

Nonreciprocal Scattering and Implications for Thermal Emission Control on a Mid-Infrared Spatiotemporally Modulated Metasurface

Scientific Achievement

A CINT User Team demonstrated spatiotemporally modulated metasurface (STMM) for nonreciprocal scattering, revealing a pathway to break time-reversal symmetry at thermal wavelengths for next-generation thermal radiation control.

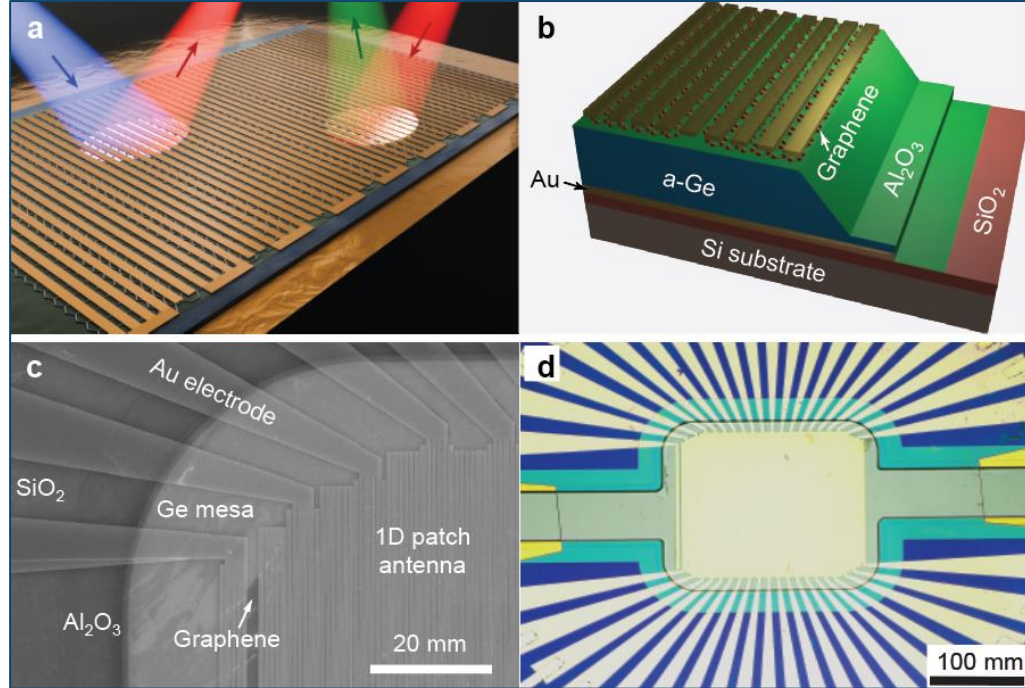


Figure: a) Nonreciprocal reflection from a graphene STMM. An incident beam (blue) impinging on an STMM is downshifted and reflected into a diffraction order (red) by the metasurface. In the reverse, the red beam is not scattered back into the original blue beam but is further down-shifted and diffracted into a new direction (green). b) Schematic of layered structure of an STMM. c) Top-view SEM image of a fully fabricated STMM. d) Optical image of our STMM device.

Significance and Impact

The team established mid-infrared STMM as a new platform for breaking Lorentz reciprocity and independently controlling thermal absorption and emission, enabling transformative advances in directional thermal radiation, radiative cooling, energy conversion, and infrared sensing.

Research Details

- Fabricated a pixelated graphene-based STMM for operating at $\lambda = 9.5 \mu\text{m}$, capable of modulating at $\Omega / 2\pi = 1 \text{ GHz}$.
- Modulation is implemented by RF pixel driving, creating a directional synthetic grating in a three-pixel periodic pattern with properly controlled phase.
- Nonreciprocal scattering is measured in a Littrow configuration by illumination the STMM with an infrared QCL laser.

Efimov, A.; Chang, C.-C.; Pajovic, S.; Kort-Kamp, W. J.; Kim, D.; Chen, H.-T.; Dalvit, D. A.; Azad, A. K. Nonreciprocal Scattering and Implications for Thermal Emission Control on a Mid-Infrared Spatiotemporally Modulated Metasurface. *Nature Communications*. 2026.

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