Michał Boćkowski

Received his M.Sc. Eng. in Solid State Physics from the Warsaw University of Technology, Poland (1989), his Ph.D. in the Chemistry of Solids from the University of Montpellier II, France (1995), and his D.Sc. in Physics from the Institute of Physics, Polish Academy of Sciences (IP PAS), Poland (2013). He was awarded the title of Professor by the President of the Republic of Poland in 2021. Since 1989, he has been affiliated with the Institute of High Pressure Physics of the Polish Academy of Sciences (IHPP PAS). Currently, he holds the position of Chief Director at IHPP PAS. In addition to his role at IHPP PAS, he is a professor at the Center for Integrated Research of Future Electronics (CIRFE) within the Institute of Materials and Systems for Sustainability (IMaSS) at Nagoya University. He is also an International Fellow of the Japan Society of Applied Physics (JSAP). Boćkowski is featured in all TOP 2% researcher ranking lists. His primary scientific interests include nitride semiconductors, material processing, and crystal growth.

Shaping the Future of GaN Crystal Growth Technology

Michał Boćkowski

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This lecture provides a comprehensive overview of bulk GaN crystallization, tracing its evolution, key milestones, recent advancements, and future prospects. Various growth techniques will be examined, including halide vapor phase epitaxy (HVPE) and the ammonothermal method, the latter being the most promising. A comparative analysis of acidic and basic ammonothermal growth will highlight their advantages, limitations, and technological challenges. The integration of ammonothermal and HVPE technologies presents significant potential for further advancements. However, scaling GaN crystal growth for commercial applications remains a critical challenge. This lecture will explore current progress and realistic development timelines. Additionally, the transition from bulk crystal growth to usable substrates requires precise processing techniques, such as wafer cutting and surface treatment. The discussion will conclude with key applications of GaN substrates in optoelectronic and electronic devices.

Andrzej Wysmolek

Professor Andrzej Wysmolek earned his doctoral degree from the University of Warsaw and has been a fellow of both the Foundation for Polish Science and the Alexander von Humboldt Foundation. He has completed numerous research internships at prestigious international institutions, including the Max Planck Institute in Stuttgart and the High Magnetic Field Laboratory in Grenoble.

Currently, he is a faculty member at the Faculty of Physics, University of Warsaw, where his research focuses on the optical properties of semiconductors and semiconductor nanostructures. His work is particularly centered on hybrid systems involving graphene, transition metal dichalcogenides, and hexagonal boron nitride.

Professor Wysmolek has co-authored over 200 scientific articles, which have been cited nearly 3,000 times. He has also played an active role in academic leadership, serving two terms as Vice Dean for Student Affairs at the Faculty of Physics. In addition, he supports student innovation through the Makerspace@UW project and currently chairs the Polish Main Committee of the Physics Olympiad.

Epitaxial BN: growth, properties and applications

A. Wysmołek

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Recently, hexagonal boron nitride (hBN) has attracted significant interest as a promising material for a wide range of applications related to van der Waals heterostructures. Due to its wide bandgap, hBN can host defect centers that emit light across a broad spectral range, from infrared to ultraviolet. Some of these defects can serve as single photon emitters (SPE) or optically active spin defects with the prime example being the negatively charged boron vacancy (VB-) making hBN an excellent platform for sensing applications. However, a key bottleneck for the industrial application of hBN in quantum technologies is the fabrication of high-quality, large-area layers with controlled defect properties, enabling their integration into specialized applications. In this context, one of the most promising growth techniques for hBN is Metal-Organic Chemical Vapor Epitaxy (MOVPE).

At the University of Warsaw, we explore homoepitaxial [1] and heteroepitaxial growth of hBN [2, 3] for various applications, including hydrogen barriers [4], spin defects, single-photon emitters [5, 6], and as a useful substrate for the growth and gating of other 2D materials [7] as well as leading to polarization-dependent Raman enhancement [8]. Notably, MOVPE enables the optimization of defect emissions within the desired spectral range [9], including the deep UV region, where controlling carbon-related defects is of utmost importance [10, 11].

In this presentation, I will discuss how modifications in MOVPE growth influence the properties of epitaxial hBN, which is crucial for different optoelectronic applications.

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Maria Rosário P. Correia

Associate Professor at the University of Aveiro and researcher of the Associated Laboratory i3N, leading the Raman Laboratory. She supervised/co-supervised students of different graduation levels, PhD, MSc, BSc, post-doc researchers, PhD internships, and BI research fellows throughout her academic career. Her research has focused mainly on fundamental studies using Raman and Photoluminescence, covering different materials, including semiconductor oxides, graphene, chalcogenides thin films, and III-Nitride-based heterostructures. More recently, research interest has been in physical phenomena related to metal nanoparticles and semiconductor interfaces and their application in photovoltaic systems and light emitters.

Insights from Raman Spectroscopy on the Structural and Optical Properties of Semiconductors for Light Emitters and Photovoltaics

Maria Rosário P. Correia

Nowadays, Raman spectroscopy is crucial in studying semiconductors by providing insights into their structural, vibrational, and electronic properties and stability under light exposition. This presentation focuses on studies we conducted on III-Nitride heterostructures for solid-state light emitters and chalcogenide thin films for photovoltaic applications.

For III-Nitrides, Raman spectroscopy helps analyze crystalline phase, strain, composition, and defect density, particularly in ion-implanted materials. It detects disorder-induced vibrational changes and enables the study of phonon lifetimes, anharmonic effects, and size-dependent phonon behavior, crucial for optimizing optoelectronic and high-power devices.

In chalcogenide thin films, particularly $Sb_2(S, Se)_3$, Raman is widely used but can be affected by in situ surface reactions. These reactions may lead to phase transformations, resulting in misinterpretation of Raman spectra, highlighting the need for careful experimental conditions.

Dr. Andreas Popp

Studied physics and received his Ph.D. in 2017. His doctoral thesis focused on the electronic structure and morphology of epitaxial-grown chalcopyrite thin films for photovoltaics. In December 2017, he moved to the Leibniz Institute of Crystal Growth (IKZ) as a post-doc, where he was in charge of the epitaxial deposition of oxide thin films using MOVPE. Since April 2019, he has been leading his own research group, "Epitaxy of semiconducting gallium oxide," which focuses on material development for power electronics. The research projects acquired by Dr. Popp enabled him to build up and expand his research group, which is one of the world's leading academic research groups on the material Ga_2O_3. The success of his group is reflected in numerous publications, internationally invited lectures and two patents. The prospect of making a contribution to decarbonization with our material development and thus being able to solve social problems inspires him.

Abstract

Dr. Andreas Popp

The increasing reliance on efficient power-switching technologies necessitates advancements in semiconductor materials to reduce energy losses. This study investigates the potential of beta-gallium oxide (β-Ga_2O_3) for power electronic converters, leveraging its ultra-wide bandgap and high breakdown field strength. Homoepitaxial β-Ga_2O_3 films up to 4µm thick were grown via metal-organic vapor phase epitaxy (MOVPE) on (100) 4° off-oriented substrates. The research explores growth mechanisms, including step-flow growth optimization, and addresses challenges in vertical device architectures requiring thick, low-doped layers. The growth approach used in this work enabled for the (100) orientation record mobilities above 160 cm^2/Vs and improved growth rates, enhancing the material's viability for next-generation power electronics.

Dra. Elena del Corro

I got the Doctorate in Chemistry in 2011 in the Universidad Complutense de Madrid, holding a **FPU Fellowship** and 2 mobility grants to visit the Université Lyon I (France 2007, 3.5 months) for high pressure experiments in graphene and the University of Texas at Dallas (USA 2010, 3 months) to perform “straintronics” in carbon nanotubes. I 2012 I was granted with the **PhD Extraordinary Award** in 2012. As post-doc I first hold a **competitive CNPq grant** in Prof. Pimenta´s group in the Universidade Federal Minas Gerais (Brazil 2012, 13 months) for resonant Raman studies in new 2D materials; then I move with a contract to Heyrovsky Inst. (Prague 2014, 28.5 months) for high pressure combined with Raman studies on 2D materials. In 2017 to the present I joined the Advanced Electronic Materials and Devices group in the ICN2, holding a **Juan de la Cierva Incorporación grant** and was later on granted with a **Ramon y** Cajal tenure grant. Recently, I got a **scientist position of the Consejo Superior de Investigaciones Científicas (CSIC)**. I lead national and European research projects and have been recently granted with an **ERC-Consolidator grant**.

Triboelectric Nanogenerators For Medical Applications

Dra. Elena del Corro

Active implantable medical devices have experienced enormous development over the past years. However, one limiting factor remains a challenge, its reliance on external batteries. Furthermore, in the case of neural interfaces, the use of bulky batteries limits the advance of our understanding of the nervous system, since the presence, on the head/body of a moving animal under study, of a bulky head-stage originates the large variability found in the existing results on this regard. In an ideal scenario, medical implants should be powered using long-lasting power suppliers that pose no mechanical or chemical danger to the body. We work towards the development of an energy autonomous neural stimulation technology by exploring the coupling of triboelectric nanogenerators and our neural graphene-based microelectronics.

Elison Matioli

Is a professor in the institute of electrical and micro-engineering at Ecole Polytechnique Fédérale de Lausanne (EPFL). He received a B.Sc. degree in applied physics and applied mathematics from Ecole Polytechnique (Palaiseau, France), followed by a Ph.D. degree from the Materials Department at the University of California, Santa Barbara (UCSB), and a post-doctoral at the Massachusetts Institute of Technology (MIT).
The main research interests of his team at EPFL includes the development of new semiconductor device technologies for both power electronics and RF applications, from the electronic and thermal perspectives on a device-level, to the analysis of their performance and losses on a circuit-level aiming to reach higher efficiency, improved cooling and higher power density converters.

Emerging Technologies for High-Performance GaN power devices

Elison Matioli

Institute of Electrical and Micro Engineering

Ecole Polytechnique Fédérale de Lausanne (EPFL)

This presentation will discuss recent advancements and emerging technologies based on III-Nitride semiconductors that aim to address some of the challenges in power electronics. We will highlight the significant improvements in device performance achieved through the use of multi-channel structures, resulting in figures of merit that far exceed current standards. To address the challenge of managing high heat fluxes in compact devices, we will explore recent advancements in the thermal management of GaN devices. This includes the co-design of microfluidics and electronics within the same semiconductor substrate, a technology that offers significantly greater cooling capabilities than currently available and enables denser integration of GaN devices on a single chip. These emerging technologies present exciting opportunities for the future development of III-nitride electronic devices.

Julien Pernot

Professor at Univ. Grenoble Alpes (France), Julien Pernot teaches in the Department of Electronics, Electrical Engineering, Control and Systems and carries out research at Institut Néel. Julien obtained his PhD from the University of Montpellier (France) in 2001, where he worked on the electrical transport properties of silicon carbide until 2002. In 2003, he joined the University of Nijmegen (Netherlands) as a postdoc to study defects in wide bandgap semiconductors. At the end of 2003, he was appointed associate professor at Grenoble Alpes University and the NEEL/CNRS Institute. His current research focuses on the electrical transport properties of wide-bandgap semiconductors such as GaN and ZnO, and ultra-wide-bandgap semiconductors such as diamond, AlGaN and AlN for energy conversion and light emission applications. His main scientific contribution concerns innovative devices and electrical measurements carried out on substrate, thin films, microwires or nanowires. At university, he teaches semiconductor physics and electronics. He became a Junior Member in 2012 and a Senior Member in 2024 of the Institut Universitaire de France. He was promoted to Professor in 2016 and awarded the Blondel Medal in 2019. He is co-author of more than 100 articles and a tenth of patents. He is currently deputy director of Institut Néel in charge of innovation and partnership.

Abstract

Julien Pernot

Assessment of diamond substrates by time of flight electron beam induced current

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In this work this presentation will focus on a newly developed tool for measuring carrier mobility in thick diamond crystals: Time of Flight Electron Beam Induced Current (ToF-EBIC)1. This technique has been initially proposed in 1970 for silicon2. Following a brief description of the experimental method, we will illustrate how this technique can be used to evaluate the purity and quality of diamond crystals. Various crystals will be examined, including electronic-grade substrates from Element Six Ltd. and heteroepitaxial diamond substrates synthesized using the CVD method (KENZAN diamond process) provided by Orbray Co., Ltd. Carrier mobility values will be determined using this technique and limitations of the experimental technique will be discussed. The carrier mobility in intrinsic diamond will be compared with other methods such as photo-excited ToF or cyclotron resonance measurements6. For hetero-epitaxial diamond substrates, we will demonstrate that this technique is highly effective in assessing the suitability of different crystals for use as substrates in electronic devices.

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Dr. Simon Fichtner

Dr. Simon Fichtner is Director of Science and Technology at the Fraunhofer Institute for Silicon Technology (ISIT) as well as group leader at Kiel University, where he completed his PhD in 2019. In 2018, he discovered the ferroelectric properties of wurtzite-type solid solutions in AlScN, which was recognized with the Hugo Geiger Award of the Fraunhofer Society. His current research interest focuses on expanding the basic understanding and integrability of wurtzite ferroelectrics for applications in III-N semiconductor technology, (neuromorphic) memory devices as well as electromechanical systems.

Ferroelectricity in III-N based Semiconductors: New Paradigms for Material and Device Design

Dr. Simon Fichtner

The spontaneous polarization P_{spont} is a key property of the wurtzite III-N semiconductors AlN, GaN and InN and a unique feature compared to alternative semiconductor classes like Si, SiC or GaAs. While previously, the direction and magnitude of P_{spont} in III-Ns was exclusively determined during film growth, ferroelectricity now allows to select and measure direction and net-magnitude of P_{spont} through the application of external bias. Intense research on adding non-volatile memory functionality, tailored excitation of higher acoustic modes and functional domain walls to III-N technology has therefore commenced and is in the process of extending to optoelectronics. At the same time, chances are that the ability to measure P_{spont} will reverberate strongly to established III-N technology, as it provided experimental evidence that P_{spont} of GaN, AlN and InN surpasses conventional wisdom by more than one order of magnitude. This development should lead to new design paradigm for e.g. the polarization based GaN high electron mobility transistor (HEMT).

In addition to highlighting how ferroelectricity can thus shape a new perspective on III-N semiconductors, this contribution will discuss recent progress towards understanding and harnessing the implications of ferroelectric domains in III-Ns: electric field induced polarization discontinuities are apparently able to concentrate massive bound charge (~ 200 $\mu C/cm^2$) in atomically sharp interfaces. This bound charge in turn induces conductive sheets that can e.g. directly serve for the purpose of resistive memories. On/off ratios and operating voltages attractive for in-memory computing are demonstrated.

Konstantinos Zekentes

Konstantinos Zekentes received his undergraduate degree in Physics, from the University of Crete, Greece, and his Ph.D., in Physics of Semiconductors, from the University of Montpellier, France.

He is currently a Senior Researcher with the Microelectronics Research Group (MRG) of the Foundation for Research and Technology-Hellas (FORTH) in Heraklion, Crete, Greece and visiting researcher in CROMA, Grenoble INP, France. The objective of his work is to coordinate and supervise the MRG's and CROMA's effort for the development of SiC-related technology for elaborating SiC-based devices. His current research interest is the development of SiC-based bio-related components. Dr. Zekentes has more than hundred eighty journal and conference publications, 4 chapter books and one US patent.

Abstract

Konstantinos Zekentes

Biosensors and neural interfaces are intensively investigated the last decades. Silicon, although the main material for fabricating this type of devices, suffers from both the lack of long-term chemical stability in physiological environments and the low biocompatibility. Hence, replacing the silicon with another semiconducting material offering in addition to technology maturity, inherent chemical robustness, comparable electronic properties as well as biocompatibility is an absolute necessity. In this regard, silicon carbide SiC could be an alternative material in the development of bio-devices due to its superior characteristics. Biosensors and neural interfaces based on SiC are under development using SiC device fabrication technology. A review of the state-of-the-art of employed technology (ohmic contact formation, plasma etching, ion-implantation, a-SiC as well as poly-SiC deposition) will be given.