Active metasurfaces open new doors for achieving dynamic wavefront manipulation in an ultracompact footprint. One method to provide this tunability is to integrate plasmonic metasurfaces with active materials. Plasmonic resonances provide large local field enhancement which can be engineered to coincide with a thin film active material. This is particularly amenable for field effect-based modulation where an extremely small volume is modulated\(^1\), though the inclusion of metallic resonators generates unwanted absorption loss. Dielectric resonators are an interesting substitute for plasmonic metasurfaces since they are far less lossy while still exhibiting strong resonances. However, their volumetric modes make them difficult to dynamically tune compared to plasmonic variants with strong field confinement.

In this talk I will discuss how we overcome this challenge by combining dielectric resonators with an ENZ mode in a thin film (ITO) placed on top of the resonator. By tuning the coupling between the resonators and the ENZ point of the ITO thin film, active control over the transmission amplitude is achieved. We design the metasurface to operate at the Huygens’ point where the electric and magnetic dipole modes are overlapped. This results in near-unity transmission in the on-state. Upon moving the ITO film through its ENZ point, absorption is increased reducing transmission. I will also discuss additional degrees of freedom such as spatially patterning the modulated area to create beam steering devices such as diffraction gratings. While we will focus on transmission modulation, use of lower loss ENZ films may allow this approach to be translated into phase modulators in the future.

Figure 1. (a) Schematic of metasurface unit cell. The blue material is silicon and the green material is ITO. \( p_x = p_y = 800\) nm, \( h = 230\) nm, \( h_{\text{ITO}} = 10\) nm, and \( d = 480\) nm. (b) Experimentally measured transmission as a function of electrical bias (c) Optical and Fourier plane images for device with the active layer patterned into a diffraction grating in both the transmissive state (+10V) and absorbing state (-10V). In the absorbing state a diffraction grating is generated which generates off-normal beams.

References