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Miniaturized Biosensors for Healthcare

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Miniaturized biosensors that can measure ions and biomolecules in real time with high sensitivity and resolution have the potential to bring about transformative advances in healthcare. This talk focuses on electronic biosensing devices for continuous monitoring and early medical diagnostic applications. Recently, we proposed and demonstrated biosensors with novel transducer device and reference electrode components. These innovations resulted in significant improvements in sensitivity and resolution, in comparison to literature data.^{1,2} Furthermore, the proposed sensors have an inherently simpler one-point calibration procedure, and therefore are a superior option for mobile applications such as wearables, where continuous monitoring is required with minimal human intervention. Unlike existing biosensors, these new sensors can continuously measure analytes from both aqueous solutions and solid mediums (e.g., tissue, slurries) over extended time periods, and are well suited for implantable and ingestible sensing applications. Results for these new BJT sensors and examples^{1,3,4} of their applications will be discussed.

Measurement of biomolecules at ultra-low concentrations is another important sensing area for applications in early disease diagnosis. For over a decade, nanowire field effect transistor (FET) sensors have been extensively investigated for this application. Despite their promise, there has been limited success in commercializing them. In this talk, results for highly optimized silicon nanowire FET biosensors will be presented.⁵ These optimized biosensors are shown to address nanofabrication issues that have hindered their commercial applications. Challenges associated with nanofabrication and sensing surface functionalization, and approaches for resolving them will be discussed. This research has been successfully licensed to a medical diagnostic company (NanoDx Inc.) for commercialization rights.

Lastly, applications of these biosensors to other areas such as sustainable agriculture will be discussed. The presentation is concluded with a discussion on challenges and opportunities related to biosensor research.

References: [1] Sufi Zafar et al, Scientific Reports-Nature Publishing Group, 2017. [2] Sufi Zafar, et al, Applied Physics Lett., 2015. [3] Payel Das and Sufi Zafar, ACS Nano, 2015. [4] Y. Xiong et. al, ACS Nano, 2020. [5] Sufi Zafar et al, ACS Nano, 2018.