UNIVERSITÀ POLITECNICA DELLE MARCHE

DII DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Seminar Announcement

13/03/2024, 2.30pm-6.30pm room 150/1

"Raman Spectroscopy at Nanoscale"

"Emerging high-frequency microelectronics and photonics applications for wide band gap nanoscale oxides"

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Raman Spectroscopy at Nanoscale. Raman spectroscopy, when applied at the nanoscale, provides captivating glimpses into the chemical composition of materials. In this presentation, I will offer an overview of Raman spectroscopy's applications across diverse fields, ranging from microelectronics to life science. After introducing the fundamentals of Raman spectroscopy, I will delve into nine distinct case studies where it yields valuable insights. Raman spectroscopy plays a crucial role in characterizing two-dimensional (2D) materials such as graphene and transition metal dichalcogenides (TMDCs). Raman spectroscopy offer insights on: i) Materials Defects: Detecting defects, impurities, and lattice vibrations; ii) Strain Mapping: Quantifying strain in nanoscale structures; iii) Chemical Mapping: Identifying chemical composition and distribution; iv) Phonon Modes: Studying vibrational modes and lattice dynamics. Ultimately, this talk aims to highlight Raman spectroscopy's capabilities in investigating physical and chemical phenomena at the nanoscale level.

Emerging high-frequency microelectronics and photonics applications for wide band gap nanoscale oxides. The discovery of HfO2-based ferroelectrics has had a significant impact, particularly in the design and fabrication of CMOS-compatible high-frequency tunable devices. These devices include phase-shifters, antenna arrays, and filters, all of which exhibit remarkable tunability and miniaturization. Importantly, they operate at very low DC voltages. In contrast, devices fabricated using classical ferroelectrics are not CMOS compatible and require much higher voltages (tens of V). Consequently, these classical ferroelectrics were abandoned as tunable devices for high-frequency applications. Given the demands of 5G, 6G, and IoT communications, where tunable microwave and THz devices must work with biases provided by batteries, the use of CMOS-compatible HfO2-based ferroelectrics offers a potential solution. Additionally, I will explore three other emerging classes of nanomaterials:

- Bidimensional (2D) Transition Metal Chalcogenides (MoS2): These ultrathin materials exhibit intriguing properties, including the ability to open a bandgap in graphene monolayers when placed on HfO2 ferroelectrics.
- Semiconductor Ferroelectrics with Nitrogen-Doped Nickel Oxides: These materials hold promise for various applications, and we'll discuss their latest uses.
- Emerging phase change materials, Molybdenum oxides: The materials hold promise for ultrafast switches and for the photonics phase change materials beyond the well-established GeSbTe (GST). In summary, HfO2-based ferroelectrics and emerging nanomaterials play pivotal roles in advancing modern electronics and communication technologies.

Short-bio: Dr. Mircea Modreanu obtained his Ph.D. in Condensed Matter Physics in 2002 from the University of Bucharest, Romania. Since 2002, he has been a Principal Investigator at the Tyndall National Institute-University College Cork, Ireland. His research spans several EU-funded and Irish-funded research projects. Mircea has over 30 years of expertise in material science, particularly in oxide materials, novel materials for microelectronics and optoelectronics, and optical spectroscopies for thin films and interfaces. Since 2003, Mircea has organized ten international conferences focused on optical and X-ray metrology for advanced materials and devices in Europe and Japan. These conferences have facilitated knowledge exchange and collaboration among experts in the field. As the Project Coordinator of the European Innovation Council FETProactive project "Nanomaterials Enabling Smart Energy Harvesting For Next-Generation Internet-Of-Things" (NANO-EH), Mircea is at the forefront of cutting-edge research. The project aims to revolutionize energy harvesting for IoT devices, contributing to a sustainable future. Mircea's track record includes being awarded seven EC research grants and three Irish research grants. These grants fuel innovation and drive progress. Mircea has co-authored over 170 peer-reviewed publications in ISI-ranked journals, disseminating valuable knowledge to the scientific community. Additionally, he has delivered over 30 invited talks, sharing insights, and fostering collaboration.

Per info:

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