THz graphene-based metasurfaces for wave manipulation

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We discuss the unique possibilities stemming from exploiting the exotic properties of artificial metasurfaces designed for operation in the THz regime. Metasurfaces are electromagnetically ultrathin artificial materials with macroscopic properties defined by the architecture of the building blocks, the meta-atoms. Adjusting the meta-atoms enables the control over different aspects the electromagnetic waves and the realization of unusual electromagnetic functions. Within this framework we present groups of metasurface configurations incorporating different constituent materials. We mainly focus on graphene based metasurfaces acting as modulators for the THz regime. Graphene, the acclaimed two-dimensional (2D) material made of carbon atoms arranged in a honeycomb lattice, exhibits unique optical properties particularly in the THz spectrum, where it predominantly exhibits a Drude-like response. We focus on planar metasurfaces structures, starting from the simple metal-insulator-metal scheme to carbon nanotubes of variable number of interlayers and we show that the effective medium analysis unveils a rich palette of electromagnetic features that can be engineered by the adjustment of the geometry [1,2]. Additionally we show that ultrafast modulation response can be assessed with the use of a broadband THz time-domain-spectroscopic system (THz-TDS) in an IR pump-THz probe configuration and also with nonlinear self-action [2,3]. The proper design of the metasurface provides the means for achieving critical coupling and hence increased/perfect tunable absorption. The near-IR stimulus generates hot carriers in the graphene metasurface which effectively reduces its THz conductivity. Similar phenomenon can be induced by self-modulation using intense THz fields. The simple scheme of the absorber can be used as a platform for ultrafast flat optics and metasurfaces. Apart from that, we review additional recent THz metasurface findings with some interesting features. For example it has been shown, that using hybrid metasurfaces with metals combined with graphene one is able to produce switchable and tunable terahertz electromagnetic advanced functions like wavefront shaping.

References

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