## Functional Thin Films and Surfaces
## Room Town & Country D - Session MB2-1-WeM

### Thin Films for Electronic Devices I

**Moderators: Klaus Boebel**, Oerlikon Surface Solution AG, Liechtenstein, **Panos Patsalas**, Aristotle University of Thessaloniki, Greece, **Jörg Patscheider**, Evatec AG, Switzerland

8:00am **MB2-1-WeM-1 N-Doped Ba(Ti,Zr,Ta,Hf,Mo)$O_3$ Films Based Thin Film Transistors for UV Sensing**, ***Van Dung Nguyen (dungk57v@gmail.com)***, National Cheng Kung University (NCKU), Taiwan, Viet Nam; *K. Chang,* National Cheng Kung University (NCKU), Taiwan

In this research, N-doped Ba(Ti,Zr,Ta,Hf,Mo)$O_3$ dielectric films were integrated into ZnSnO-channel thin film transistor for a UV detector. The combinatorial sputtering was developed to fabricate the N-doped Ba(Ti,Zr,Ta,Hf,Mo)$O_3$ film. N-doped Ba(Ti,Zr,Ta,Hf,Mo)$O_3$ film exhibited a high dielectric constant (k ≈ 322), low leakage current density ($J_L \approx 10^{-11}$), and low dielectric loss of approximately 0.1, which is promising for gate dielectric layer in TFT applications. The resulting TFTs exhibited a high on/off current ratio of $10^8$, high saturation mobility (μsat) of 196.36 $cm^2V^{-1}s^{-1}$, low threshold voltage ($V_T$) of 0.02 V, and low subthreshold swing of 0.072 $Vdec^{-1}$. Moreover, the devices exhibited stable performance with small $V_T$ shifts and negligible changes in the maximum drain current under gate bias stress (GBS). Furthermore, the N-doped Ba(Ti,Zr,Ta,Hf,Mo) $O_3$-based phototransistor exhibited high sensitivity (S) up to $10^6$ and high responsibility (R) of 1171.85 A/W.

8:20am **MB2-1-WeM-2 Electrical Properties Based on 2D GaSe Nanobelts on the Metal-Semiconductor-Metal Photodetector**, ***Bo-Lin He (money332482587@gmail.com)***, *C. Wang,* National Taiwan University of Science and Technology, Taiwan

Gallium Selenide (GaSe) nanobelts grows in the furnace through gold catalysis methods. Scanning electron microscopy (SEM) image can observe that on the top of GaSe nanobelts have an Au particle. It shows the growth mechanism is vapor liquid solid (VLS) on the substrate. Firstly, the X-ray diffraction pattern (XRD) shows that GaSe exhibits a hexagonal crystal structure, where gallium and selenium atoms are arranged in alternating layers, forming a layered structure. Secondly, the Raman spectrum shows the different vibration modes at different four peaks. Lastly, GaSe demonstrates a direct bandgap of approximately 2.12 eV, in the ultraviolet-visible (UV) analysis shows the direct bandgap of approximately 2.33 eV.

In this work, GaSe nanobelts device with Ni electrodes are used the rapid temperature annealing (RTA) to control it and the results of SEM, EDS and line scan show the Ni is diffusing into the GaSe nanobelt, thus, forming the NiGaSe/GaSe heterojunction structure, the electrical characteristic results also imply the structural transformation of nanobelt. The varied temperature measurement results that determined the value of Schottky barrier is ~ 0.2 eV and the band alignment structure also proves the contact type is Schottky barrier. The electrical measurement results prove that the electrical property is improving and the performance of photodetector exhibits different to the device without annealing. The electrical results of MOSFETs of GaSe nanobelts by increasing drain currents with higher minus gate voltage means the electron-holes are the mainly charge carriers in the GaSe nanobelts, the results also show the electron-holes are leading the drain currents and it indicates that the GaSe is a p-type semiconductor. The gm (Transconductance) which defined as the ratio of changing out-put current at changing in-put voltage is about $3 \times 10^{-13}$ S, and the mobility reveals how easy of charge carriers flow into the semiconductor and the value is about $1.5 \times 10^{-3}$ $cm^2/V{\cdot}S$.

Keywords: nanobelts, hexagonal, vapor liquid solid (VLS), direct bandgap, rapid temperature annealing (RTA), heterojunction structure, electrical characteristic, Schottky barrier, photodetector, MOSFETs

8:40am **MB2-1-WeM-3 Strain-Induced Self-Rolled-Up Thin Films for Extreme Miniaturization and Integration of Passive Electronic Components**, ***Xiuling Li (xiuling.li@utexas.edu)***, The University of Texas at Austin, USA **INVITED**

The fundamental physical principle underlying self-rolled-up membrane (S-RuM) nanotechnology is the strain-driven spontaneous deformation of 2D membranes into 3D architectures. S-RuM technology offers a unique solution for achieving 3D functional hierarchical architectures without the challenges associated with processing in three dimensions. Through strain engineering, it opens up new possibilities by facilitating the creation of practically unlimited complexity in L-C circuits, integrated photonics, and lab-on-a-chip integration of soft and hard materials. Importantly, these advancements are achieved through the utilization of well-established CMOS-compatible planar processing techniques.

In this talk, I will present examples of S-RuM based passive electronic components, including on-chip inductors, transformers, L-C networks.I will discuss how S-RuM technology can potentially to break the constraints of size, weight, and performance of RFICs and power electronics.

9:20am **MB2-1-WeM-5 Electrolyte Gated Transistors for Neuromorphic Signal Processing and Biosensing**, ***Luke Sylvander (luke.sylvander@rmit.edu.au)***, *P. Le, C. Tan, H. Tran,* RMIT University, Australia; *D. McKenzie,* University of Sydney, Australia; *D. McCulloch, J. Partridge,* RMIT University, Australia

An Ar plasma immersion ion implantation (PIII) process has been employed to introduce free-radical covalent binding sites in spin-on polymer layers. These layers have been incorporated as dielectric layers into lateral electrolyte-gated transistors (EGTs) with characteristics resembling those of biological synapses. Specifically, if the gate electrode of the EGT is taken to be the pre-synapse and voltage pulses are applied, the resulting source-drain output mimics aspects of postsynaptic signals. Notably, this postsynaptic output is sensitive to the dynamics of the double layers (DLs) that are formed at the two polymer/electrolyte interfaces when the presynaptic voltage is applied. If biomolecules are covalently immobilised on the PIII-treated polymer dielectric layer, the dynamics of the DL formation/decay are altered, as are the postsynaptic signals. This provides a neuromorphic detection signal and enables the EGTs to be used as artificial sensory synapses. This talk will cover the PIII treatment of the polymer layers, device fabrication/characterisation and biosensing measurements from the EGTs.

11:20am **MB2-1-WeM-11 Tracking the Metal-Insulator Transition at $YTiO_3/LaTiO_3$ Interfaces Grown by the Soft Chemical Method**, ***Alexandre Simoes (zirpoli.simoes@unesp.br)***, UNESP, Brazil

In the last couple of years, perovskites and transition metal oxides have demonstrated high potential for energy storage/processing applications. Materials usually used in random access memory devices, such as perovskites and transition metal oxides (TMO), have shown potential to be applied in the fabrication of other types of nonvolatile memories. Correlated electron random access memories (CeRAMs) were recently developed for exhibiting partially filled *3d* bands in addition to showing resistive switching as a result of strong electronic correlations. It is worth mentioning that the band structure of related electronic materials depends not only on the d-orbitals of the transition metals, but also on the p-orbitals of neighboring oxygen atoms. In this work, oxide interfaces with piezoelectric, magnetic and metal-insulator transition based on $YTiO_3/LaTiO_3$heterostructured films were investigated. The Mott insulator, $YTiO_3$, was deposited onto a Mott insulator, $LaTiO_3$,via polymeric precursor method. Spin coating was performed to obtain a $YTiO_3/LaTiO_3$ heterostructured thin films deposited onto $Pt/TiO_2/SiO_2/Si$ substrates. Structure, morphology, and electrical properties of the films were assessed. The $YTiO_3/LaTiO_3$heterostructures exhibit ferromagnetic and piezoelectric behavior ($d_{33máx}$≈8.11 pm/V), which may be attributed to smaller grain (average grain size≈20.00 nm) and, thus, a higher grain boundary density, and stress in the film plane due to the different properties of the interface. The dielectric permittivity and dielectric loss at 1 KHz were found to be 70 and 0.41, respectively. *I-V* measurements on different electrode areas confirmed a metal-to-insulator transition, indicating a potential application in correlated electron random access memory (CeRAM).

11:40am **MB2-1-WeM-12 Adsorbing Chiral Molecules on High Entropy Iron Vanadate ($FeVO_3$) for Biomolecule Detection and Photoelectrochemical Cell Applications**, ***Amit Kumar Sharma (z11212022@ncku.edu.tw)***, *Y. Su,* National Cheng Kung University (NCKU), Taiwan

Chiral-induced spin selectivity (CISS) is at the forefront of photoelectrochemical water splitting and energy storage applications. CISS addresses the inhibition of hydrogen peroxide production by polarizing the spin of the ˙OH radical, thereby reducing the overpotential required by the photocatalyst to achieve high current density. This is achieved by conjugating chiral molecules with photocatalysts via self-assembly to induce electron spin selectivity from the electrolyte. Concurrently, numerous investigations have demonstrated the manipulation of spin polarization in metal oxides to foster spin selectivity and charge separation. However, such modifications are largely governed by the coordination structure and valence states of the transition metal. Additionally, the

conjugation of chiral molecules onto metal oxides encounters obstacles such as sensitivity to light exposure, high conductivity barrier, and inadequate active sites.

To address these challenges, we have fabricated high entropy iron vanadate metal oxide to serve a dual purpose as a biomolecular sensor and photoelectrochemical cell-based energy generator. High entropy oxides (HEO) have established their photocatalytic prowess in the UV regime of the light spectrum. To expand their applicability in visible light photocatalysis, HEOs should exhibit narrow bandgap, high electron-hole separation rate, low electron-hole recombination rate and an electronic band structure conducive to water splitting reaction.

In light of these studies, we investigate $FeVO_3$ nanosheets synthesized through solid-state reaction for enhanced near-infrared (NIR) absorption capability, magnetic property, and chromic response upon oxidation under prolonged exposure to visible light during photocatalysis. Furthermore, three enantiomers, viz. L- and D-arginine, L- and D-cysteine, L- and D-tryptophan, will be conjugated on the surface of the nanosheets to create a composite structure. The dual oxidation state of vanadium in $FeVO_3$, i.e. $VO^{2+}$ and $VO_2^{+}$, assists in NIR absorption and provides interaction sites for chiral molecules through surface defects. The chemical adsorption and CISS for $^{\bullet}OH$ radical will be assessed using circular dichroism (CD) and absorption spectroscopy. At the same time, the altered magnetic properties of the composite will be examined via magnetic force microscopy (MFM) and superconducting quantum interference device (SQUID). The selective binding affinity of the chiral amino acid towards the nanosheet will be assessed by optical and electrochemical measurements to differentiate between the L- and D- enantiomers. Appropriate composites will be selected rationally based on the visible to NIR absorption, reduced sensitivity to visible light, and photocurrent density in electrolytes.

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