Developing a Novel Flexible MoS2 Biosensor to Detect Lower-Concentrated Area of Biological Molecules at the Femtomolar Level

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Flexible and ultrasensitive nanoelectronic biosensors have many potential applications in biomedical engineering, including saliva-based in-vivo sensors and real-time sweat sensors on bare skin. To fabricate flexible electronic devices with good reliability, we require the development of novel nano-fabrication methods that can integrate two-dimensional layered transition metal dichalcogenide (TMDC) materials onto the flexible substrates with various strain and stress limitations. In this project, a flexible, ultrasensitive MoS2-based biosensor is reported for the first time. A layered MoS2 flakes serves as the conductance channel material on a pliable polyimide substrate. A few layers of MoS2 with a thickness of about 5 nm were mechanically transferred onto flexible polyimide film. Photolithography was then used in conjunction with gold metal deposition and lift-off process to form the channel and electrodes. A flexible MoS2-based biosensor with a channel width of about 7 micrometers has been successfully fabricated using this process. This biosensor was tested using two different biomolecules of streptavidin and interleukin-1beta with low concentrations. I demonstrated that the flexible MoS2-based biosensor can quantify the time-dependent reaction kinetics of streptavidin-biotin binding. Additionally, this device exhibited an interleukin 1-beta (IL-1β) detection limit as low as 50 fM, which is about 10,000 times lower than the detection limits for the current gold-standard detection method called the enzyme-linked immunosorbent assay (ELISA). This is the first successful demonstration of a flexible MoS2-based biosensor capable of detecting low-abundant biomarkers at femtomolar concentrations.

Awards Won:

Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Intel ISEF Category