# Spectrally tunable metasurface filters for long-wavelength infrared range

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The next generation of infrared (IR) imaging devices requires detection of different wavelengths – similar to how colour images are obtained by modern cameras that perform frequency-selective detection in the visible frequency range. To achieve this in IR, we propose to place a tunable filter in front of a broadband detector, and by tuning the response of the filters we will detect signals from different parts of the IR spectrum. To realise the tunable filter, we integrate a metasurface with a micro-electro-mechanical system (MEMS).

Our metasurface is an array of rectangular holes in a thin metallic sheet that exhibits extraordinary optical transmission for one of the polarisations [1]. Transmission characteristics of the developed metasurface are defined by the coupling of the IR radiation with plasmons - electronic excitations on the surface of the periodically patterned metal film. We design a structure where a high-index dielectric material (MEMS membrane) can move close to the holes in the metal layer, affecting the position of the transmission resonance. After careful optimisation, we propose a tunable band-pass filter with the band moving across the whole long-wavelength IR band (8-12 μm), while the MEMS membrane moves by just 500 nm (Fig. 1). The transmission magnitude stays close to 50% across the whole tunability range. The particular shape of the membrane ensures that it operates in an elastic regime and avoids the membrane sticking to the substrate. Proposed tunable metasurfaces will make an impact in many applications, from remote IR imaging to sensing.

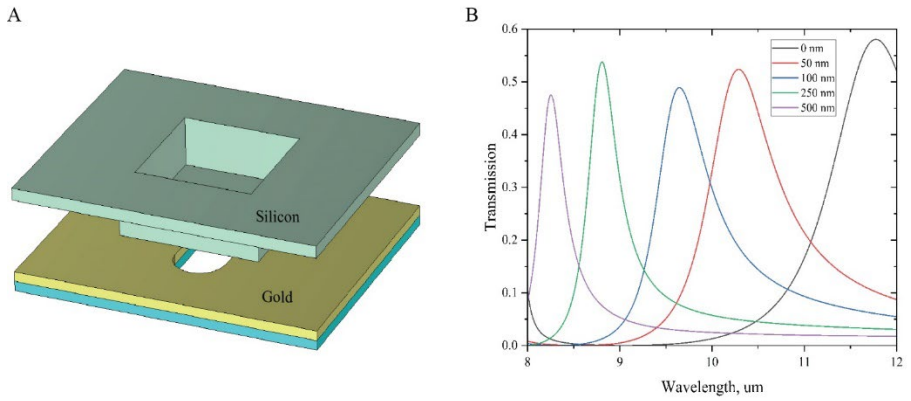


Figure 1. (A) Schematics of the unit cell of the proposed tunable filter: the silicon membrane is placed over the perforated thin layers of gold and silicon nitride. (B) Transmission for different spacing between the membrane and the metasurface.

[1] T. W. Ebbesen, H. J. Lezec, H. F. Ghaemi, T. Thio, and P. A. Wolff, *Extraordinary optical transmission through sub-wavelength hole arrays, Nature*, vol. 391, no. 6668, pp. 667–669 (1998).