Monday Afternoon, May 12, 2025

Functional Thin Films and Surfaces
Room Palm 5-6 - Session MB2-2-MoA

Thin Films for Electronic Devices II

Moderators: Spyros Kassavetis, Aristotle University of Thessaloniki, Tomas Kubart, Angstrom

2:00pm **MB2-2-MoA-2 "Flexible Electronics" Sustainability — Challenges and Opportunities: a Materials Science View*, Natalie Stigelin,*** Georgia Institute of Technology, USA **INVITED**

In recent years, immense efforts in the flexible electronics field have led to unprecedented progress and to devices of ever increasing performance. Despite these advances, new opportunities are sought in order to widen the applications of flexible electronics technologies, expand their functionalities and features, with an increasing view on delivering sustainable solutions. We discuss here opportunities the use of multicomponent systems for, *e.g.*, increasing the mechanical flexibility and stability of organic electronic products, or introducing other features such as self-encapsulation and faster mixed ion-electron transport. One specific strategy is based on blending polymeric *insulators* with organic semiconductors; which has led to a desired improvement of the mechanical properties of organic devices, producing in certain scenarios robust and stable architectures. Here we discuss the working principle of semiconductor:insulator blends, examining the different approaches that have recently been reported in literature. We illustrate how organic field-effect transistors (OFET)s and organic solar cells (OPV)s can be fabricated with such systems without detrimental effects on the resulting device characteristics even at high contents of the insulator. Furthermore, we review how blending can assist in the fabrication of more reliable and versatile organic electrochemical transistors (OECT)s.

2:40pm **MB2-2-MoA-4 Polycarbonate Transfer Techniques for the Fabrication of MoS_2 Based Field Effect Transistors***, Chih-Hao Chiang,* ***Ruo-Yao Wang****, Meng-Lin Tsai,* National Taiwan University of Science and Technology, Taiwan

In recent years, transition metal dichalcogenides (TMDs) have received significant attention due to their immense potential to extend Moore's Law, positioning them as promising semiconductor materials for next-generation electronic devices. The challenges of large-scale production and commercialization of TMDs remain key challenges for future development in practical applications. In the fabrication of TMD-based semiconductor devices, the interface between metal electrodes and TMD layers is critical. Traditional metal electrode deposition techniques facilitate the diffusion of metals in the TMD, potentially reducing the device performance or preventing proper operation. In this study, the metal electrode transfer technique using polycarbonate has been developed to significantly reduce such damage, ensuring the reliable operation of semiconductor devices. Gold electrodes initially deposited on silicon or SiO_2/Si substrates via metal mask (channel length of 20 µm) and photolithography (channel lengths of 8 µm for photodetectors and 3 µm for field-effect transistors, FETs) have been successfully onto chemical vapor deposition (CVD)-grown MoS_2 nanosheets. The as-fabricated field effect transistors (FETs) have been characterized to exhibit switching current ratios of approximately 10^4.

3:00pm **MB2-2-MoA-5 Advancing Piezo-Gated Transistor Performance by Bilayer of V-doped ZnO and Mesoporous PVDF-TrFE*, YU ZHEN ZHANG,*** National Cheng Kung University (NCKU), Taiwan

In recent years, technology has rapidly advanced, enabling the development of flexible wearable electronics with great potential for applications such as nanogenerators and pressure sensors. Among flexible materials, β-phase PVDF-TrFE, which exhibits piezoelectric properties (d_{33}=30–40pC/N), stands out as a promising composite. This polymer has a semicrystalline structure and displays excellent piezoelectric and ferroelectric properties while maintaining flexibility. However, VZO (d_{33}=12–22pC/N) is also a piezoelectric material, and we aim to improve the device output by depositing it on PVDF-TrFE.

In this study, we aimed to enhance the flexibility and piezoelectric performance of PVDF-TrFE by blending it with zinc oxide nanoparticles and subjecting the mixture to thermal annealing at 120°C. We then applied 11,000 V through corona poling to align the dipole directions within the composite, followed by etching the ZnO to create a porous structure. Additionally, we used radio frequency magnetron co-sputtering that uses ZnO and V_2O_5 as targets to deposit VZO thin film on both sides of the PVDF-TrFE to serve as conduction pathways. Finally, we deposited two Au electrodes to make a piezoelectric gate transistor device.

In the XRD analysis, we examined unpoled and corona-poled samples. The XRD patterns of the unpoled sample showed two peaks corresponding to the α phase which has negatively affects the piezoelectric properties. After poling, the pattern of the poled sample confirmed that the β phase completely dominates the PVDF-TrFE.

We investigated the current output of the piezoelectric gate transistor under various mechanical stresses at a 1V bias and 1Hz frequency. Devices with different dipole orientations exhibited opposite behaviors. Applying mechanical stress to the positively polarized surface generated negative charges at the VZO and PVDF-TrFE interface, creating a depletion region in the top surface channel and reducing current. Conversely, this led to an accumulation region, enhancing current. By applying a piezoelectric field to the gate, we could adjust the semiconductor channel's resistance and control current flow. This technique significantly advances the piezoelectric gate transistor device, paving the way for advanced applications in flexible and wearable electronics and sensing technologies.

3:20pm **MB2-2-MoA-6 Enhanced Synaptic Characteristics Under Applied Magnetic Field in V_2O_5/Nimnin Based Switching Device for Neuromorphic Computing*, Kumar Kaushlendra,*** Indian Institute of technology Roorkee, India*; Davinder Kaur,* Indian Institute of Technology Roorkee, India

The present study reports a memory structure Al/V_2O_5/NiMnIn on a flexible stainless-steel (SS) substrate for neuromorphic applications. The fabricated device exhibits gradual SET and RESET switching characteristics with an OFF/ON resistance ratio of ~100, good consistency of 4500, and excellent data retention capability up to 3000 s. The current-voltage (I-V) study supports an Ohmic conduction mechanism in the low resistance state (LRS). In contrast, the trap-controlled modified space charge conduction mechanism demonstrated the high resistance state (HRS). The resistance versus temperature measurement (R-T) in the LRS and HRS of the device signifies that oxygen vacancies form the conduction filament. We further analyze the synaptic functioning by applying identical consecutive voltage pulses, and the device's conductance change has been observed. These characteristics show a good representation of the biological memory synapse in terms of the artificial memory device. Long-term potentiation (LTP) and long-term depression (LTD) show nonlinear and asymmetry behavior, which is substantial for neuromorphic applications. A considerable shift in LTP and LTD was detected by applying external temperature and magnetic field. This is explained via temperature and magnetic field strain in the functional NiMnIn bottom electrode of the fabricated device. The mechanical flexibility of the memory structure was tested by exploring the switching characteristics with various bending angles and bending cycles. Therefore, the present study offers new avenues for flexible devices with high data storage capability for futuristic neuromorphic applications.

4:00pm **MB2-2-MoA-8 Fabrication and Characterization of Iron Titanate Thin Films as a Potential Tunnel Barrier for Magnetic Tunnel Junction (MTJ's)*, Adnan Kareem,*** Jozef Stefan Institute, Slovenia, Pakistan

Spintronics addresses rising power dissipation in electronic circuits by offering advantages such as 0% standby leakage, low power consumption, unlimited durability, non-volatility, and compatibility with CMOS technology [1]. In this research work focuses on magnetic tunnel junctions (MTJs) in spintronics, investigating the barrier layer for efficient electron spin transfer, crucial for Magnetic Random Access Memory (MRAM). Iron titanate thin films have attracted research interest due to their potential applications in spintronic devices [2]. An application-oriented electrodeposition technique was used to prepare iron titanate thin films with varying electrolyte molarities [1,2]. XRD results reveals the amorphous behavior of As-deposited thin films. Magnetic field (MF) annealing improved the structural and magnetic properties, the Fe2TiO4 phase was observed, confirming a spinel structure with increased crystallite size and strengthened phase as molarity increased. Magnetic analysis using a vibrating sample magnetometer (VSM) showed soft ferromagnetic behavior in annealed thin films, while the as deposited thin films show para-ferromagnetic mixed behavior. As-deposited films had lower saturation magnetization compared to annealed films.

In conclusion, Fe_2TiO_4 thin films fabricated via electrodeposition demonstrate significant potential for future spintronic devices specifically in the advancements of MRAM technology.

References:

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Omari, L.H., Hajji, L., Haddad, M., Lamhasni, T. and Jama, C., (2019). Synthesis, Structural, Optical and electrical properties of La-modified Lead Iron Titanate Ceramics for NTCR thermo-resistance-based sensors. Materials chemistry and Physics, 233, pp.60-67

4:20pm **MB2-2-MoA-9 Fabrication of IZO/IGZO-Based Vertical Thin-Film Transistor and Its Integration with OLEDs for High-Density Display***,*
Nahyun Kim*, Seok Hee Hong, Jun Hyeok Lee, Ho Jin Lee, Tae Geun Kim,* Korea University, Republic of Korea

The rising demand for next-generation applications, such as augmented reality (AR), virtual reality (VR), and wearable devices, has made ultra-high-resolution displays with pixel densities reaching thousands of pixels per inch (PPI) essential. Achieving such high resolutions requires innovative driving circuits and advanced structures for the driving units. Conventional planar thin-film transistors (TFTs) face significant challenges at nanoscale channel lengths, including short-channel effects and threshold voltage (V_{th}) instability, which reduce reliability and performance [1]. Therefore, planar TFTs are inadequate as drivers for high-resolution displays, positioning vertical channel TFTs (VTFTs) as a promising alternative [2]. Conventional VTFTs feature spacers between the top and bottom electrodes, with a channel layer formed along the spacer sidewalls. However, sidewall interface conditions can result in unstable channel characteristics and lower carrier mobility compared to planar TFTs [3],[4].

Herein, we propose a novel VTFT architecture utilizing a dual-layer metal oxide channel structure, as depicted in Figure 1(a). To further enhance integration, the top electrode of the VTFT is employed as the reflective electrode in OLED devices, enabling a VTFT-based top-emitting OLED integration. We address channel stability by implementing an HfO_X-based dual-layer oxide spacer, which generates a quasi-2D electron gas at the oxide interfaces with high electron density, as shown in Figure 1(b). This concentrated electron layer facilitates main channel formation at the interface while optimizing the dual-layer thickness maximizes carrier mobility along the channel path. Additionally, pulsed Joule heating enables localized activation of the active layer without external thermal processing, allowing low-temperature processing by avoiding direct substrate heating. This supports flexible display applications compatible with various substrate materials. Experimental results indicate high performance with a mobility of 16.34 cm^2/Vs, V_{th} of 0.2 V, subthreshold swing of 0.4 V/dec, and an on/off ratio exceeding 10^5 (Figure 1(c)).

Finally, based on these results, we propose an integrated VTFT/OLED structure, realizing a high-integration display component. The integrated VTFT/OLED solution not only offers superior mobility and stability but also supports low-temperature processing for diverse substrates, contributing significantly to advancements in next-generation display technologies. This approach shows substantial potential for applications in AR/VR, wearable devices, and high-resolution monitors, advancing new possibilities in display technology.

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