New sensing paradigms based on 2D materials and machine learning-enhanced optical probes

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Biomolecular sensing techniques with high multiplexity, high specificity, and rapid detection are central to a variety of fields including accurate surveillance of infectious diseases and early diagnosis of neurodegenerative disorders. The realization of such sensing techniques requires fingerprinting signals from biomolecules, and a sensor material to efficiently interact with biomolecules. This talk introduces pioneering discoveries and novel approaches to fulfill these two requirements. I will introduce a new biosensing mechanism, Raman enhancement through 2D materials, an enhancement effect of molecular Raman fingerprints on the atomically-flat 2D material surfaces. It offers a new paradigm of biochemical sensing with high specificity, high multiplexity, and low noise. The selection rule for the 2D material substrates has been revealed, which is critical for device design. Two sensing applications for Alzheimer's disease and respiratory viruses will be discussed, where machine learning was further applied for new knowledge discovery. The works presented in this talk resolved several critical challenges of high multiplexity, high specificity biosensing. They offer important guidelines to design high-performance biosensing devices using quantum materials, and are significant in fundamental material science and quantum science. The methodologies used here also provide a framework for a wide range of biosensing needs.