Tuesday Afternoon, November 5, 2024

MEMS and NEMS
Room 125 - Session MN2-TuA
MEMS Sensing and Computation

Moderators: Matthew Jordan, Sandia National Laboratories, **Yanan Wang**, University of Nebraska-Lincoln

4:00pm **MN2-TuA-8 Development of an in-Situ Helium Purity Sensor for Cryopump Contamination Detection**, ***Peter Moran***, *N. Kozomora, M. Salvetti,* Edwards Vacuum, LLC.

This paper presents a novel approach to assessing the purity of helium streams in cryogenic pump applications, a critical factor in ensuring optimal performance and longevity of the system. Leveraging the unique properties of Micro-Electro-Mechanical Systems (MEMS) Thermal Conductivity Detectors (TCDs), the development and implementation of an in-situ helium purity sensor will be discussed.

The importance of helium stream purity in cryogenic pump applications cannot be overstated. Contaminants in the helium stream can lead to significant performance degradation, and in severe cases, can cause system failure. Therefore, the ability to detect and quantify these contaminants in real-time is of paramount importance.

The presented solution utilizes a MEMS TCD, capitalizing on the significant difference in thermal conductivity between helium and potential contaminants. This allows for excellent detection capabilities, achieving a limit of detection of less than 35ppm and a limit of quantification of less than 50ppm. This level of sensitivity enables contamination detection before any noticeable impact on cryocooler performance.

The integration of the TCD sensor with pressure and temperature measurements allows for accurate contamination quantification, even in the presence of system fluctuations. The low-cost and compact nature of MEMS technology make it an ideal solution for this application, providing a cost-effective, efficient, and robust method for maintaining helium stream purity in cryogenic pump systems.

4:15pm **MN2-TuA-9 Facile Fabrication of CuO/ZnO Heterojunctions from Sputtered Films UV Sensing**, *P. Pathak,* ***Mohammadreza Chimehrad***, *P. Borjian, H. Cho,* University of Central Florida

UV sensors are highly demanded for environmental monitoring, healthcare, and manufacturing, where understanding UV radiation's impacts is essential. Despite the prevalence of silicon-based photodetectors, their reliance on external power and broad absorption spectra are significant drawbacks. Addressing these challenges, we present a novel low-cost wet chemical method for constructing CuO/ZnO heterojunctions from sputtered thin films. This technique simplifies the traditional complex fabrication processes by using a one-step oxidation of DC-sputtered zinc and copper films on ITO-coated glass slides, resulting in the formation of p-type CuO nanowires and n-type ZnO nanoparticles that create a self-powered p-n junction. The morphological and chemical properties of the fabricated heterojunctions were meticulously analyzed using Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD), and X-ray Photoelectron Spectroscopy (XPS). These analyses confirmed the successful creation of heterojunctions, which are critical for the desired sensor functionality. The optical properties were evaluated through UV-visible spectroscopy, demonstrating a strong absorption in the UV range, which is essential for UV sensing applications. Photonic responses based on current-voltage (I-V) relationships under a 365 nm laser were examined. The fabricated sensing device exhibited excellent photovoltaic behavior with a significant increase in current under illumination compared to dark conditions, showcasing an ideal p-n junction behavior with impressive responsivity (0.108 A/W) and photosensitivity (114). These characteristics indicate an efficient separation of photo-generated charge carriers at the junction which facilitates a strong and stable photoresponse without the necessity for an external power source. This work not only pioneers a simplified approach to heterojunction fabrication but also positions the resultant UV sensors as a good candidate for sustainable, low-power applications. The development presents significant advancements over traditional multi-step and high-temperature processes, offering a promising avenue for the scalable, low-temperature production of efficient UV sensors out of sputtered films

4:30pm **MN2-TuA-10 Diamagnetically Levitating Graphite Plate Resonators**, *Y. Wang, S. Yousuf,* University of Florida*;* ***Jaesung Lee***, University of Central Florida*; P. Feng,* University of Florida

Diamagnetically levitated and trapped systems hold great promise for developing high-performance anchor-less resonant devices with excellent stability. This scheme generates sufficiently large levitation force via diamagnetism, effectively counteracting gravity and facilitating levitation at room temperature without external power. Also, they are mechanically isolated from the external environments, enabling outstanding stability and minimal energy dissipation.

In this work, we combine theoretical analysis with experimental investigations to explore the complete levitation and rigid body resonances of diamagnetically levitating millimeter-scale graphite plates. Leveraging the strong diamagnetic susceptibility of graphite, we employ a square graphite plate (length of L=2.5mm, thickness of t=0.5mm, and mass of m=7mg), which exhibits stable levitation above permanent magnets without requiring active control. The resonance motions of the levitating graphite device are excited by electrostatic or dielectric gradient forces and detected by using an ultrasensitive optical interferometry system. We observed two distinct rigid body resonance motions at frequencies of f_1=37.7Hz and f_2=49.1Hz with quality (Q) factors of Q_1=48 and Q_2=37 in atmospheric pressure at room temperature. Notably, we find that the Q factors are primarily compromised by air damping.

Our initial study represents a significant step toward developing stabilized levitating systems at room temperature with a large mass. Furthermore, the findings presented here shall contribute to building high-performance resonant sensors.

4:45pm **MN2-TuA-11 A Novel MEMS Reservoir Computing Approach for Classifying Human Acceleration Activity Signal**, *F. Alsaleem,* ***Mohammad Okour***, *M. Megdadi, A. Al Zubi, M. Fayad,* University of Nebraska - Lincoln

Neuromorphic computing, drawing inspiration from the human brain, harnesses specialized hardware and software to mimic intricate information processing. A pivotal component within this domain is the Micro-Electro-Mechanical Systems (MEMS). This paper marks a pioneering effort by introducing a groundbreaking MEMS reservoir computing model that departs from conventional virtual node concepts. This novel approach couples multiple MEMS systems to create dynamic and high-dimensional responses. The primary objective of our study is to distinguish between walking and running signals based on acceleration measurements. Our research advances the boundaries of reservoir computing and MEMS applications and marks an important milestone in signal processing analysis and classification. In this paper, we achieved a remarkable classification accuracy of 96%, demonstrating the practical potential of this technology across various applications in wearable technology and beyond.

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