Hybrid Graphene – Gold Metasurfaces for Enhanced Third Harmonic Generation Efficiency

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Graphene is a unique nonlinear material for THz applications due to its strong third order nonlinearity in combination with the capability to support tightly-confined surface plasmons [1]. The short wavelength of propagating graphene plasmons enables the design of metasurfaces (MSs) supporting higher-order resonances, while the lattice constant remains subwavelength even for higher harmonic frequencies avoiding diffraction effects. A proven approach for boosting the efficiency of third harmonic generation (THG) process is to carefully align the fundamental (FF) and third-harmonic (TH) frequencies with MS resonances, a strategy which has been termed double-resonant enhancement [2]. In our previous work [3], we studied MS structures where the graphene was patterned into rectangular patches and reported third harmonic generation conversion efficiency (CE) of -20dB (at input intensity of 0.1 MW/cm^2) [3]. In this work, we target an implementation that is friendlier to an experimental demonstration and, at the same time, aims to further increase the efficiency.

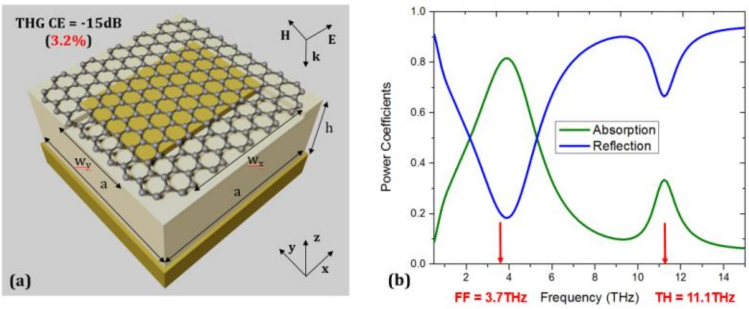

Figure 1: (a) Metasurface structure with gold patches covered with a uniform graphene layer (b) Linear plane-wave scattering spectrum (Reflected and Absorbed power coefficients) for the optimum geometrical parameters of the structure, with $w_x = 0.95a$ and $w_y = 0.65a$. The fundamental frequency and the third harmonic frequency (red arrows) are aligned with absorption peaks.

Our proposed MS [Fig. 1(a)] is composed of a uniform graphene layer on top of gold patches (with size $w_x \times w_y$), rectangular in the optimal case, residing on a dielectric substrate (thickness h = 8.3 μm), backed by a gold backreflector. The lattice constant is a = 5.6 μm. To optimize the structure response, a parametric study with respect to the length and width of the resonating patches, w_x and w_y. The CE is calculated under continuous wave (CW) conditions with a frequency-domain finite element method by using two linear simulations, at the FF and TH frequencies, respectively [4]. The optimum point in the w_x-w_y map resulted in a conversion efficiency CE = -15dB (3.2%) for the E_x polarization.

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References

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