

# Probing photonic resonant modes in InAs semiconductor nanostructures by STEM-EELS

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## Background incl. aims

Dielectric and semiconductor nanostructures are garnering increased interest due to their low radiative loss properties. This makes them a promising alternative to metal plasmonic structures for manipulating light fields at the nanoscale. The flexibility to manipulate optical resonance can be further enhanced by electrically doping and gating the mobile carrier density in semiconductors. In this study, we present the experimental observation of distinct optical resonances in one-dimensional InAs nanostructures, achieved through high-energy electron excitation.

## Methods

The nanowires were grown with molecular beam epitaxy (MBE) system. Their length and width were finely tuned by modifying the growth conditions. The STEM-EELS investigation was conducted using a double-aberration corrected microscope (Thermo Fisher Scientific Themis Z) fitted with a high-resolution monochromator and a Gatan 1066 continuum spectrometer. The energy resolution is approximately 200 meV.

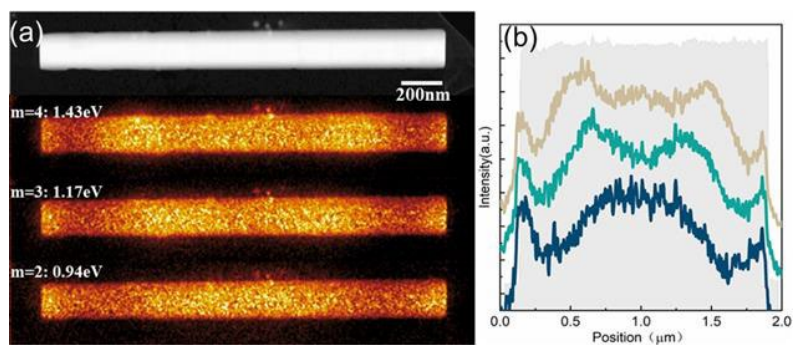
## Results

Figure 1 presents the two-dimensional EELS mapping of an individual InAs nanowire across various energy windows. It's evident that as the energy loss increases from 0.94 eV to 1.17 eV and further to 1.43 eV, the EELS intensity distributions display different nodal patterns. These patterns correspond to resonant modes from  $m = 2$  to 4 and can be recognized as standing wave Fabry–Perot type resonances. Figure 1(b) shows the intensity line profiles along the direction of the nanowire's growth, taken from the central area. To fully understand the experimental observation, we applied the quasi-normal mode theory and boundary element methods to simulate the resonant excitations in similar geometric structures. The simulated results successfully interpret the subtle changes in the EELS response across different energy windows within a given geometric confinement.

## Conclusion

Our STEM EELS investigation and simulation show that InAs nanostructures are a promising candidate for local light field manipulation covering the near infrared-visible-ultraviolet (NIR-vis-UV) spectral range.

**Graphic:**



**Keywords:**

Optical resonance, InAs nanowire, STEM-EELS

**Reference:**

Duncan T. L. Alexander, Valentin Flauraud, and Frank Demming-Janssen, Near-Field Mapping of Photonic Eigenmodes in Patterned Silicon Nanocavities by Electron Energy-Loss Spectroscopy, *ACS Nano* 15 (10) (2021) 16501-16514. DOI: 10.1021/acsnano.1c06065.