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Graphene-Metasurface Structures for Low-Terahertz Applications

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Graphene, as a single-atom layer formed in a hexagonal lattice of carbon atoms, in recent years has attracted the attention of researchers due to its superior thermal, mechanical, and electrical properties. The surface conductivity model of graphene is based on the Kubo formula [1], which takes into account both interband and intraband contributions. Despite of various electrical and electromagnetic applications, graphene and graphene based structures demonstrate a low intensity of the light-matter interaction unless an assumption on high mobility or high Fermi-energy level is made. In recent work [2] it has been shown that perfect absorption at low-terahertz frequencies can be realized even for a very practical graphene with low mobility and low level of Fermi energy, wherein the graphene is placed directly on the periodic metallic surface resulting in significant reduction of graphene losses.

Here we elaborate on the analysis of such graphene-metasurface structures and demonstrate various applications at low-terahertz frequencies. Specifically, we propose a technique of cloaking metallic objects, based on the work in [2], and show how a non-pristine graphene with a low relaxation time of $\tau = 20$ fs and a low chemical potential of $\mu_c = 0.1$ eV can provide electromagnetic invisibility for a perfect electric conductor (PEC) elliptical cylinder shown in Fig. 1(a). The detailed design parameters will be given in the presentation. The total scattering width results for the uncloaked and cloaked cases are also shown in Fig. 1(b).

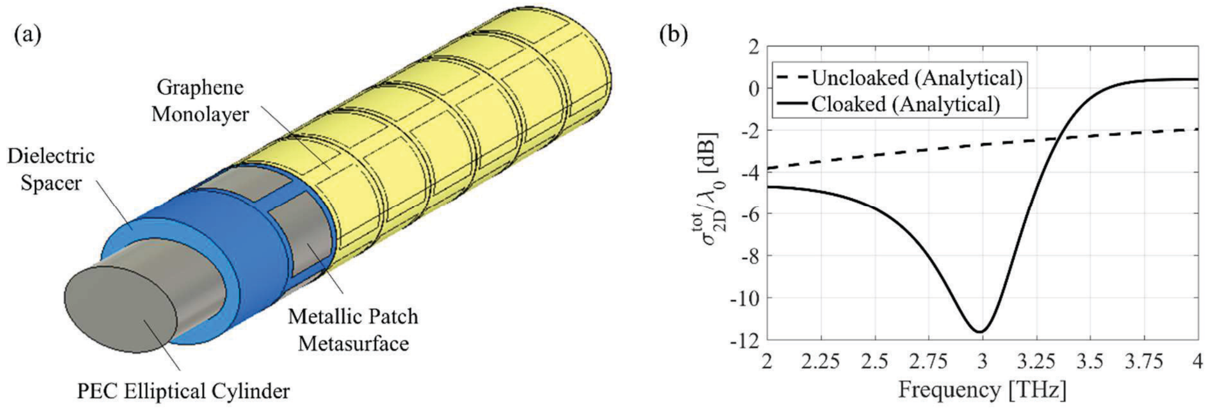

Figure 1. PEC elliptical cylinder is covered by a dielectric spacer (with the permittivity of $\boldsymbol{\varepsilon_d = 10}$), a capacitive metallic patch metasurface, and a graphene monolayer placed right on top of the metasurface. (a) General view and (b) The total scattering width versus frequency for uncloaked and cloaked elliptical cylinders.

We also study the response of graphene-metasurface structures in a layered environment with the developed transmission matrix approach for applications to multiband absorbers. We integrate such graphene-metasurface structures in the homogenization models of wire media and demonstrate applications to absorbers with stable angle characteristics at low-terahertz frequencies. In addition, the surface-wave propagation is studied with applications to the near-field excitation problems.

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