

Integrated Thermomechanical Systems for Chemical and Biological Sensing

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Micromechanical sensors have attracted considerable attention over the last decade because of their potential as a highly sensitive sensor platform for high-throughput, multiplexed, label-free detection of chemicals. Although micromechanical sensors enable chemical sensing with unprecedented sensitivity using variations in mass and stress, obtaining chemical selectivity still remains as a crucial challenge. Chemoselectivity in small molecule detection using immobilized selective layers that rely on weak chemical interactions provides only partial selectivity. This is mainly because of the generality of the weak chemical interactions that form the basis for reversible detection. However, the extremely small thermal mass of the sensor allows the use of higher energy chemical interactions and regeneration by thermal cycling. The low thermal mass also allows measurement of thermomechanical signals for obtaining chemical selectivity. The thermomechanical phenomena produce unique responses that can be used for analyte specific detection without losing sensitivity or reversibility. Broadly, the thermomechanical effects include thermal behavior of adsorbed molecules as well as photothermal and photoacoustic effects. Controlled heating of the micromechanical sensors with adsorbed molecules can produce unique, adsorbate specific mechanical and thermal responses for achieving very high specificity. It is also possible to achieve chemical selectivity by exposing the adsorbate-covered micromechanical structures to optical excitation. Such exposure of micromechanical structures to tunable optical wavelengths results in photothermal and photoacoustic responses. These thermomechanical techniques have the advantage of obtaining signal from picogram quantities of adsorbed analytes. The sensitivity of detection could be further improved by geometrical optimization of the micromechanical device. I will discuss various thermomechanical techniques as well as signal transduction techniques. I will also present recent results of thermomechanical detection of chemicals, explosives, and biomolecules.

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