Optical detection of VOCs using metal-organic framework decorated metasurfaces

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Metasurfaces provide a great platform for point-of-care devices as they are non-invasive, rapid, and robust [1-2]. A typical plasmonic metasurface confines the light partially, hence exhibit low quality-factor (Q-factor) and high dissipative losses. For effective sensing applications, the Q-factor should be increased several times over the plasmonic resonators. Recent work shows that high Q-factors can be achieved by employing high-index dielectric metasurfaces based on the concept of Bound States in Continuum (BIC) [2]. While BIC modes have infinite Q-factor and do not couple to free space, here, we introduce a small degree of structural asymmetry to open a small radiation channel, thereby forming a quasi-BIC. As shown in the figure 1a, one of the ovals is squeezed along the y-axis to introduce asymmetry. By controlling the dimensions of these ovals, we were able to obtain a very high Q-factor (~180) and high sensitivity (~210 nm/RIU).

Diabetic patients exhale high levels of acetone which indicate ketoacidosis condition. There is need to develop real-time breath sensors to monitor human breath under ambient conditions. Metasurfaces coated with metal-organic frameworks (MOFs) would provide such a platform. Metasurfaces sensing works based on refractometry, yet lacks the capability to selectively sense the target volatile organic compounds (VOCs)[3]. We have immobilized a thin layer of Metal Organic Framework -MOF) on top of the metasurface to sense acetone vapors. As shown in figure 1 b and c, we can detect acetone with a limit of detection of 400 ppm. Further optimization of ZIF-8 thickness will increase the detection limit and selectivity towards sensing of acetone vapors. Since acetone is contained in the breath of diabetic patients our sensor can be adopted to test Hyperglycemic condition.

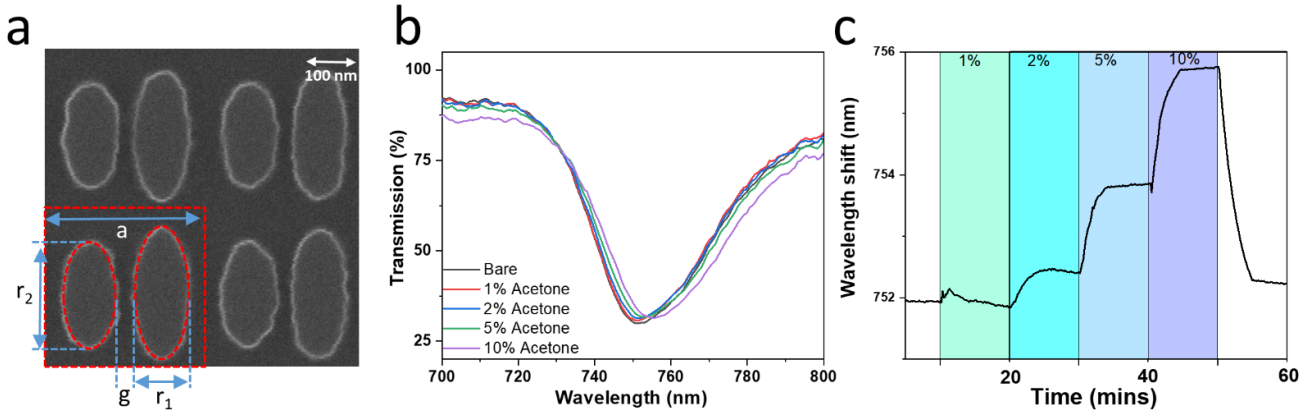

Figure 1 a) Schematics of a single unit-cell of the metasurfaces, where a = 420 nm, r1 = 120 nm, g = 60 nm, r2= 260 nm, r2 = 320 nm, and height of the disks is 70 nm. b) Transmission spectra measured after exposing to acetone vapor. C) Wavelength shift over time.

[1] B. I. Karawdeniya, et al., Chem. Rev. (2022).

[2] F. Yesilkoy, et al., Nat. Photonics, **13**, 390-396 (2019).

[3] Z. Fusco, et al., Adv. Mater., **30**, 1800931, (2018).