Addressing the Molecular Selectivity Challenges in MEMS Chemical and Biological Sensors

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MEMS sensor platform offers many advantages such as unprecedented sensitivity for multi-analyte detection, miniature size, and low power consumption. However, despite all of these advantages, MEMS chemical and biological sensors still remain just a laboratory tool without any commercial success. Poor molecular selectivity, especially for small molecules, pose formidable challenges in translating this highly sensitive sensor platform into a commercial reality. Commonly used approach obtaining molecular selectivity using immobilized receptors and chemical interfaces often leads unacceptable rates of false positives. The very low thermal mass of a microfabricated cantilever sensor offers an exciting opportunity for overcoming the selectivity challenge by integrating opto-calorimetric approach. This mechanical calorimetry, which combines the molecular selectivity of infrared spectroscopy with the very high thermal sensitivity of a bi-material cantilever, overcomes the molecular selectivity challenges encountered in MEMS. Calorimetric spectroscopic data can be collected simultaneously with molecular-adsorption induced shifts in resonance frequency and cantilever bending using array sensors. For liquid analytes, we have fabricated cantilevers as hollow channels for confining the samples for multi-modal detection. Analyzing the multi-modal data using deep learning techniques provides enhanced molecular selectivity and reliability in MEMS chemical and biological sensors. Our recent results show that this approach can selectively identify molecules even in the presence of interfering compounds in complex environments. This lecture will include details of integrating multi-modal, multi-physics approach for obtaining enhancing molecular selectivity, sensitivity, and reliability in MEMS sensors.