Book of Abstracts

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SEMICONDUCTOR MATERIALS & DEVICE PHYSICS CONFERENCE

(SEMIMATER 2025)

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APRIL 8-14, 2025

Invited Speakers

Yunqiu Wu	University of Electronic Science and Technology of China
Walter Raniero	Istituto Nazionale di Fisica Nucleare, Italy
Yuehang Xu	University of Electronic Science and Technology of China, China
Gennady Panin	Russian Academy of Sciences, Russian Federation
Mauro Menichelli	INFN Perugia University, Italy

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Aygun Z. Aliyeva	Institute of Petrochemical Processes Named Acad. Y.H. Mammadaliyev of MSE, Azerbaijan
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Aygun Z. Aliyeva	Institute of Petrochemical Processes Named Acad. Y.H. Mammadaliyev of MSE, Azerbaijan
Shakhboz Ibodullaev	Tashkent State Technical University, Uzbekistan
Ahmed Hassanein	Purdue University, USA

PLENARY PRESENTATION

Id-35

Two-dimensional Valleytronic Materials: From Principles to Device Applications

S. WANG[A*], H. TIAN[B]

[a] College of Science, Jinling Institute of Technology, Nanjing 211169, People's Republic of China

[b] School of Physics and Electronic Engineering, Linyi University, Linyi 276005, People's Republic of China

[*] Corresponding author: IsaacWang@jit.edu.cn

Abstract. In recent years, with the successful experimental preparation of two-dimensional (2D) materials, such as monolayer graphene, group-VI transition-metal dichalcogenides (MoS_2, $MoSe_2$, WS_2 and WSe_2), and so on, the valley degree of freedom (local maximum/minimum on the valence/conduction band) has attracted wide attention from researchers. Valleytronics based on 2D materials is a brand-new field which considered the heart of next-generation semiconductor technology. It proposes to use the valley degree of freedom as an information carrier. By manipulating and controlling these valleys, researchers are opening up new avenues for developing faster, more efficient, and more versatile electronic and optoelectronic devices. The potential applications span from high-speed data processing to innovative light-emitting diodes, making valleytronics a pivotal area of research in modern technology. This work is structured to guide the reader through both the theoretical underpinnings and practical applications of 2D valleytronic materials. We start with an in-depth introduction to the basics of 2D materials and principles of valleytronics. This foundational knowledge is crucial for understanding the subsequent discussions on device applications and technology integration. Then, we progress to explore the approaches in various disciplines to manipulate and utilize valley degree of freedom in a logical journey, such as geometric structures, intrinsic electronic properties, electrical techniques, magnetic techniques, thermal techniques, optical methods, heterostructures, etc. We also inspect the interplay between these approaches. As we explore the intricate principles and cutting-edge applications of valleytronics, we invite you to join us in this exploration and envision the possibilities that lie ahead. The field of valleytronics is rapidly evolving, and the insights presented in this work are intended to contribute to its continued growth and innovation. This work was supported by the National Natural Science Foundation of China (No. 12264059), the Natural Science Foundation of Jiangsu (No. BK20211002) and Shandong Province of China (No. ZR2023MA027), the China Scholarship Council (No. 201908320001) and Qinglan Project of Jiangsu Province of China.

Keywords: Two-Dimensional Materials; Graphene; Transitional-Metal Dichalcogenides; Valleytronics; Semiconductor.

INVITED PRESENTATION

Id-31

Graphene Transistor Sensors

Y. WU, T. XU, K. KANG*

University of Electronic Science and Technology of China

* Corresponding author: kangkai@uestc.edu.cn

Abstract. Graphene is a two-dimensional material composed of carbon atoms arranged in a single layer with a hexagonal honeycomb structure, which has high carrier mobility, high surface sensitivity, and functionalizable properties. As a result, graphene transistors are widely used in a variety of sensor applications. This report will introduce the related works of graphene transistor sensors from two aspects, which are biomolecular detection,and gas detection.In biomolecular detection, a liquid-gated graphene transistor has been designed and applied to detect exosomes successfully, through which can help the fast detection of cancer. When using liquid-gated graphene transistor to detect exosomes, the change of Dirac-point gate voltage is greater than 80%, the change of saturation current is greater than 18.8%, and the detection time is less than 30s. In order to realize the rapid detection of exosomes and clarify the detection mechanism, the gate capacitance model is modified based on the double-layer capacitance model. Subquently, the DC model of the liquid-gated graphene transistor is established. Then, based on the theory of chemical reaction kinetics, a dynamic concentration-dependent model is established, and the relative error of the model is less than 5.7%. In gas detection, the graphene was functionalized specifically for ammonia gas, and the hydroxylated graphene transistors were obtained. Compared with the intrinsic graphene transistor, it can improve selectivity and responsiveness to ammonia. In order to realize the rapid and accurate detection of ammonia gas, a DC model of solid-gate graphene transistor was established. Based on chemical reaction kinetics theory, a concentration-time correlation model was established by considering chemical adsorption and physical adsorption. Compared to measurement results, the model demonstrates good agreement.

Keywords: Graphene; Sensors; Transistors.

INVITED PRESENTATION

Id-33

RF Semiconductor Device Based on Diamond

Y. XU*, Y. DUAN

University of Electronic Science and Technology of China

* Corresponding author: yuehangxu@uestc.edu.cn

Abstract. To further increase the out-power of RF device, diamond has been attracted by many institutes after the great success of GaN material. Compared with GaN, diamond has four times higher breakdown electric field, 10 times higher thermal conductivity, and similar carrier saturation velocity, which enable its great potential in next generation of RF solid-state power devices. In this talk, the history of microwave solid-state power devices from first generation semiconductors (i.e. Si) to second generation semiconductors (i.e. GaAs) and to third generation semiconductors (i.e. GaN) will be reviewed first. Then the physical basis of diamond material and its progress as an electronic material will be presented. For microwave solid-state devices, very high quality and large area man-made diamond will be needed, which has been an obstacle for many years. Besides diamond material, various state-of-the-art devices will be demonstrated, such as H-terminal MOSFET, Si-terminal MOSFET, etc. Though there are a few good results have been reported for H-terminal MOSFET in microwave band, its performance is still far away from state-of-the-art GaN devices. There are still many mechanisms need to be explored, and novel structures are also needed. Finally, the challenges of diamond microwave solid-state power devices will be given out for open discussions.

Keywords: RF; Diamond; Power Device.

INVITED PRESENTATION

Id-37

Pulse Laser Melting for Contact/Junction on HPGe Crystal

W. RANIERO[A*], S. BERTOLDO[B], C. CARRARO[B], G. MAGGİONİ[A,B], S. CARTURAN[A,B], D. R. NAPOLİ[A], D. D. SALVADOR[A,B], E. NAPOLİTANİ[A,B]

[a] Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Legnaro, Viale dell'Università 2, 35020 Legnaro (PD), Italy

[b] Dipartimento di Fisica e Astronomia "G. Galilei", Università di Padova, Via Marzolo 8, 35121 Padova (PD), Italy

[*] Corresponding author: walter.raniero@lnl.infn.it

Abstract. Gamma-ray detectors are widely used in nuclear spectroscopy experiments due to their high-energy resolution. Leading gamma-ray detector arrays worldwide, such as AGATA in Europe and GRETA/GRETINA in the USA, use High Purity Germanium (HPGe) due to its exceptionally low impurity concentration in the crystal lattice (<10^10 cm^-3). This minimal impurity level significantly enhances gamma-ray resolution and detection efficiency compared to materials like Sodium Iodide (NaI) or Cadmium Zinc Telluride (CZT). However, commercial n-type HPGe detectors often employ thick contacts or junctions, which reduce the detector's active volume and are highly sensitive to neutron damage. Segmentation of HPGe detectors plays a crucial role in nuclear spectroscopy, as it enables accurate tracking of gamma rays produced during interactions. Advancing the efficiency of segmentation designs is essential to enhance the discrimination of gamma event locations within the HPGe crystal, thereby improving the precision and reliability of gamma-ray tracking.Objective: Exchange the contact/junction with a Pulse Laser Melting (PLM) technique, and to apply it to a p-type HPGe detector that is more resistant to neutron damage.Methods: The PLM technique consist to expose a HPGe crystal, that have a material precursor on the surface, made by PVD magnetron sputtering, and with a UV laser melting the crystal surface. This melting time is very short <10ns that permits to doping the crystal only in a thin layer <150nm only in the surface of the crystal. Results: Researchers at the LNL-INFN research center the University of Padua developed planar, coaxial, and segmented HPGe detectors with lateral surface leakage currents below 100 pA. Electrical I-V measurements and gamma spectroscopy using calibrated sources (e.g., ^{241}Am and ^{60}Co) confirmed the detectors' excellent energy resolution. Conclusion: The PLM technique is a promise method to made at the same time contact or junction on a HPGe detector with a very thin doping profile that are easily segmentable and resistant to thermal cycles from cryogenic 80K (LN2) to the annealing temperature (105°C). This work has been funded under PRONG (PROcesses for Next Generation Germanium Gamma detectors) 2019-2020, N3G (Next Generation Germanium Gamma Detectors) 2021–2024 and LACE (Laser Anneling Coaxial dEtectors) 2024, INFN Italy National grant agreement.

Keywords: PLM; HPGe; Gamma Segmented Detector; Magnetron Sputtering; Neutron Damage.

INVITED PRESENTATION

Id-40

Optoelectronic Memristor Sensor Based on Low-Dimensional Crystals

G. N. PANIN*

Institute of Microelectronics Technology and High-Purity Materials, Russian Academy of Sciences, Chernogolovka, Russia

* Corresponding author:panin@iptm.ru

Abstract. A photomemristor sensor consisting of photomemristors allows energy-efficient processing of visual information in real time. The emergence of new low-dimensional crystals such as graphene and transition metal dichalcogenides opens up unique possibilities for fast processing of electrical and optical signals in a wide spectral range from ultraviolet to terahertz radiation. Energy-independent resistive states in memristor structures fabricated on the basis of two-dimensional crystals and quasi-one-dimensional quantum dots [8,9] can be controlled by light and electric polarization, photoinduced structural transitions, ferroelectric and ferromagnetic states, as well as the rearrangement of carbon atoms in sp^2-sp^3 hybridization in an electric field. Such devices have high photosensitivity and demonstrate dynamic behavior [4], which is necessary for neuromorphic processing of optical information directly in the sensor. This reduces the energy and time costs associated with transferring data between the detector, memory and processor in the von Neumann architecture. An optoelectronic device for detecting, storing and processing visual information made of two-dimensional materials such as graphene, graphene oxide, diamane, molybdenum oxysulfide and quantum dots is considered. An intelligent optoelectronic memristor sensor based on graphene and molybdenum oxysulfide with an integrated optoelectronic neural network enables the creation of an energy-efficient neuromorphic embedded system for detection and autonomous recognition of optical information in real time. The work was carried out with the support of the Russian Science Foundation, grant No. 23-49-00159 and support for the operation of the equipment of the IPTM RAS within the framework of state assignment No. 075-00296-24-00.

Keywords: Photomemristor; Optoelectronics; Graphene; Molybdenum Dichalkogenides; Sensors.

INVITED PRESENTATION

Id-41

Hydrogenated Amorphous Silicon Sensors on Flexible Substrates for Dosimetry and Radiation Flux Measurements in the HASPIDE Project

M. MENICHELLI*

INFN Perugia University, Italy

* Corresponding author: mauro.menichelli@pg.infn.it

Abstract. The HASPIDE project (Hydrogenated Amorphous Silicon PIxel DEtector) has been conceived in order to study the design, fabrication and testing of hydrogenated amorphous silicon sensor onflexible substrate for applications in clinical and non-clinical accelerators beam flux measurement, neutron flux measurement and direct measurement of doses in the space environment, especially during solar events. The main reasons for the choice of the material for this sensor development are the possibility of depositing this material in flexible substrates (in our case polyimmide) and its very high radiation resistance. The fabrication architectures of these sensors are mainly three: n-i-p structures, charge selective contacts (mostly using MoOx as hole selective contact and TiO2 or ZnO:Al as electron selective contact) structures and the recently developed hybrid structure based on n/i/MoOx junctions. In the four years of the project four versions of these detectors have been fabricated and tested. Testing is divided into two phases: characterization testing and operational testing. In characterization testing we perform acceptance and performance tests on all functional sensors produced; during this phase we perform leakage current measurement and radiation sensitivity measurement using x-ray tubes at the photon production energy of 40 kV. Characterization tests also include, on a limited number of samples, radiation damage tests and operation under bending tests. Concerning operational tests, we have tested these detectors in operative conditions in clinical beams and non-clinical beams for flux measurements. The description of these sensors (including fabrication) and the results of these tests will be presented in this talk together with an overview about the future of the HASPIDE project.

Keywords: Amorphous Silicon Sensors; Dosimetry and Radiation; HASPIDE Project.

All Submissions & Topics

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