Functional Thin Films and Surfaces
Room Palm 5-6 - Session MB2-1-MoM

Thin Films for Electronic Devices I

Moderators: Dr. Jiri Houska, University of West Bohemia, Czechia, **Spyros Kassavetis**, Aristotle University of Thessaloniki, Greece

10:40am **MB2-1-MoM-3 Impact of Zn Alloying to CsZnxPb1-xi3 Power Conversion Efficiency of Solar Cells**, ***Abdul Mannan Majeed [mannan.majeed@ff.vu.lt]***, Vilnius University, Lithuania

High-quality perovskite films are essential for developing efficient planar perovskite solar cells (PSCs). However, as-prepared perovskite films typically exhibit low crystallinity and high trap densities, leading to degraded performance in PSCs. Moreover, the challenge of creating low-toxicity, high-performance mixed Zn/Pb halide perovskite solar cells at a reduced cost remains a significant hurdle. To address this, zinc (Zn) was introduced as a cation substitute for the toxic lead (Pb) in the $CsZn_xPb_{1-x}I_3$ perovskite compound, leveraging its non-toxic nature, oxidation resistance, and earth abundance. This study investigates the structural and photovoltaic properties of Zn-alloyed Pb/Zn hybrid perovskite solar cells (PSCs). The results demonstrate that a 50% Zn-alloyed perovskite significantly enhances crystal quality, surface coverage, and grain size while reducing non-radiative recombination by increasing carrier lifetime. These improvements lead to a notable boost in photovoltaic performance. Specifically, the $CsZn_{0.5}Pb_{0.5}I_3$ compound achieved a power conversion efficiency (PCE) of 10.3%, with a fill factor (FF) of 53%, demonstrating the highest performance with minimal Pb content. Additionally, the device exhibited a V_{oc} of 0.99 V and an I_{sc} of 18.7 mA/cm^2. The performance of the $CsZn_{0.5}Pb_{0.5}I_3$ solar cell was found to vary with light intensity, showing changes in short-circuit current and open-circuit voltage. These findings open new avenues for further research into lead-reduced hybrid perovskite solar cells and offer valuable insights into the mechanisms underlying PCE degradation in practical devices, thereby contributing to the advancement of perovskite solar cell technology.

11:00am **MB2-1-MoM-4 Experimental Investigation of Thermal Conductivity During Aging of Nanoporous Sintered Silver Joints**, *Yann Billaud, Anas Sghuri, Didier Saury,* ***Xavier Milhet [xavier.milhet@ensma.fr]***, Institut Pprime - CNRS - ENSMA - Université de Poitiers, France

Silver (Ag) paste sintering is used as a die-bonding technology for the next generation of power electronic modules as Ag offers a high melting temperature as well as excellent thermal and electrical conductivities. Ag paste sintering is performed using specific conditions depending on the type of paste and the users'specifications (temperature, time, pressure), ending up in a porous joint. As a result, the properties of those joints are heavily influenced by their densities (i.e. porosity). Despite the numerous studies reported in the literature, the relationship between the density of the joint and its thermal conductivity remains an issue since access to the density of an embedded thin joint is very challenging. Furthermore, little is known on the evolution of the thermal conductivity in operating conditions. In this study, these issues were investigated by developing self-standing specimens with microstructures representative of those of real joints. In order to study a wide range of porosity, sintering was performed using a single time/temperature under various pressures. The thermal conductivity was measured using 3D flash method, consisting in applying a short non-uniform laser excitation on the surface of the sample, leading to three-dimensional heat transfer. The relationship between porosity and thermal conductivity is established for the as-sintered state and after aging up to 500h at temperatures ranging from 150 ◦C to 350 ◦C and is compared to existing models. The evolution of the thermal properties during thermal aging is discussed considering both the elaboration conditions and the microstructure evolution.

11:20am **MB2-1-MoM-5 Patterned Silver Nanowire Network for CdSe@CdZnS/ZnS Green Quantum Dot Light-Emitting Diodes**, *Chia-Yu Lin, Tzu-Hsu Wen,* ***Chun-Yuan Huang [cyhuang2004@gm.nttu.edu.tw]***, National Taitung University, Taiwan

Silver nanowire (AgNW) network possesses excellent conductivity and flexibility, making it an ideal material for electrodes of flexible optoelectronic devices. However, their high surface roughness can negatively impact device performance. To address this issue, the roughness of the patterned AgNW network electrode was reduced using a transparent photopolymer. To fabricate the patterned AgNW films, firstly, the polydimethylsiloxane (PDMS) substrates with proper size (18×18 mm^2)were covered with the stainless-steel shadow mask and then treated with UV ozone for 30 minutes. A 2 wt % AgNWs-ethanol solution was spin-coated, annealed, and then covered with UV-curable polyurethane (Norland Optical Adhesive 63, Edmund Optics). After UV curing, the composite of AgNW/polyurethane was then peeled off from the PDMS, allowing the AgNWs/polyurethane composite conductive film to adhere to the poly(ethylene terephthalate)(PET) substrate. Accordingly, with high transparency of 77% and low sheet resistance of 7~9 Ω/sq, the patterned AgNW network embedded in the polyurethane matrix was obtained for the subsequent fabrication of quantum dot light-emitting diodes (QLEDs). The electrode was applied as the anode in green CdSe/CdZnS/ZnS QLEDs. With the device structure of AgNW network/PEDOT:PSS/TFB/QD/MgZnO/Al, the QLED emitting pure green light centered at 536 nm resulted in a turn-on voltage of 2.4 V, a maximum brightness of 72,922 cd/m^2, and a current efficiency of 27.8 cd/A.

11:40am **MB2-1-MoM-6 Effects of Room Temperature Sputtered Nano-Interfaced WxMoyO₃ Nanograins on Highly Responsive NO Sensing**, ***Somdatta Singh [somdatta@ic.iitr.ac.in]***, Indian Institute of Technology Roorkee, India*; Ravikant Adalati,* University of Mons, Belgium, India*; Prachi Gurawal, Raman Devi,* Indian Institute of Technology Roorkee, India*; Gaurav Malik,* Jeonbuk National University, Republic of Korea, India*; Davinder Kaur, Ramesh Chandra,* Indian Institute of Technology Roorkee, India

This work demonstrates a heterostructure of monoclinic molybdenum trioxide (n-MoO_3) and tungsten trioxide (n-WO_3) with nano-interfaced (n-i@WxMoyO3) based NO gas sensing material. The nanocrystalline n-i@$W_xMo_yO_3$ thin film was coated using a single-step magnetron sputtering technique on an n-type (100) silicon substrate. Within the temperature range of approximately ambient temperature (50°C) to 350°C, this sensing material, $W_xMo_yO_3$ (where x = 0.71 and y = 0.29), detects NO gas and investigates the impact of crystal structure and nanointerfaces on sensing performance. A heterostructure composed of several materials can enhance the interaction between the gas molecules and the sensor surface by producing interfaces that promote charge transfer. With a response/recovery time of around 300 seconds/125 seconds at 300°C, the n-i@$W_xMo_yO_3$ has a low limit of detection (DL) of about 39 ppb and an excellent sensor response (SR = R_g/R_a) of about 44.15 for 50 ppm NO gas. Even at 50°C, the enhanced sensitivity of the sensing material with the nanointerface shows a strong affinity for NO molecules. It provides around 1.03 SR with response/recovery times of 53 and 71 seconds, respectively. The robustness of the n-i@$W_xMo_yO_3$ thin film sensor was established by its excellent selectivity (SR = ~44.15) and long-term stability (60 days) towards 50 ppm NO at 300°C. The remarkable sensing properties of MoO_3 functionalized WO_3 nanograins indicate an exciting potential for NO gas sensors that operate close to ambient temperature (50°C).

12:00pm **MB2-1-MoM-7 Study on the Effect of Different Oxygen Flow Rates on Vanadium-Doped Zinc Oxide Thin Film Piezoelectric Pressure Sensors**, ***CHENG HAN HSU [e204242271@gmail.com]***, National Cheng Kung University (NCKU), Taiwan

The piezoelectric effect is a phenomenon where certain materials generate an electric charge when subjected to mechanical stress.This property is widely utilized in sensors,and energy-harvesting devices because it converts mechanical energy into electrical energy.ZnO is a promising material for energy-harvesting devices due to its piezoelectric and semiconductor properties,along with good biocompatibility and low environmental impact.However,its relatively low piezoelectric coefficient (12.4 pC/N) limits its potential in these applications.To enhance the piezoelectric coefficient,vanadium was doped into ZnO thin films.Vanadium ions have a higher valence than zinc ions,which improves electric polarization and increases the piezoelectric coefficient.Additionally,V^{5+}ions,having a higher positive charge than V^{3+}ions,create stronger polarity,further boosting the piezoelectric properties.By adjusting the oxygen flow rate during the sputtering process,the V^{5+}content in the films is increased,enhancing the piezoelectric coefficient.In this study,we utilized an RF sputtering system with varying oxygen flow rates to prepare vanadium-doped zinc oxide thin films, which were then used to fabricate piezoelectric pressure sensor devices.The results show that as the oxygen flow rate increases,the grain shape of the thin films changes,and the grain size decreases. SEM reveal significant changes in the grain structure.XRD shows that the intensity of the 002 peak weakens as the oxygen flow rate increases,indicating structural changes in the thin films.XPS reveals that the content of pentavalent vanadium increases with higher oxygen flow rates, but decreases after reaching a critical value,which correlates with the trend observed in piezoelectric coefficient measurements.Further analysis of the O1s XPS shows that the lattice oxygen content in the films is higher than the surface adsorbed oxygen,with the lowest number of oxygen vacancies at a certain oxygen flow rate,which then increases as the oxygen flow rate rises.UV-visible spectra indicate that,due to the Burstein-Moss effect,the energy band structure of the thin films initially decreases and then increases with increasing oxygen flow rates.Finally,piezoelectric pressure sensors were fabricated from these thin films,and the stress sensitivity at different oxygen flow rates was measured.This study provides a comprehensive investigation of the structural,optical,piezoelectric properties of V-doped zinc oxide thin films at varying oxygen flow rates and explores their application as piezoelectric pressure sensors.The findings offer insights for optimizing thin film performancein piezoelectric sensing devices.

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