Reflectionless perfect absorber based on hybridization of electric and magnetic resonant modes

J. P. Del Risco[(1)], J. D. Baena*[(1)], Andrey Sayanskiy[(2)], and Stanislav B. Glybovski[(2)]
(1) Universidad Nacional de Colombia, Bogota 111321, Colombia
(2) ITMO University, Saint Petersburg 197101, Russia

In 2008, David Smith's group designed a perfect metamaterial absorber with an absorption of 99% at the frequency of 11.65 GHz (N. I. Landy, Phys Rev. Lett., 100, 207402, 2008). However, an important drawback of this structure is that the reflection is high for frequencies different to this value. It was solved by Tretyakov and co-worker who a few years later proposed a new type of broadband reflectionless metasheets (V. S. Asadchy et al., Phys. Rev. X, 5, 031005, 2015), whose unit cell was composed of metallic inclusions hold by slab of foam. The main drawbacks of this structure come from the need of volumetric inclusions which makes it difficult to manufacture big samples and threaten the robustness of the final device. In 2018, we proposed a new type of reflectionless and transparent metasurface for full control of the phase (M. Londoño et al., Phys. Rev. Appl., 10, 034026, 2018). Its unit cell was like the one shown in Fig. 1(a), composed of two split ring resonators (SRR) which are laterally shifted and mounted with inversion symmetry. Because of the coupling, the resonance of one single SRR could be split into two resonances (magnetic and electric). It was demonstrated there that, for some specific value of the lateral shift *s*, the two SRRs can be electromagnetically uncoupled, and thus the two resonant modes collapse in a single hybridized resonant mode. When the magnetic and electric polarizabilities equal one each other, any reflection disappear in a wide range of frequencies. In a subsequent work by the same group (J. P. del Risco, et all., Proc. Metamaterials, 34-36, 2018), the same cell was used to design a perfect absorber by replacing the metal with a hypothetical material with very low conductivity (about 10^4 S/m), which is rather strange for natural materials. In this work, instead of the dissipation in conductors, we have studied the possibility of dissipation in the dielectric substrate. We have found that the cheap and common FR4 substrate is an excellent candidate for perfect absorption at a single frequency. All parameters of the simulated structure are shown in Fig. 1(a). The incident plane wave is linearly polarized along the *y*-axis and propagates along the *z*-axis. The simulated absorbance and reflectance are depicted in Fig. 1(b) within the band from 2.0 to 4.0 GHz. A maximum absorption of 99% take place at 3.18 GHz while the reflectance is always below 0.3%.

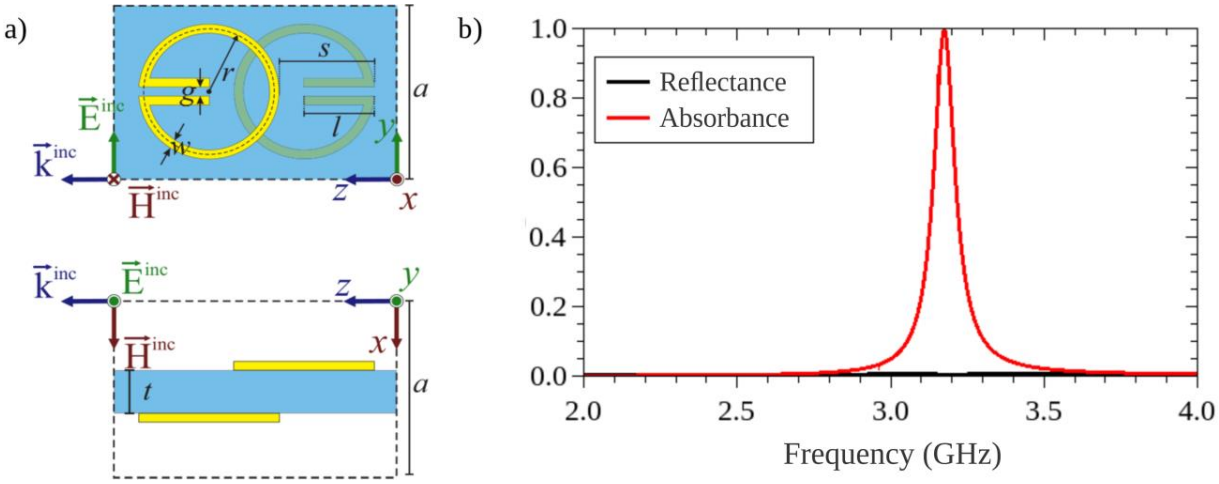

Figure 1. a) The unit cell made of copper over a FR4 substrate ($\varepsilon_r = 4.32$, $\tan\delta = 0.015$). Geometric parameters (in mm): $a = 15.2$, $l = 5.13$, $s = 4.75$, $r = 3.02$, $g = 0.35$, $w = 0.42$, and $t = 0.20$. b) Simulated absorbance and reflectance.