Department of Biomedical Engineering
UNIVERSITY OF WISCONSIN–MADISON

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Integrated Plasmonic Biosensors: From Critical Care Medicine to Airborne Virus Monitoring

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Nanoparticle-based plasmonic biosensors are label-free, robust, rapid, cost-effective, and easy to integrate into miniaturized fluidic microsystems. These advantageous features make plasmonic biosensors promising candidates for point-of-care testing (POCT) of diseases. However, many of these sensors still fall short of satisfying both the speed and sensitivity required for timely diagnosing and intervening life-threatening critical illnesses resulting from severe infection, trauma, surgery, and immunotherapy side effects. This talk presents recent advances of miniaturized integrated nanomaterial-based biosensors enabling high-performance on-chip plasmonic optoelectronic assay of protein biomarkers by my research group and collaborators. The unique biosensing scheme used for the intergraded biosensors device employs (i) biologically tuned nanoplasmonic light absorbance resonance shifts and (ii) high-responsivity, high-quantum efficiency photoelectronic conversion by two-dimensional atomically layered semiconducting transition metal dichalcogenide (TMDC) (e.g, MoS2) nanosheet channels. Using the biosensors, my group demonstrated multi-time-point monitoring of the profiles of circulating sepsis biomarkers in serum in a rapid (< 20 min), sensitive (< 50 fM), sample-sparing (< 10 L) manner. The biosensors have recently been adapted for a homogeneous plasmonic colorimetric assay based on analyte-controlled plasmonic probe aggregation/assembly with a multilayer MoS2 channel. The near-infrared (NIR) operation of the biosensors at = 650 nm provides highly sensitive wash-free "mix-and-detection" quantification of a protein cancer biomarker, carcinoembryonic antigen (CEA), with an ultralow limit of detection (< 1 fM) and a 6-log linear dynamic detection range while suppressing the background optical interferences of unprocessed physiological fluids, such as human whole blood (WB), urine, and saliva. The biosensor technology has the potential to be translated into well-regulated immune therapy. Additionally, this talk will present the implementation of the integrated plasmonic biosensors for airborne virus particle detection in the context of future ride share settings, where autonomous automobiles will shared by a number of unknown riders. Our airborne virus detection system could also be used for non-invasive rapid COVID breath testing and for continuous biological aerosol monitoring in laboratories, classrooms, and other public spaces.

Katsuo Kurabayashi is a Professor of Mechanical Engineering and Electrical Engineering and Computer Science at the University of Michigan, Ann Arbor. He received a B.S. in Precision Engineering from the University of Tokyo, Japan, in 1992, and a M.S. and Ph.D. in Materials Science and Engineering from Stanford University, CA, in 1994 and 1998, respectively. His current research focuses on optofluidics, nanoplasmonic and biomolecular biosensing, and BioMEMS/microsystems for immunoassay, clinical diagnosis, single-cell study, and analytical chemistry. He has authored and co-authored 180 peer-reviewed papers and holds 11 U.S. patents. He received a 2001 NSF Early Faculty Career Development (CAREER) Award, and the Robert Caddell Memorial Award in 2005, the Pi Tau Sigma Outstanding Professor Award in 2007, the University of Michigan Mechanical Engineering Outstanding Achievement Award in 2013, the Ted Kennedy Award in 2015, and the Wise-Najafi Prize for Engineering Excellence in the Miniature World in 2019 from the College of Engineering at the University of Michigan. He is also a Fellow of the Royal Society of Chemistry (RSC) and the American Society of Mechanical Engineering (ASME).

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1003 Engineering Centers Building (Tong Auditorium)