A Porous Silicon Optical Nanosensor for the Detection of Volatile Organic Compounds

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Recent news of the use of nerve agents in terrorist attacks poses an immediate concern to international security. In addition, Volatile Organic Compounds (VOCs) diminish indoor air quality and can contribute to the formation of smog. Thus, developing field chemical detection methods is a priority, with applications in border protection and environmental monitoring. This research aims to utilize the optical properties of a porous silicon (pSi) rugate filter to develop a low-cost, real-time sensor for a broad range of VOCs. pSi optical rugate filters were electrochemically fabricated and functionalized for stability. A broad range of VOCs were cycled through a flow chamber, undergoing microcapillary condensation in the pores and changing the composite refractive index. A CCD spectrometer continuously monitored for changes in the reflected stopband of the sensor to identify the compounds by their unique spectral shifts. Surface functionalization produced a high hydrophobicity and a stable stopband in varying thermal and alkaline conditions. The VOC sensing for both pure and complex mixtures produced real-time, predictable stopband shifts with a mean precision of 0.05 nm for pure VOCs and 1.0 nm for complex mixtures and a threshold detection concentration of 1.0 ppm. With state-of-the-art accuracy, high reusability, quick response and recovery, and an estimated cost less than $100, this portable sensor is viable in chemical detection systems for real-time air quality monitoring and forensic analysis. Future work includes introducing multiparametric dimensions, such as electrical signals, for increased specificity, as well as integrating the sensors with a smartphone camera.

Awards Won:

Second Award of $1,500