Chiral plate perfect absorber metamaterial for infra-red spectral range based on 3D spiral architecture

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Recently, perfect electromagnetic metamaterial absorbers utilizing single-turn metallic helix architecture have been proposed and realized in practice[1]. However, up till now these structures had large unit cell size (on the order of centimeters) and consequently, their absorption resonances were found at radio frequencies. In order to tune these resonances towards optical range, unit cell of the structure must be drastically scaled down to micrometers. These efforts are usually hindered by the absence of suitable 3D micro- and nano-fabrication techniques. Here we report design, fabrication and optical characteristics of chiral plate perfect absorber for infra-red (IR) spectral range based on metallic helices. The absorber architecture uses periodic arrangement of single-turn gold spirals located on a metallic plane. Such arrangement produces resonant electromagnetic coupling leading to nearly perfect extinction of an incident plane wave within a single, sub-wavelength layer of the absorber. The structures were designed and optimized using finite-element electromagnetic simulation, which took dielectric dispersion of gold[2] into account. To fabricate the samples, femtosecond direct laser write (DLW) technique in a dielectric photoresist was used. This approach allows fast prototyping of various 3D architectures with sub-micrometer spatial resolution. The fabricated dielectric structures were subsequently metalized using gold sputtering. The resulting structures were characterized using infra-red reflection spectroscopy, and were found do exhibit a resonant absorption band centered near the 7.6 μm wavelength, with peak absorptivity in excess of 90% in accordance to the theoretical predictions. Thus, experimental evidence that these structures indeed behave as resonant perfect absorbers were obtained. Thus, significant downscaling of the unit cell by the factor of ~10^4 and the corresponding wavelength shift from radio-frequency range into optical range have been achieved. has been In this report we will describe their design, fabrication, and characteristics in more detail. In the future, this class of metallic perfect absorber metamaterials based on spiral architecture may be applied for enhancement of IR radiation harvesting, thermal detection, and electromagnetic energy conversion efficiency.

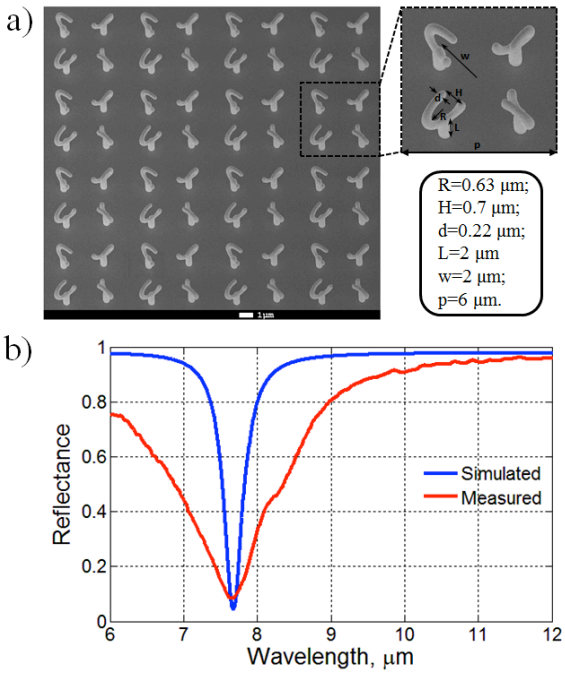

Fig. 1 (a) Scanning electron microscopy image of the spiral architecture perfect absorber sample fabricated by DLW technique in photoresist and coated by gold sputtering along with main structural parameters of the spiral structure, (b) comparison between numerically simulated and measured reflectivity spectra (at normal incidence).

References

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[2] R.L. Olmon et al., Phys. Rev. B 86, 235147 (2012).

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