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PIXELATED METASURFACES FOR TERAHERTZ ABSORPTION AND POLARIZATION CONVERSION

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As electromagnetic research in the terahertz regime is expanding to encompass spectroscopy for medical diagnostics, imaging, security, defense, etc., terahertz metasurfaces are being designed and implemented for absorbers, antennas, cloaks, polarizers, and other devices.

A metasurface is a biperiodic array of electrically thin metaatoms with electrically small periodicity. In our work, a pixelated metasurface decorates the top surface of a dielectric substrate of relative permittivity ε_s and thickness L_s backed by a metal of complex relative permittivity ε_m and thickness L_m. Every metaatom occupies a square of side $a \ll \lambda_c$, where λ_c is the lowest operational value of the free-space wavelength. An inner square of side $a-t$, $t \ll a$, is is partitioned into square pixels of side $b+d=(a-t)/N_r$, where $N_r \in \{1,2,3,\dots\}$ and $d \ll b$. The maximum number of pixels in the metaatom is $N_{max} = N_r^2$. As many as $N_p \in [1, N_{max}]$ pixels are covered by a polymer layer of relative permittivity ε_p and thickness L_p on which is overlaid a square gold lid of side b, thickness L_g, and complex relative permittivity ε_g. The metal-backed substrate is bare on the remaining $N_{max} - N_p$ pixels. Figures 1(a) and (b) show a metaatom possible for $N_r = 3$.

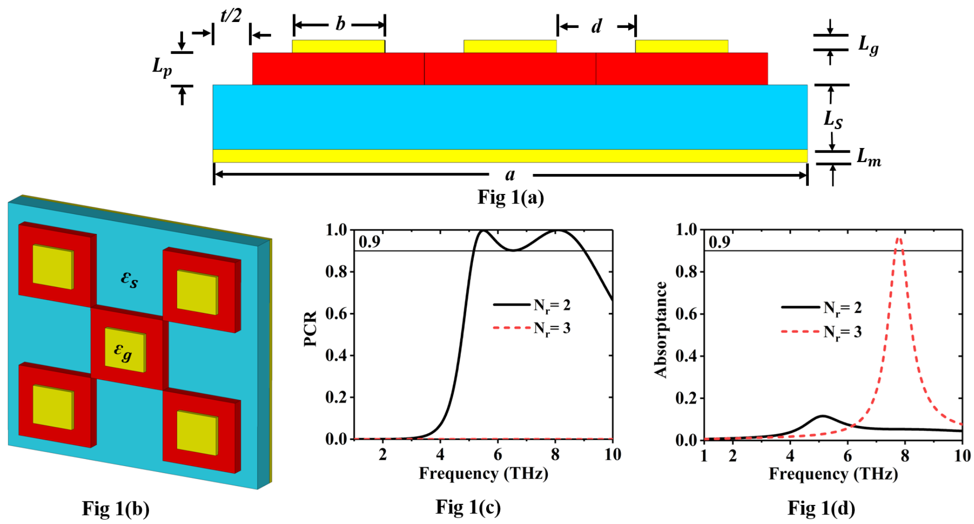

Figure 1. (a) Side and (b) perspective views of a pixelated metaatom for $N_r = 3$. Simulated spectra of (c) polarization-conversion ratio and (d) absorptance of the best-performing metasurfaces with (i) $N_r = 2$, $t = 0.08$ μm, and $L_s = 3$ μm, and (ii) $N_r = 3$, $t = 0.1$ μm, and $L_s = 0.5$ μm, when a plane wave is normally incident with electric field aligned parallel to one edge of a representative metaatom; other parameters are as follows: $d = 0$, $a = 6$ μm, $L_p = 0.25$ μm, $L_m = L_g = 0.1$ μm, $\varepsilon_s = 4.82$, and $\varepsilon_p = 2.89$. Gold was used also as the metal backing the substrate.

With N_r and N_p fixed, the best-performing metaatoms were identified and optimized for either wideband linear-polarization conversion or wideband absorption in the 1-10 THz spectral regime, using CST Microwave Studio™. Polarization conversion is associated with either electric or magnetic resonance, whereas ohmic loss in the gold lids gives rise to absorptance. Significant effects with $d = 0$ were found to deteriorate with increase in d, indicating that d should be chosen as small as practicable for fabrication. As N_r increased from 2 to 4 to 6, the bandwidth for polarization conversion decreased. The best results are displayed in Figs. 1(c) and (d). We plan to extensively employ the pixel-based approach for diverse terahertz applications.