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Standing-wave plasmon resonances in THz metamaterials[1]

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Metamaterials are man-made composite materials designed to have specific electromagnetic properties that go beyond those found in naturally occurring materials. The most common implementation of a metamaterial utilizes a metallic resonant particle periodically distributed in an insulator matrix where the periodicity is significantly smaller than the wavelength of operation. Their electromagnetic properties arise from the interaction of the resonator units with either or both the incident electric and magnetic fields and are manifested as resonances in the spectra of the metamaterials. Understanding how these properties arise will better enable the development of devices that exploit them, such as negative index materials, superlenses and invisibility cloaks among others. We fabricated split-ring resonators with a resonant response in the terahertz (THz) range of the electromagnetic spectrum (0.1 – 10 THz; 3000 – 30 microns) due to ease of fabrication and the considerable application potential for communications, spectroscopic imaging and chemical or biological sensing. They were fabricated using standard photolithographic techniques on a large-area, low-stress, free-standing silicon nitride membrane. We characterized them using terahertz time domain spectroscopy (THz-TDS) and a Fourier transform infrared (FTIR) spectrometer equipped with terahertz optics. Our results show multiple resonances in the THz region both, for electric fields polarized parallel and perpendicular to the gap. Analysis and finite-element electromagnetic simulations indicate that these resonances may be interpreted as collective excitations of the electrons in the metallic resonator units, i.e. standing-wave plasmon resonances.

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