Ultrasensitive Rapid Cytokine Sensors Based on Asymmetric Geometry MoS_2 Diodes

Mirette Fawzy, Thushani De Silva, Michael M. Adachi, Karen L. Kavanagh
Simon Fraser University, Burnaby, Canada
mfawzy@sfu.ca

Cytokines are small immune system signaling proteins found in body fluids such as blood, saliva, and sweat, that are considered as biomarkers for numerous health conditions and diseases. An abnormal variation in cytokine concentrations is an indicator of uncontrolled inflammatory reactions that has been associated with diseases such as cancer, diabetes, and Alzheimer's. Most diseases, particularly cancers, can often be cured if they are detected at an early stage. Thus, the ability to monitor and detect a slight change in cytokine levels is of great significance for early clinical diagnosis.
In our recently published work [1], we reported the development of biosensors based on asymmetric MoS_2 diodes for rapid, label-free, highly sensitive and specific detection of tumor nercosis factor-α (TNF-α), a representative inflammatory cytokine biomarker.
Our biosensors employ mechanically exfoliated multilayer MoS_2 flakes with asymmetric geometry as the sensing channel, and aptamers (short single-stranded nucleic segments) as the bioreceptors. The sensing area is passivated with a thin aluminum oxide layer (around 5 nm) using atomic layer deposition technique (ALD) to provide available sites for facile functionalization with bioreceptors. Interactions between the immobilized aptamers and TNF-α at the sensor surface induce a change in surface energy that alters the current-voltage rectification behavior of the MoS_2 diode, which can be read out using a two-electrode configuration.
The key advantages of this diode sensor are the simple fabrication process and electrical readout, and therefore, the potential to be applied in a rapid and easy-to-use, point-of-care, diagnostic tool.

References

[1] De Silva, T., Fawzy, M**.,** Hasani, A., Ghanbari, H., Abnavi, A., Askar, A., Ling, Y., Mohammadzadeh, M.R., Kabir, F., Ahmadi, R., Rosin, M., Kavanagh, K.L., and Adachi, M.M. "Ultrasensitive Rapid Cytokine Sensors Based on Asymmetric Geometry Two-Dimensional MoS_2 Diodes". *Nature Communications* **13**, 7593 (2022).

Figures

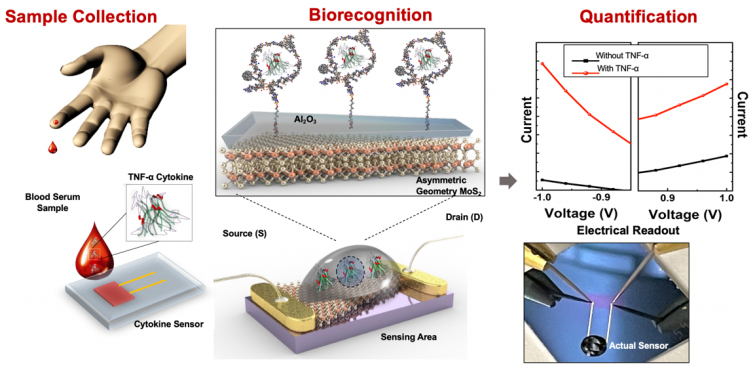

Figure 1: A schematic illustration of the concept of the cytokine sensor operation.