Topical Symposium on Sustainable Surface Engineering
Room Palm 5-6 - Session TS2-1-WeA

Coatings and Surfaces for Renewable Energy Technology I

Moderators: Arnaud Le Febvrier, Uppsala University, Sweden, **Marcus Hans**, RWTH Aachen University, Germany

2:00pm **TS2-1-WeA-1 Development of Cu, Ni-co-doped Bi2Te2.7Se0.3 for Thermoelectric Energy Generation Using Pulsed Laser Deposition**, ***Yakubu Wudil [yaqubswudil@gmail.com]**,* King Fahd University of Petroleum & Minerals, Saudi Arabia

This work reports the preparation of ternary Cu/Ni/Bi2Te2.7Se0.3 nanocomposite thin films via pulsed laser deposition. For comparison, pure Bi2Te2.7Se0.3 (BTS) and binary Cu/Bi2Te2.7Se0.3 and Ni/Bi2Te2.7Se0.3 nanocomposites were also synthesized. Morphological characterizations revealed the presence of abundant grains typical of the BTS sample. Energy-dispersive spectroscopy confirmed trace amounts of Cu and Ni within the films, while X-ray photoelectron spectroscopy indicated that both metals were present as unoxidized metallic atoms, free from telluride formation. Structural analyses using X-ray diffraction and Raman spectroscopy showed peaks consistent with the pure BTS structure, suggesting that the dopants were primarily located at the grain boundaries within the BTS matrix. The ternary nanocomposites were prepared using a specialized configuration at three different Cu/Ni concentrations. The highest room temperature thermoelectric figure of merit (ZT) of 0.97 was achieved at the optimal doping concentration (BTS-2Cu/Ni), attributed to a simultaneous increase in power factor (2988 $\mu W/mK^2$) and a decrease in thermal conductivity (0.93 W/mK). The enhanced thermoelectric power factor resulted from the selective filtering of low-energy charge carriers, which improved the Seebeck coefficient. Additionally, the introduction of Cu and Ni into the nanocomposites created abundant grain boundaries that scattered phonons, reducing intrinsic lattice thermal conductivity and thereby enhancing the ZT value.

2:20pm **TS2-1-WeA-2 Strain Engineering of ScN Thin Film by HiPIMS and Its Effect on Optical, Electrical and Thermoelectric Properties**, ***Arnaud le Febvrier [arnaud.lefebvrier@kemi.uu.se]**, Sanath Kumar Honnali,* Uppsala University, Angstrom Laboratory, Sweden*; Charlotte Poterie,* Universite de Poitiers-CNRS, France*; Tiago V. Fernandes, Robert Frost,* Uppsala University, Angstrom Laboratory, Sweden*; Vladyslav Rogoz,* Linköping University, Sweden*; Martin Magnuson,* Linkoping University, Sweden*; Fabien Giovannelli,* Université de Tours, France*; Joaquim P. Leitão,* Universidade de Aveiro, Portugal*; Jean Francois Barbot,* Universite de Poitiers-CNRS, France*; Per Eklund,* Uppsala University, Angstrom Laboratory, Sweden

Scandium nitride (ScN) is a cubic NaCl-structured, degenerated narrow-bandgap n-type semiconductor with an indirect bandgap of ∼0.9 eV and a direct band gap estimated at around 2.6 eV. It has remarkable semiconducting phonon-polariton application, electrical, thermoelectric and piezoelectric application. The physical properties of ScN nitride are sensitive to defects such as crystal defect, morphology, intentional or unintentional doping. In this work, the impact of strain on the electrical transport properties and optical properties has been investigated. For the purpose of reducing the deposition temperature of ScN, High power impulse magnetron sputtering (HIPIMS) technique was used to produce a series of film on c-sapphire in a 250-850 °C temperature range. The composition and overall crystal structure of the film remained relatively the same in the sample series while its optical and electrical properties were deteriorated upon temperature decrease. Using in depth XRD, optical and electrical characterization, the effect of strain and dislocation on the semiconductor properties of ScN was evaluated. A reduction of deposition temperature from 850 °C to 450 °C yield a slow degradation of the electrical, and optical properties to a drastic change for a film deposited below 450 °C. Below 450 °C, the films present a high dislocation density (10^{11} m^{-2}) along with a rhombohedral distortion of ScN cell (α: 90° → 88.6°) being the main cause of electrical transport deterioration (σ/10000; n/100, μ/100). The presence of dislocation / crystal defect in the film creates defect states near the valence and conduction bands which impact the electron density, hence their correlated electrical transport and thermoelectric properties. To the best the ScN shows promising thermoelectric properties and having an orange appearance when grown at high temperatures while behaving like a poor semiconductor with a black appearance when grown at low temperature.

2:40pm **TS2-1-WeA-3 1D & 2D Material-Based Electronic Devices for Energy Harvesting and Sustainable Technology**, ***Elisabetta Dimaggio [elisabetta.dimaggio@unipi.it]**,* University of Pisa, Italy **INVITED**

As we move toward a greener economy, sustainability must be at the core of any technological advancement. In a future filled with smart devices and driven by the Internet of Things (IoT), the design of integrated electronic circuits requires new approaches that target environmental friendliness, and renewable energy sources for power. Our efforts in this direction focus on harvesting energy from sustainable sources following standard Integrated circuits (IC) techniques. In the talk, innovative approaches for on-chip thermoelectric devices (TED) will be presented, exploiting silicon nanostructures as core components, and based on classic IC fabrication technologies[1,2]. The reason for using silicon nanostructures stems from their distinctive properties in terms of electrical conductivity and Seebeck coefficient, which can be tailored with technological solutions, and low thermal conductivity. Two strategies will be discussed. The first focuses on enhancing the Seebeck coefficient via the energy filtering effect, achieved by introducing multiple energy barriers, each tens of nanometers wide, through selective doping of silicon nanomembranes. The second involves the development of a prototype on-chip TED that integrates numerous silicon nanobeams into a compact device measuring only a few square millimeters. These devices can generate several milliwatts of power from hot surfaces, enabling low-power electronic systems, such as sensor nodes, to operate in a battery-less mode.

[1] E.Dimaggio, A.Masci, A. De Seta, M.Salleras, L.Fonseca, G.Pennelli, *On-chip Thermoelectric Devices Based on Standard Silicon Processing*, **Small** 2405411, 2024

[2] A.Masci, E.Dimaggio, N.Neophytou, D.Narducci, G.Pennelli, *Large Increase of the Thermoelectric Power Factor in Multi-barrier Nanodevices*, **Nano Energy** 132, 110391, 2024

3:20pm **TS2-1-WeA-5 Harnessing the mechanical and magnetic energy with PMN-PT/Ni-Mn-In-based flexible piezoelectric nanogenerator**, ***Satyam Shankhdhar [satyam_s1@ph.iitr.ac.in]**,* Indian Institute of Technology Roorkee (IIT R), India

Multifunctional piezoelectric nanogenerators (PENG) hold significant potential in developing smart sensing technologies for the military, healthcare, and industrial sectors. Here, we present the efficient energy harvesting from mechanical and magnetic stimuli in 0.67Pb $(Mg_{1/3}Nb_{2/3})O_3$-0.33$PbTiO_3$ (PMN-PT) / $Ni_{50}Mn_{35}In_{15}$ (Ni-Mn-In)-based PENG fabricated on a flexible nickel substrate using the DC/RF magnetron sputtering technique. The performance of the device has been assessed by imparting forces in the range of 0.12 to 0.61 N using various weights, finger tapping, bending, and magnetic fields. The device generates the maximum open circuit voltage (V_{oc}) of 9.3 V and 6 V with 0.61 N of force and finger tapping, respectively. The corresponding short circuit current (I_{sc}) has been obtained as 1.33 μA (0.61 N) and 0.9 μA (finger tapping). The device shows a maximum V_{oc} of 10.6 V and I_{sc} of 1.51 μA at the bending angle of 120°. Furthermore, the V_{oc} and I_{sc} have increased from 0 mV and 0 nA to 240 mV and 35 nA under the presence of 0 Oe to 500 Oe of DC magnetic field, respectively. The fabricated device exhibited a power density of 2.7 $\mu W/cm^2$ with a high mechanical stability of 2500 cycles. Additionally, LEDs of green, red, yellow, and white colour have been illuminated. The receptiveness of the fabricated PENG towards mechanical and magnetic stimuli highlights its potential in areas such as tactile sensing, wearable electronics, human-machine interfaces, and biomedical devices

3:40pm **TS2-1-WeA-6 High Power Impulse Magnetron Sputtering of CoCrFeNiV High Entropy Alloy Thin Films for Enhanced Supercapacitor Applications**, ***KRISHNAKANT TIWARI [KRISHHH0901@GMAIL.COM]**,* Ming Chi University of Technology, Taiwan*; BIH SHOW LOU,* Chang Gung University, Taoyuan, Taiwan*; JYH-WEI LEE,* Ming Chi University of Technology, Taiwan

In this study, CoCrFeNiV high entropy alloy (HEA) thin films were successfully deposited on nickel foam substrates using a high power impulse magnetron sputtering (HiPIMS) system for application as advanced electrode materials in supercapacitors. The use of HiPIMS enabled precise control over film composition and enhanced adatom mobility, promoting uniform growth and strong adhesion of the HEA coating on the porous Ni foam surface. Comprehensive materials characterization, including morphological, structural, and compositional analyses, was conducted to understand the evolution of film microstructure during deposition and the elemental distribution across the coating. The electrochemical performance was systematically evaluated through cyclic voltammetry, galvanostatic charge–discharge, and electrochemical impedance spectroscopy. The

CoCrFeNiV HEA electrode exhibited a remarkably high specific capacitance and excellent rate capability, demonstrating superior energy storage characteristics. Furthermore, long-term cyclic stability tests confirmed outstanding charge–discharge durability, highlighting the potential of HiPIMS-deposited CoCrFeNiV HEA thin films as promising electrode materials for next-generation high-performance supercapacitors.

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