This configuration prevents thermal crosstalk and facilitates adjustable repetition rate differences without complicating the system. We achieved fundamental modelocking with up to 4.4 MHz difference in pulse repetition rates during dual-comb operation. Additionally, we demonstrated a low-noise, down-converted microwave frequency comb that enables coherent averaging to imrpove measurement accuracy. The laser's gigahertz repetition rate permits rapid, aliasing-free measurements. Remarkably, these capabilities were realized with the laser in a free-running mode, foregoing the need for stabilization loops, a method previously demonstrated only in diode-pumped solid-state lasers. Our findings underscore the potential of dual-comb MIXSELs as efficient tools for applications demanding high-speed, precise measurements. This work advances ultrafast laser technology in the SWIR domain and promises significant benefits for fields like spectroscopy and metrology.

Keywords: Optically Pumped Semiconductor Laser; Passive Modelocking; Frequency Comb; Dual-Comb Modelocking

Biography:

Ursula Keller, a tenured physics professor at ETH Zurich since 1993, directed the NCCR MUST ultrafast science program from 2010 to 2022. She earned her Diplom from ETH Zurich in 1984 and a Ph.D. from Stanford University in 1989. As a Member of Technical Staff (MTS) at Bell Labs from 1989 to 1993, she launched her independent research career. Keller co-founded Time-Bandwidth Products (was acquired by JDSU in 2014), and K2 Photonics in 2023. Since 2022, she has served on the supervisory board of Jenoptik. Her research is dedicated to advancing ultrafast science and technology with advancements in ultrafast solid-state and semiconductor lasers, utilizing semiconductor saturable absorber mirrors (SESAMs) and achieving ultrashort pulse generation in the one to two optical-cycle regime with frequency comb generation and stabilization. She applied these lasers to conduct attosecond experiments testing fundamental processes in quantum mechanics and pioneered the attoclock technique. Her awards include the Swiss Science Prize Marcel Benoist (2022), OSA Frederic Ives Medal (2020), SPIE Gold Medal (2020), IEEE Edison Medal (2019), OSA Charles H. Townes Award (2015), EPS Senior Prize (2011), and two ERC advanced grants (2012 and 2018). Keller has supervised 95 Ph.D. students, authored 516 journal articles, and holds an h-index of 120 with over 55,000 citations according to Google Scholar. In 2022, she authored a new graduate textbook on "Ultrafast Lasers" published by Springer Verlag.

Theory and Simulations of High-Speed Micro-Oleds and Organic Laser Diodes

Daan Lenstra
Eindhoven Hendrik Casimir Institute, Eindhoven University of Technology, P.O. Box 513, 5600, MB Eindhoven, Netherlands

Abstract:

Organic Light-Emitting Diodes (OLEDs) are based on organic semiconductors and combine optoelectronic properties with relatively simple fabrication. A new generation of micro-OLEDs has been demonstrated to exhibit ultra-fast sub-nanosecond dynamics. which makes them promising for gigabit optical communication [1]. However, the lasing variant of this electrically driven device meets severe problems, among others due to bimolecular processes hampering the optical gain for stimulated emission. A possible solution to this problem is a recent proposal by Yoshida et al [2] to spatially separate the charge injection and the laser light generation, where the active layer of the laser is optically pumped by the OLED deposited on top. By eliminating the above-mentioned bimolecular loss processes, the idea is to reach the lasing threshold more easily compared to a direct-pumped organic laser diode. With a dynamical model validated for an electrically pumped OLED [3,4], the generation of pulsed or continuous wave (CW)-light is simulated. This light then excites the organic active molecules in the resonant medium, leading to the generation of singlet excitons necessary for lasing. The model includes i) field-enhanced Langevin recombination in the OLED, (ii) Stokes-shifted reabsorption in both the OLED and organic laser, and (iii) an optical cavity in the latter. The results confirm that in this configuration the threshold for lasing in terms of required cavity Q-factor can be significantly reduced compared to direct electrical pumping. Despite the optical pumping of the active region, triplet states are generated due to intersystem crossing (ISC) and singlet-singlet absorption (SSA), but at a much slower rate than in the case of direct electrical pumping. The triplet lifetime of 1.5x10-5 s will allow the pulsed laser to operate at ~1KHz repetition rate, which is necessary for optimal light communication. Moreover, relaxation oscillations on the order of a few GHz are predicted, which is also favourable for gigabit optical communication. On the other hand, to obtain CW-emission, organic materials with lower bimolecular absorption (singlet-singlet absorption and singlet-triplet absorption (STA)) should be employed.

Keywords: OLED; Organic Laser Diode; Integrated OLED pumping.

Biography:

Daan Lenstra (Amsterdam, 1947) is theoretical physicist (M.Sc., University of Groningen, 1972; Ph.D., Delft University of Technology, 1979). He researched topics in quantum optics, condensed matter, semiconductor diode lasers, nonlinear dynamics in optical systems, analogies between optics and microelectronics, optical phase conjugation, all-optical ultrafast signal processing and organic laser diodes. Prof. Em. Lenstra is now with the Department of Electrical Engineering, Eindhoven University of Technology. His research involves topics in nonlinear dynamics of integrated semiconductor lasers and organic diode lasers. Daan Lenstra (co)authored more than 500 publications in international scientific journals and conference proceedings. He (co)edited 10 books and supervised 24 PhD students.

The Study of PnP Technology Based on SpaceFibre Network

Yi Xiaosu
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Abstract:

With the increased complexity and diversities of space on-board networks and space missions, together with the strong need for low cost of every space mission, the on-board space network operation must be flexible and adapt easily to the changes of complex network topology, the adding and dropping of a large number of on-board devices. This puts a high demand for Plug and Play (PnP) technology. SpaceFibre is a very high speed serial link and network technology, designed specifically for use on board spacecraft. SpaceFibre aims to support high data rate payloads and provides robust communications for launcher applications. SpaceFibre together with PnP technology will have more plays in future space mission. The paper presents our current studies on the PnP management technology based on Space Fibre network. The paper briefly outlines SpaceFibre-PnP network management mechanism from three aspects: the network architecture, protocols, as well as functions, and describes the key technologies of SpaceFibre-PnP network management. The key SpaceFibre network discovery algorithms to realize PnP functions are studied. The width traversal algorithm was applied to dynamic discovery of space on-board network topology and the dynamic configuration of on-board devices, providing the efficient management services and the fast response in on-board SpaceFibre network. In addition, a SpaceFibre -PnP network management platform is designed, built and tested. Simulation based on OPNET and experimental results show the feasibility end effectiveness of the technology presented in the paper.

Keywords: SpaceFibre; Plug and Play; Network Management; OPNET

Biography:

Dr. Yi Xiaosu received the Physics B.Sc degree, Communication and Media Engineering MSc degree, Ph.D degree from Shaanxi Normal University, China, Offenburg University of Applied Science, Germany and Beihang University, China in 1985, 2001 and 2008 respectively. From 1985 to 1995 Lecturer, Physics Department, XIAN Petroleum University. Major research activities during this time were focused on oil acoustic logging. From 1996 to 1999 Engineer, Beijing Control Devices Institute. From Feb, 2002 to February, 2024, Associate Professor, Instrumentation Science and Opto-electircal Engineering School/International School, Beihang University. Research interests are focused on Optical sensors & optical fiber communication. More than 50 papers published on academic journals and presented at international conferences. Has obtained more than 20 national patents and several Ministerial level scientific research awards.

Unusual Anisotropic Magnetoresistance in Bilayer Heterostructure

Xiangrong Wang
The Hong Kong University of Science and Technology, China

Abstract:

The observation of magnetoresistance (MR) varying with the rotation of magnetization in the plane perpendicular to the electric current is an important discovery in spintronics in recent years. The famous conventional anisotropic MR (AMR) says that the resistance of a polycrystalline magnetic material must depend on magnetization component along the current direction only, thus cannot account for this newly observed unusual AMR (UAMR). This UAMR leads to the notion of the spin-Hall MR (SMR) in the famous SMR theory. However, the SMR theory may only explain UAMR observed in heavy-metal/magnetic-insulator bilayers, not other types of bilayers. Here, we present a two-vector theory that can explain not only all existing experiments on the unusual angular dependence of longitudinal and transverse resistivity when the magnetization rotates in three mutually perpendicular planes, but also how three amplitudes of MR angular oscillation are related to each other. The theory is general, and its correctness depends only on the assumption that magnetization and interfacial field are the only vectors affecting electron transport. Experiments that can test this theory against the SMR theory are also proposed.

Biography:

Prof. Xiangrong Wang obtained his BSc degree (1984) from Wuhan University and PhD degree (1990) from the University of Rochester. After two-year post-doc. experience in University of Minnesota, he joined the Physics Department of the Hong Kong University of Science and Technology as a faculty member in 1992. He is currently a professor there. He was a Qian Ren Professor and is guest professors at several universities and research institutions in the Mainland of China. Professor Wang is working in the field of theoretical condensed matter physics and statistical physics. His current research interests include static and dynamical properties of topological objects and topological states, magnetization dynamics and spintronics, quantum phase transitions of two-dimensional systems. He published more than 180 papers.

Terahertz Inverse Spin Hall Effect in Spintronic Nanostructures

Roman Sobolewski
University of Rochester, Rochester, NY 14627-0321, USA

Abstract:

Spintronic nanostructures, typically consisting of ferromagnet/heavy metal (FM/HM) nanobilayers, manipulate simultaneously both the electron's charge and spin degrees of freedom, and emerge as a new direction in practical generation of THz transients, i.e., bursts of electromagnetic radiation, typically, characterized by approx. a single picosecond time duration and a 0.1 to 5 THz spectral range. The inverse spin Hall effect (ISHE) is the core physical mechanism of these transient emissions. We performed exhaustive experiments using large spin-orbit coupling (SOC) Pt or Ir nanolayers on top of either soft (FeNi) or hard (FeCo) FM films as spintronic nanostructures and excited them with 100-fs-wide optical pulses, generated by a commercial Ti:Sapphire laser. As a result, we observed efficient generation of THz transients, fully in agreement with the ISHE model. Our detection scheme was an optical pump-probe sampling arrangement that allowed one to obtain a sub-picosecond time resolution of the detected THz transients. We also demonstrated that when in a spintronic emitter, a 2-dimensional (2D) graphene was substituted for HM, one could also observe large, emitted THz transients. The reason is the FM-induced Rashba texture in graphene, leading to the enhanced SOC value, and resulting in efficient spin-to-charge current conversion, called the inverse Rashba-Edelstein effect (IREE). In case of IREE, injection of a transient, optically excited, 3D spin-polarized current (from FM) into a 2D material (graphene) creates an imbalance in the distribution of charge carriers and, consequently, a transient 2D charge current, leading to emission of a THz transient.

Biography:

Roman Sobolewski is a Professor of Electrical and Computer Engineering, Physics, and Materials Science, as well as a Senior Scientist of Laser Energetics at the University of Rochester, Rochester, NY, USA. He received his PhD and DSc (Habilitation) degrees in Physics from the Polish Academy of Sciences, Warszawa, Poland, in 1983 and 1992, respectively. In 2006, he was granted the State Professorship of the Republic of Poland. In 2015, he was named a Distinguished Fellow of the Kosciuszko Foundation Collegium of Eminent Scientists of Polish Origin and Ancestry. Dr. Sobolewski is the Optica (former OSA) Travelling Lecturer, as well as the European Union ERASMUS+ Lecturer. His current research interests are concentrated on ultrafast phenomena in condensed matter, novel nanostructured semiconducting, spintronic, and superconducting devices and materials, single-photon quantum detection and quantum communications, and on generation and detection of THz radiation transients and time-resolved THz spectroscopy imaging. He has published over 400 peer-reviewed papers and presented well over 200 invited conference talks, lectures, seminars, and colloquia worldwide.

Atomic Scale Revelation of Sites, Constellations, Elemental Nature and Dynamics of Individual Atoms in 2-D Materials Envisaged for Quantum Device Development

Ursel Bangert
Bernal Chair-Microscopy & Imaging, University of Limerick, Ireland

Abstract:

2-D materials have risen enormous interest in the last 2 decades, due to their promising, huge application potential, and a large number of theoretical and experimental methodologies have been employed to investigate these stunning phenomena. Functionalising 2-D materials to include them in scalable manufacturing processes, integratable in semiconductor technologies, i.e., by controllably introducing dopants, has become a big goal. We explored ion-implantation at ultra-low energies for electronic doping of 2-Ds, to tailor their work function and bandgap. Recent advances in electron microscopy, especially in scanning transmission electron microscopy (STEM) enable direct visualization of sites of individual atoms as well as disclosure of their chemical nature, electronic structure and dynamic behaviour. In this talk STEM investigations revealing position, structure, and dynamics of individual ion-implanted dopants and point defects in 2-D transition metal dichalcogenides (TDMCs) will be presented. Establishing this is vital regarding applications of 2-D materials in nano-devices for opto-electronics in order to controllably functionalise/dope these 2-Ds, i.e., to create single photon emitters. STEM investigations have furthermore been extended to sub-atomic structural studies of 2-D ferro-electrics, to establish the constellations of electric dipoles therein. Also, atomic dipole constellations at domain walls, which in themselves represent 2-D entities in 3-D ferro-electric materials, and whether these domain walls are charged and can be mobilised under electric bias, so that they can be used as nano-switches in nano-devices, e.g., for on/off switching of single photon emitters, have been explored. The high resolution transmission electron microscopy and spectroscopy observations have also been carried out under in-situ conditions, e.g., under heating and/or biasing, enabling observations of atom dynamics under these conditions. All experimental results are supported by simulations and modelling, which in turn are backed up by DFT calculations of the nano-materials' bandstructure, supporting the observation of the constellations of atoms, their dynamics and energetics.

Biography:

Ursel Bangert is Bernal Chair in Microscopy and Imaging at the University of Limerick (Ireland), following positions of Reader and Lecturer at Manchester and Surrey University (UK), conducting research in the area of electron microscopy for over 30 years. She has been involved in the conception and managerial activities of prominent Electron Microscopy Facilities at Liverpool University (Northwest STEM), at Daresbury Laboratories (SuperSTEM) and at Manchester University and is currently establishing an International Centre for Ultra-High Resolution Imaging and Characterization at the University of Limerick. Her current research activities concentrate on investigations of structure, growth phenomena and structurally related opto-electronic properties of Nano-materials, in particular of 2 dimensional materials (her characterization of Graphene has contributed to the Nobel Prize achievement in 2010 by A. Geim), to reveal materialsâ€™ features and dynamics on the atomic scale. She has got 300 publications including Nature papers, Review Articles, Perspectives, Book Chapters, and has contributed prolifically at national and international conferences including numerous invited talks and seminars.

Proximitized 1D Xenes Nanoribbons: A New Platform for Majorana Zero Modes for Quantum Computing

Guy Le Lay
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Abstract:

For the realization of Majorana zero modes (MZMs), which could form decoherence resistant qbits due to topological protection, we design a new generic material platform [1]. Massively parallel 1D atom-thin nanoribbons of silicene or penta-Silicene (SiNRs) [2,3] could, typically, host such spin-polarized MZMs at their extremities when p-wave superconductivity is induced by proximity with a standard superconductor. Eventually, these MZMs could be detected by STM/STS [4] and possibly braided for quantum computing operations [5,6]. Multilayer SiNRs [7] or heavy Xene NRs, like NRs of bismuthene [8], a candidate for the Quantum Spin Hall effect at room temperature [9], formed spontaneously on Ag(110) or Ag(111) surfaces, could further favor device fabrication.

Biography:

Guy Le Lay, Professor Emeritus at Aix-Marseille University, is the 2021 laureate of the international Fernand Holweck Medal and Grand Prize jointly awarded by the Institute of Physics in the UK and the SociÃ©tÃ© FranÃ§aise de Physique in France, for his pioneering works on Xenes, the artificial counterparts of graphene, from silicene synthesized in 2012 to plumbene realized in 2019. He is an expert in NanoScience and Synchrotron Radiation, serving for eight years as a member of the European Round Table on Synchrotron Radiation and Free Electron Lasers. He has also collaborated with the ESA and the NASA as co-PI of the Mercuric Iodide Crystal Growth experiment inside the First International Microgravity Laboratory (IML-1) onboard the Discovery shuttle, in January 1992. During his career, he has chaired and organized a large number of international Schools, Workshops and Conferences and served in many UNESCO, NATO, EC, international, national and regional panels and expert committees.

A New Type of Phononic Crystal with Complete Band-Gap: A Theoretical Study

David Rohlig
Free State of Saxony, Germany

Abstract:

It is known from solid-state physics that electron waves in a periodic crystal lattice can be subject to a propagation restriction in certain energy ranges. Similar behaviour has been discovered for light and elastic waves, among other things: the periodic juxtaposition of different materials creates a photonic or phononic lattice, which, in contrast to the crystal lattice at atomic level, has a step-like structural function with a sharp edge at the material transitions. Based on theoretical first-principles calculations, we recently proposed a novel type of phononic crystal for which the materials parameters are continuous functions of space coordinates without discontinuities, ensuring a seamless integration of constituent materials within the crystal lattice [1]. Through this approach, we expand the established concept of phononic crystals, enabling an exploration of the shift from traditional phononic crystals (with a step-like parameter function) to a new category, which we call function phononic crystals. Our investigation primarily delved into the impact of deviating from the standard parameter step function on the phononic density of states. Our analysis uncovers a distinctive rapid convergence: even a subtle departure from the ideal step function holds the power to catalyze radical transformations in the band structure. The outcome is fascinating, with the emergence of coveted features, especially the opening of multiple complete phononic band gaps. This concept can also be transferred to light and linked to elastic waves: periodic structures that influence the propagation of both types of waves are also known as phoxonic crystals. These open up new possibilities in the field of metamaterials.

Biography:

David Rohlig is a theoretical physicist and holds a Master’s (2021) and a Bachelor’s degree (2019) in Physics from Chemnitz University of Technology. He is currently doing his doctorate in the field of Photonics and Phononics at the professorship Theoretical Physics Simulation of New Materials with Prof. Dr. Angela ThrÃ¤nhardt at the Institute of Physics in Chemnitz. His work is funded by a Ph.D. scholarship awarded by the Free State of Saxony. His research interests regard electromagnetic, elastic and acoustic wave propagation in periodic structures.

Current Induced by Fluctuations Free Standing Graphene and Charging Capacitors from Thermal Fluctuationssss

Luis L. Bonilla
Director-G. Millan Institute of Fluid Dynamics, Nanoscience & Industrial Mathematics, Spain

Abstract:

At room temperature, micron-sized sheets of freestanding graphene have ripples that are in constant motion due to thermal fluctuations, even in the presence of an applied bias voltage. Using a nearby metal electrode coupled to a circuit containing diodes, the displacement current due to moving ripples is collected at a single temperature and the produced thermal power equals the power dissipated in a load resistor. When the circuit contains a junction followed by two diodes wired in opposition, the approach to equilibrium may become ultraslow. Detailed balance is temporarily broken as current flows between the two diodes and charges storage capacitors, which eventually discharge when thermal equilibrium is restored. The energy harvested by each capacitor comes from the thermal bath of the diodes while the system obeys the first and second laws of thermodynamics. When a temperature difference between the diodes is maintained, it is possible to charge permanently the storage capacitors in the resulting stationary state.

Biography:

Luis L. Bonilla is a Professor of Applied Mathematics at Universidad Carlos III de Madrid, Spain, and Director of the G. Millan Institute of Fluid Dynamics, Nanoscience and Industrial Mathematics. Previous positions in Theoretical Physics and Condensed Matter Physics at Sevilla and Barcelona universities, visiting positions at Duke and UC Irvine, visiting scholar at Stanford, Harvard and New York Universities. His research interests lie in modeling and analysis of nonlinear problems in condensed and active matter physics including charge transport in semiconductor nanostructures, mechanical defects, and biological physics. He is author and coauthor of more than 280 research papers in international scientific journals and conference proceedings. Coauthored one monograph and edited six books and supervised 24 PhD students.

New Method of Enantioseparation of Chiral Molecules and its Importance in Pharmacology and Medicine

Lech Tomasz Baczewski
Institute of Physics, Polish Academy of Sciences, Warszawa, Poland

Abstract:

In ferromagnets magnetization reversal can be realized either by the external magnetic field or by the spin-polarized current. The manipulation of magnetization by spin-current occurs through the spin-transfer torque (STT) effect. This effect serves, for example, in modern magnetoresistive random access memory (MRAM). However, the current density required for inducing STT is of the order of 1×106 A·cm-2, or about 1x1025 electrons·sec-1·cm-2. This relatively high current density significantly affects the devices' structure and performance. In his study a new effect is discovered: magnetization switching of ferromagnetic (FM) thin layers induced solely by adsorption of chiral molecules (magnetism induced by a proximity of adsorbed chiral molecules - MIPAC). The local magnetization switching is achieved by adsorbing the chiral molecules as a self-assembled monolayer (SAM) on a gold-coated FM layer with perpendicular magnetic anisotropy. The direction of the magnetization depends on the handedness of the adsorbed chiral molecules. Owing to spin-selective electron transfer, the FM layer underneath the SAM molecules becomes spin polarized, and hence magnetization direction is determined. In the present work we combined the two effects, the electron transfer due to SAM formation and the chiral-induced spin selectivity (CISS) effect (where the spin is polarized either parallel or anti-parallel to the electrons' velocity vector according to the handedness of the molecules) in order to demonstrate the ability to control magnetization direction in a FM layer, by adsorption of SAM made from chiral molecules. This concept was demonstrated in optically [1] and electrically [2] induced spin transport experiments in a sandwich type epitaxial nanostructures: Al2O3/Pt/Au/Co (1.5-2.2 nm)/Au (5 nm) with the easy magnetization axis in the out-of-plane direction. The SAMs were made with two enantiomers of the oligopeptide, which are based on α-helix polyalanine L and D. The oligopeptides were adsorbed on predetermined areas on the top gold layer. Enantio-separation of chiral molecules adsorbed on a magnetic nanostructure with perpendicular anisotropy was also demonstrated [3] what is an extremely important process in the pharmaceutical and chemical industries.

Keywords: Nanomagnetism, Chiral Molecules, Spin Polarization, Chiral-Induced Spin Selectivity

Biography:

Prof. Lech T. Baczewski is a Head of the Magnetic Heterostructures Laboratory in the Institute of Physics Polish Academy of sciences in Warsaw, Poland. He is involved in studying the metallic magnetic thin films and nanostructures grown by Molecular Beam Epitaxy (MBE). Topics of interest: exchange interactions in rare-earths- transition metals thin films and multilayers, spin reorientation transition in magnetic Co based nanostructures â€“ tailoring of magnetic properties, interface related magnetic phenomena studied by Polarized Neutron Reflectivity (PNR) and Xray Magnetic Circular Dichroism (XMCD) â€“ induced magnetic moment, magnetic and structural studies of Co nanotubes grown on ZnTe nanowires template, nanomagnetism â€“ magnetic anisotropy in ultra-thin Co nanostructures depending on type of buffer and/or cover layer such as Co/Au, Co/Pt, Co/Mo, Co/V, anisotropy origin in Fe/Pt and FeNi L10 nanostructures, the chiral-induced spin selectivity, magnetism induced by a proximity of adsorbed chiral molecules. Invited professor at University of Nancy, University of Grenoble and Laboratoire Louis Neel, CNRS, University Paris-Sud, Orsay in France, Kyoto University and Tohoku University in Japan. President of the Management Board of the Polish Academy of Sciences Scientific Centre â€œNanophysics and Spintronics - SPINLABâ€. Author and co-author of more than 200 publications in international scientific journals.

Electro-Optical Up-Controller Based on a SOA-MZI Standard Modulation Approach

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Abstract:

The minimal losses, enormous bandwidth, and excellent tolerance to electrical interference of the optical fibre are all advantages for the propagation of radiofrequency (RF) communications through systems of optical fibres. Some functionalities can be accomplished through electronic, optical, or electro-optical instruments thanks to the combination components of such platforms. Frequency conversion, which is extremely crucial and also known as frequency mixing, is one of these tasks. A signal that is moved from the intermediate frequency (IF) realm to the RF region is called a frequency up-converted signal. The benefits of small size, the possibility of integration into additional optical components, and a potentially cheap cost can be offered by SOA-based (Semiconductor Optical Amplifier) designs, among various other alternates. Furthermore, a frequency conversion with high gain and frequency range is possible because of SOAs' optical gain. In this work, we provide an experimental and simulated investigation of an electro-optical up-converter dependent on a SOA Mach-Zehnder Interferometer (SOA-MZI) employing a conventional modulation topology. The sampling control signal is driven by an optical pulse clock (OPC) operating at a frequency of f_s= 19.5 GHz. At output mixing frequencies nf_s±f_IF, where n is the harmonic order of the used OPC, the IF signal conveying quadratic phase shift keying (QPSK) data at a frequency f_IF is up-mixed at the exit of the employed SOA-MZI. We develop sampled QPSK signals using the Virtual Photonics Inc. (VPI) emulator and examine their features using conversion gains and error vector magnitudes (EVMs). Through the SOA-MZI, which operates in a frequency band reaching 195.5 GHz, we simulated the up-mixing process. The electro-optical SOA-MZI up mixer achieves its positive conversion gain throughout the range of output mixing frequencies. The simulated conversion gain drops from 38 dB at the output mixing frequency of 20 GHz to 13 dB at 195.5 GHz. The accomplishment of the electro-optical SOA-MZI up-convertor using the standard modulation methodology is assessed by measuring the error vector magnitude (EVM). At a bit rate of 5 Gbit/s at 195.5 GHz, the EVM achieves 24%. In the frequency range up to 59 GHz, the simulated findings are compared in juxtaposition with the real ones throughout the experimental operation. This validates that they perform the same implementation and achievement.

Biography:

Hassan Termos received the B.S. and M.S. degrees in the area of electronics from the science faculty at Lebanese University in Beirut, Lebanon, in 2010 and 2012, respectively. He was a Master's STIP (Signal, Telecommunication, Image, and Parole) student at GIPSA Lab, Grenoble, France, in 2012. He received the Ph.D. degree from the Université de Bretagne Occidentale, Brest, France, in 2017. In 2017, he started a two-year postdoctoral position at ENSTA Bretagne, Brest, France. He joined the American University of Culture and Education as an associate professor in 2019 in Lebanon. He started a postdoctoral position at ICFO in 2022 in Barcelona, Spain. He is also starting a postdoctoral position at ENSTA Bretgane. His research interests are in the areas of high-speed optical transmission systems, radio over fiber applications using semiconductor optical amplifiers, optical parametric oscillators in free-space communications, and quantum systems.

Advanced ZnO Based Piezo-Phototronic Optoelectronics

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Abstract:

Since its invention in 2010, piezo-phototronic effect has been widely used in piezoelectric semiconductor materials and optoelectronic devices, e.g., solar cells, light-emitting diodes, and photodetectors, for both fundamentally physical research and potential applications. However, so far, the most related researches are mainly focused on whether piezo-phototronic effect could modulate the devices' performance, and the reported piezo-phototronic effect induced enhancement is varying from a few dozen percent to thousands of percent. Why the piezo-phototronic effect could induce such different performance improvements in different optoelectronic devices? In some special cases, the piezo-phototronic effect even causes performance degradation. Therefore, it is of great significance to carefully investigate the role of the piezo-phototronic effect plays in different optoelectronic devices, which might possibly give us more clear understandings of the piezo-phototronic effect and further constructive suggestions of how to utilize it more effectively. In our recent works in the past a few years, we have systematically studied the piezo-phototronic effect in optoelectronic devices using ZnO as the piezoelectric semiconductor material, including: photodiodes with different device structures, thin-film transistors with different charge carrier concentrations, and heterojunctions with different energy band diagram alignments, to reveal the underlying physics in piezo-phototronic effect. Our experimental and theoretical results indicate that: (1) the charge carrier concentration in ZnO is of great importance, should not being too small or too large; (2) compared to isotype photodiodes, anisotype photodiodes are preferred; (3) energy band diagram alignment is also preferred since misalignment would cause negative effects when introducing the piezo-phototronic effect. At last, we give a systematic instruction on how to utilize the piezo-phototronic effect more effectively and also our most recent research progresses about the experimental and theoretical results of piezo-phototronic and pyro-phototronic effects in multi-layered ZnO based optoelectronic devices.

Keywords: ZnO; Piezo-phototronic; Photodetector.

Biography:

Dr. Wenbo Peng is now an Associate Professor at School of Microelectronics, Xi'an Jiaotong University. He received his PhD degree in major of Electronic Science and Technology at 2016 and bachelor degree in major of Microelectronics at 2010, from Xi'an Jiaotong University. He has been a visiting scholar in School of Materials Science and Engineering, Georgia Institute of Technology from Aug 2014 to Jul 2016, working on the research fields of piezotronics and piezo-phototronics under the supervision of Prof. Zhong Lin Wang. His research interests mainly focus on advanced low dimensional piezoelectric semiconductor materials, devices and physics, and novel intelligent sensing integrated chips. He has received several fundings from NSFC, Shaanxi Province and companies. He has authored and co-authored over 50 peer-reviewed journal publications in related research fields, parts of which are published on high quality international journals, including Advanced Materials, Advanced Functional Materials, Advanced Energy Materials, Nano Energy, ACS Nano, Nano Letters, etc. His publications have been cited over 2200 times, as documented at Google Scholar (h-index: 26). He has given several Invited Talks in renowned international conferences. He is the Fellow of International Association of Advanced Materials.

Error Correction and Self-Calibration of Analogue-Digital Mixed-Signal Integrated Circuits

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Abstract:

CMOS technology is the mainstream in modern electronics, and there not only device but also some circuit and system design consideration are important for overall performance improvement. As the CMOS process is advanced, MOSFET performance is getting better, which is beneficial especially to digital circuits in terms of speed, power consumption and chip area. However, its absolute and relative variations of MOSFET characteristics as well as passive component values become larger; this degrades the overall linearity of analogue/digital mixed-signal integrated circuits (such as analogue-to-digital and digital-to-analogue converters), if its care is not taken for. In other words, in order to improve the circuit and system performance with nano-MOSFETs, error correction and self-calibration techniques are often required. This paper reviews their research results of the authors' group and discusses their unification theory. The techniques can be classified into four categories; (i) Error Correction: The circuit has some redundancy and the error is corrected without its measurement. Its typical example is "three identical circuits + majority circuit". Another example is "non-binary successive approximation analogue-to-digital converter". Notice that the quantum computer also requires error correction technology, which may have some similarities. (ii) Self-Calibration: For foreground calibration, the normal operation is stopped, the circuit itself measures its own error and then it is compensated by the circuit itself. On the other hand, for background calibration, it often uses indirect error measurements, adaptive signal processing algorithms and statistics methods, and it is performed during normal operation time. In other words, no calibration time is required. All of these works are done by the circuit itself without help of the circuit user outside. (iii) Dynamic Element Matching: The usage order of the unit elements is changed in each operation period and their errors are temporally averaged. Errors are spread or noise-shaped in frequency domain. (iv) Static Randomization: The usage order of the unit elements is pseudo randomized with respect to their layout placement on the chip, and systematic

errors depending on their places are cancelled. We also discuss their testing issues at the mass production shipping stage. Since the circuit and system with error correction and self-calibration are fault-tolerant, they have tendency to hide the error, which may degrade their reliability in fields. Finally, we try to establish their unification theory in all aspects.

Keywords: Mixed-Signal Integrated Circuit, Nano CMOS, Error Correction, Self-Calibration

Biography:

Haruo Kobayashi received the B.S. and M.S. degrees in information physics from The University of Tokyo, Tokyo, Japan, in 1980 and 1982, respectively, the M.S. degree in electrical engineering from the University of California at Los Angeles, Los Angeles, CA, USA, in 1989, and the Ph.D. degree in electrical engineering from Waseda University, Tokyo, in 1995. After working at Yokogawa Electric, he joined Gunma University as Associate Professor and promoted to Professor. He has been engaged in research and education on analogue /mixed signal LSI design & test, and signal processing algorithms. He is currently Professor Emeritus there. He has supervised 20 Ph. D. students and 160 MS students. He has published 170 journal papers and 560 international conference papers. He received the 2002 Yokoyama Science and Technology Award. He is a senior member of IEEE, IEICE and IEEJ.

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