Thin Films and Surface Modification
Room Naupaka Salon 5 - Session TF1-TuE

Thin Films - Bio- and Medical-related
Moderator: Seo-Hyun Lee, Hanyang University

5:40pm **TF1-TuE-1 Advanced Surface Engineering for Mass-Produced Medical Diagnostic Technology Addressing Tomorrow's Global Public Health Challenges***, **Christopher Muratore**, Ben Robertson, Melani K. Muratore,* University of Dayton*; Nick R. Glavin,* Air Force Research Laboratory **INVITED**

Materials with high surface-to-volume ratios demonstrate exquisite sensitivity and detection limits in diverse molecular sensing applications.Integration of nanowires, nanotubes, and two-dimensional (2D) semiconductors into sensing devices, however, presents challenges inhibiting product development.For example, thousands of trials are required to obtain US government approval for point of care diagnostics, yet producing a suitable number of 2D devices via conventional synthesis and fabrication techniques to meet this testing requirement is not currently feasible. To realize commercial applications of 2D transducers in ubiquitous low-cost diagnostic devices, new synthesis and fabrication approaches were developed. Processes for high-rate (>10^6 per day) mass-production of low-cost two-dimensional electronic medical diagnostic devices with limits of detection rivalling polymerase chain reaction (PCR) based techniques (<10 fg/mL) with response times of <2 minutes will be presented. Rapid and inexpensive sensor chip fabrication relies upon sputter deposition, laser pattering, and laser annealing processes in a roll-to-roll physical vapor deposition system. Moreover, naturally abundant and recyclable materials were selected for use in these scaled processes for reduced waste stream impact in anticipation of large numbers of devices are consumed daily.An automated high-speed Raman spectroscopy system was developed for quality control of mass-produced materials during fabrication.Fundamental studies employing this system to measure point defect densities in 2D semiconducting transducer materials will be shown to correlate synthesis and fabrication process parameters, 2D materials structure, and diagnostic device performance.

6:20pm **TF1-TuE-3 Development of Stretchable Plasma Patch using Kirigami Technique for Biomedical Applications***, **Sunghoon Jung**, Jian Kim,* Korea Institute of Materials Science, Republic of Korea

Plasma technology has recently been widely utilized in the biomedical field. Reactive oxygen and nitrogen species generated by plasma have been increasingly reported to sterilize pathogens and improve skin conditions. Traditional biomedical plasma devices include jet-type plasma sources and flexible patch-type plasmas. However, jet-type plasma is not suitable for large-area skin applications, and flexible plasma patches are not ideal for use on the stretchable surfaces of the human body. In this study, we employed the kirigami technique to impart stretchability to the existing plasma patch structure and applied it to pathogen removal.

The primary objective of this research is to develop plasma patches that naturally create discharge spaces and possess mechanical stretchability through the kirigami technique. This allows for effective plasma discharge and ozone generation without the need for additional spacers, even when deformed.

Plasma patches with 30%, 50%, and 100% stretchability were fabricated using screen printing and laser cutting technique. The discharge characteristics and ozone generation properties were evaluated in both non-attached states (large discharge space), where the patches were suspended in open space, and attached states(very small discharge space), simulating skin attachment.

In the non-attached state, where the patches were suspended in open space, the kirigami patches exhibited similar discharge characteristics to non-stretchable patches. However, when attached to a substrate, non-stretchable patches failed to generate plasma due to the lack of discharge space. In contrast, the kirigami patches, when stretched, caused the electrodes to rotate diagonally, creating discharge spaces and enabling plasma generation. This demonstrates that kirigami patches can achieve effective plasma discharge without additional spacers. Furthermore, antibacterial experiments confirmed the efficacy of the patches in eliminating Escherichia coli and Staphylococcus aureus.

The kirigami-based stretchable plasma patches offer significant advantages for biomedical applications, particularly in skin treatments. The ability to generate plasma without the need for additional spacers and the successful elimination of bacteria highlight the high potential of these patches. Future work will focus on optimizing the design and exploring further biomedical applications.

6:40pm **TF1-TuE-4 Silver-Copper Coatings: Combating Microbes on Surfaces and in Air Filtration***, Lorena Reyes-Carmona,* UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO, CU, Mexico*; Velia Mariana Perez-Bucio, Argelia Almaguer-Flores,* UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO*; Omar Sepulveda-Robles,* Instituto Mexicano del Seguro Social, Mexico*; **Sandra E Rodil**,* UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO **INVITED**

The significant risk posed to healthcare workers by the transmission of bacteria and respiratory viruses through expelled saliva microdroplets and aerosols, underscored by the SARS-CoV-2 pandemic, has driven researchers to develop nanomaterials with antimicrobial properties for respiratory protection equipment like facemasks, respirators, and air filtration systems. Beyond medical doctors, odontologists are continually exposed to bioaerosols that may contain viruses or bacteria. This study introduces SakCu®, a silver and copper nanolayer applied to one side of spun-bond polypropylene fabric using the magnetron sputtering technique. The antibacterial and antiviral properties of the AgCu nanolayer were tested against droplets landing on the material and aerosols passing through it.

The effectiveness of the nanolayer was rigorously assessed through viability assays using respiratory surrogate viruses, ssRNA Leviviridae, and ssDNA Microviridae as representatives of non-enveloped viruses. Colony-forming unit (CFU) determinations were used to evaluate the survival of four aerobic and four anaerobic bacteria, as well as multiple species present in subgingival biofilm samples taken from patients with periodontitis.

Viability assays with surrogate viruses showed significant reductions in viral replication within 2-4 hours of contact. A simulated viral filtration system demonstrated inhibition of viral replication ranging from 39% to 64%. PhiX174 viability assays showed a 2-log reduction in viral replication after 24 hours of contact and a 16.31% inhibition in viral filtration assays. Bacterial growth inhibition varied by species, with reductions ranging from 70% to 92% for aerobic bacteria and over 90% for anaerobic strains. Regarding the viability of microorganisms from the subgingival biofilm samples, a 57.8 ± 9.7% reduction was observed when the samples were in contact with the AgCu nanolayer.

In conclusion, the AgCu nanolayer demonstrated robust bactericidal and antiviral activity under both contact and aerosol conditions. These findings suggest that the nanolayer has significant potential for incorporation into personal protective equipment, effectively reducing and preventing the transmission of aerosol-borne pathogenic bacteria and respiratory viruses in real-world settings.

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