ZIF-coupled Resonant Sensors

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We present a novel method for fabrication of resonant sensors using dielectrophoretic assembly of zeolitic imidazolate frameworks (ZIFs) onto microscale resonant sensors for highly sensitive and selective gas detection. ZIFs are part of a recently invented class of materials and are constructed from transition metals bridged by imidazolate. ZIFs have attracted wide attention for their tailorable nanoporosity and functionalized cavities for various sensing methodologies, such as detecting changes of impedance, refractive index and strain [1-2]. Other research has independently investigated the potential for sensitivity enhancement with porous material coatings on resonant sensors [3]. This work marks the *first demonstration of resonant sensors using ZIFs*, which is noteworthy because ZIFs have *2.8 times* more surface area than any material previously used for resonant sensing. Also, ZIFs hold the potential for *selective* absorption of gases based on their tailorable nanoporosity.

ZIFs were assembled onto the surface of resonators through dielectrophoresis (DEP). To achieve assembly, first ever measurements were performed of the Clausius-Mosotti factor for the nanoparticles of interest, ZIF-69 [4]. After DEP assembly of ZIFs, the resonant sensors were tested in the presence of Isopropyl alcohol (IPA) and CO_2. The ZIF-coupled resonators demonstrated sensitivity improvement up to 150 times over a bare silicon resonator with identical dimensions. Perhaps more importantly, real-time absorption measurements of ZIFs revealed different absorption time constants for IPA and CO_2 (figure 2). The distinguishable absorption time constants provide the possibility of inherent selectivity for these resonant-based sensors. This presentation will include latest measurements results along with discussions of the prospects and open challenges for resonant sensing.

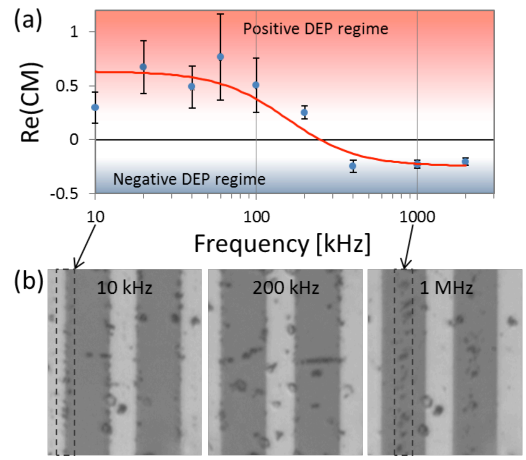

Figure 1. (a) Real part of the Clausius-Mosotti factor for ZIF-69. (b) Particle assembly with positive (10 kHz) and negative (1 MHz) DEP (c) Picture of resonator with assembled ZIFs

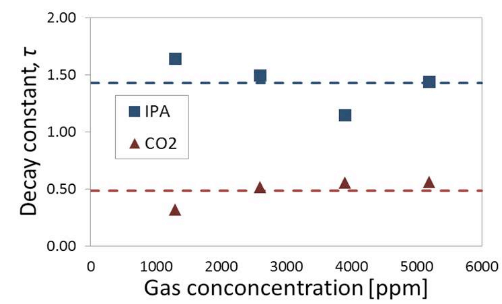

Figure 2. Absorption time constants for Isopropoyl alcohol (IPA) and CO_2 are 1.43±0.28 s and 0.49±0.17 s, respectively, demonstrating the potential to discern different gases based on absorption time

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[2] S. Achmann*, et al.*,"Metal-Organic Frameworks for Sensing Applications in the Gas Phase," *Sensors,* vol. 9, pp. 1574-1589, 2009.

[3] P. C. Xu*, et al.*,"Functionalized Mesoporous Silica for Microgravimetric Sensing of Trace Chemical Vapors," *Anal Chem,* vol. 83, pp. 3448-3454, 2011.

[4] Y. Hwang, H. Sohn, A. Phan, O. M. Yaghi, R. N. Candler, “Dielectrophoresis-Assembled Zeolitic Imidazolate Framework Nanoparticle-Coupled Resonators for Highly Sensitive and Selective Gas Detection,” Nanoletters, 13 (11), pp. 5271-5276, 2013