Graphene-based absobers exploiting guided mode resonances in nano-imprinted dielectric pillars

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The attractive optical properties of diffraction gratings have stimulated significant interest making them widely used in several applications ranging from sensing, spectroscopy and light absorption [1-2]. In this work, we propose the design of a two-dimensional (2D) array of polymethyl-methacrylate (PMMA) pillars deposited on different sputtered dielectric slabs (e.g. Ta_2O_5 and AlN) supported by a silicon dioxide (SiO_2) substrate (Fig. 1) or metallic films. The graphene monolayer is sandwiched between the PMMA pillars and the dielectric slabs representing the only material with absorption in the lossless system. The periodic structures are designed to phase-match the incident plane wave and couple discrete guided modes, also called guided mode resonances (GMRs) [3-4]. GMRs interact with the graphene monolayer enhancing the overall absorption.

The optical response is investigated by means of numerical simulations carried out by means of DiffractMOD (RSoft) that implements the Rigorous Coupled-Wave Analysis (RCWA) method. Fig. 2(a) and (b) show the absorption maps when the impinging source is tilted in the range 0°-90° for p- and s- polarizations in the case of PMMA pillars supported by a SiO_2 film. The maps clearly show a great variety of guided mode resonances that span from visible to near-infrared wavelengths.

Preliminary experimental results are reported where the PMMA pillars are realized by using nano-imprint lithography (NIL) by means of a silicon stamp.

In conclusion, the proposed configuration, based on guided mode resonances with sharp spectral features, will be exploited in a plethora of applications ranging from (bio)-sensors, biomedical applications, color control and filtering, nonlinear devices to optical absorbers.

References

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Figures

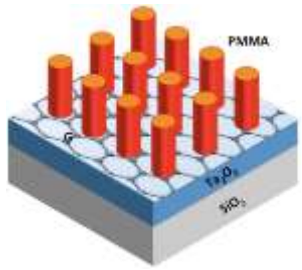

Figure 1. Sketch of the proposed device where the graphene monolayer is sandwiched between the PMMA pillars and the Ta_2O_5 slab supported by a glass substrate.

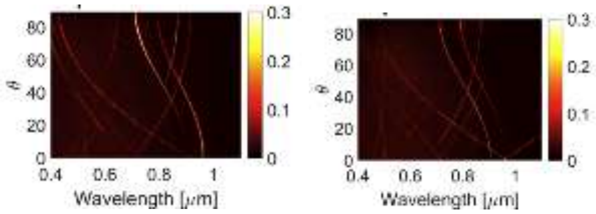

Figure 2. Numerical absorption maps for the (left) p-polarized and (right) s-polarized impinging field, respectively. The period and thickness of theTa_2O_5 slab are equal to 600 nm and 150 nm, respectively.