Imaging-based molecular barcoding with pixelated dielectric metasurfaces

Andreas Tittl, Aleksandrs Leitis, Mingkai Liu, Filiz Yesilkoy, Duk-Yong Choi, Dragomir N. Neshev, Yuri S. Kivshar Hatice Altug

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Metasurfaces for molecular detection

Although mid-infrared (mid-IR) spectroscopy is a mainstay of molecular fingerprinting, its sensitivity is diminished somewhat when looking at small volumes of sample. Nanophotonics provides a platform to enhance the detection capability. Tittl *et al.* built a mid-IR nanophotonic sensor based on reflection from an all-dielectric metasurface array of specially designed scattering elements. The scattering elements could be tuned via geometry across a broad range of wavelengths in the mid-IR. The approach successfully detected and differentiated the absorption fingerprints of various molecules. The technique offers the prospect of on-chip molecular fingerprinting without the need for spectrometry, frequency scanning, or moving mechanical parts.

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Abstract

Metasurfaces provide opportunities for wavefront control, flat optics, and subwavelength light focusing. We developed an imaging-based nanophotonic method for detecting mid-infrared molecular fingerprints and implemented it for the chemical identification and compositional analysis of surface-bound analytes. Our technique features a two-dimensional pixelated dielectric metasurface with a range of ultrasharp resonances, each tuned to a discrete frequency; this enables molecular absorption signatures to be read out at multiple spectral points, and the resulting information is then translated into a barcode-like spatial absorption map for imaging. The signatures of biological, polymer, and pesticide molecules can be detected with high sensitivity, covering applications such as biosensing and environmental monitoring. Our chemically specific technique can resolve absorption fingerprints without the need for spectrometry, frequency scanning, or moving mechanical parts, thereby paving the way toward sensitive and versatile miniaturized mid-infrared spectroscopy devices.

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