ESI: Electrically Tunable Quasioptical Filters Enabled by Inverse Design of Epsilon-Near-Zero Metasurfaces

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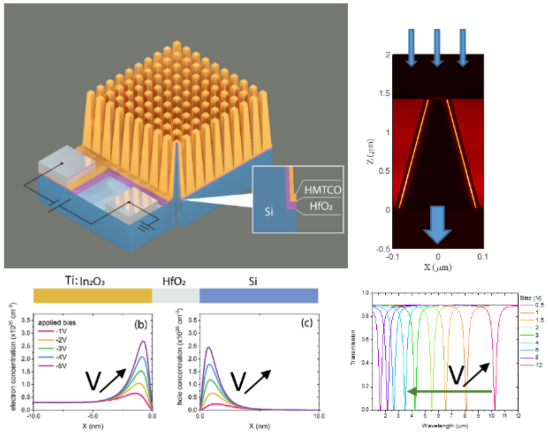
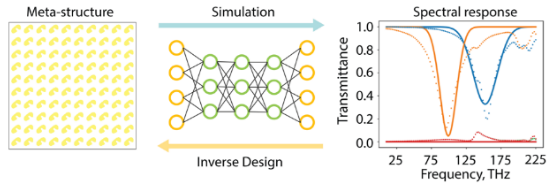
Research Objectives

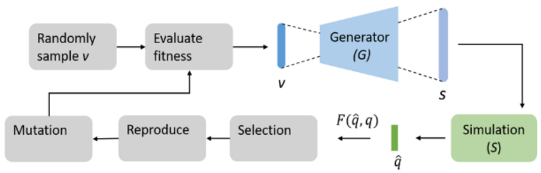
- Develop a prototype of electrically tunable, wideband (1.5~12μm wavelength), quasi-optical filters using epsilon-near-zero (ENZ) metasurfaces
- Innovation: 1) High mobility transparent conductive oxide (HMTCO) for enhanced ENZ effects; 2) Deep-learning-enabled inverse design for metasurface structures in response to customer-defined optical spectra
- Comparison to SOA: 1) Extremely large tunability from the electrically-induced ENZ effect; 2) Versatile on-demand spectral properties using artificial intelligence (AI)-based design scheme
- Projected TRL: TRL (1) to TRL (3)



Approach

- Develop deep-learning enabled frameworks for inversely designed metasurfaces
- Validate designs via fabrication and characterization of passive devices





- Sputtering deposition of high mobility Ti-doped Indium oxide ($Ti:In_2O_3$)
- Nano-fabrication of ITiO/HfO_2/p-Si (p-Ge) meta-surfaces by scalable semiconductor processes
- Spectral characterization and electric tuning of broadband spectral responses with FT-IR

Potential Impact

The proposed electrically tunable quasioptical filters will bring transformative impact to remote sensing applications:

- AI-based design to generate customer-defined spectral features for dichroics, bandpasses, notch filters, and polarizers
- Extremely large electrically tunable wavelength response in the mid-IR range from 1.5 to 12μm
- Scalable fabrication using standard silicon photonics foundry for large aperture, cost-effective filter array
- Game-changing devices for future applications such as hyperspectral imaging and infrared spectroscopy