Coherent absorption of light by graphene and other optical conducting surfaces in realistic on-substrate configurations.

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Abstract

In recent years, the advent of 2D materials [1-2] in conjunction with the concept of metasurfaces [3] has boosted the application of optical conducting surfaces (OCSs) in developing novel structures for optical devices such as wavefront-shaping devices, nonlinear optical components, wave filters, sensors, thermal emitters or memory surfaces. Hence, a precise control of the absorption of an OCS is of paramount importance. In realistic cases, due to the extremely thin nature of two-dimensional materials and/or to the implementation of patterns that are geometrically disconnected, OCS's are placed on top of a substrate. Based on this context, we propose a very general theoretical model that predicts the coherent absorptive properties of OCSs, when the OCS on the substrate is interferometrically investigated via a dual-beam illumination (Fig. 1a). Unlike in a single-beam arrangement, absorption regimes such as coherent perfect transparency (CPT) and coherent perfect absorption (CPA) [4] can be reached. In fact, by properly modulating the amplitudes and the phases of the input beams, the amount of transparency (A_{min}) and of absorption enhancement (A_{max}) can be tailored. The model predicts three main results: the CPT (A_{min} = 0) can always be reached; the CPA regime (when A_{max} = 1) is strongly dependent on the OCS conductance *G* and the optical path through the substrate (φ), as shown in Fig. 1b; OCS conductance *G* can be experimentally determined even when the substrate thickness is unknown.

To support the model, we report on experiments of coherent absorption on turbostratic multilayer graphene grown on silicon carbide substrate. By dephasing the input beams, the absorption properties of the graphene-based system are coherently modulated (Fig. 1c). From the analysis of the experimental data, we are able to estimate the graphene conductance *G* and, thus, quantify the number of layers N_G.

In conclusion, by combining the proposed theoretical model with the coherent absorption measurements, a new accurate and non-destructive spectroscopic technique for wafer scale diagnosis of optical conducting surfaces is hence enabled.

References

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Figures

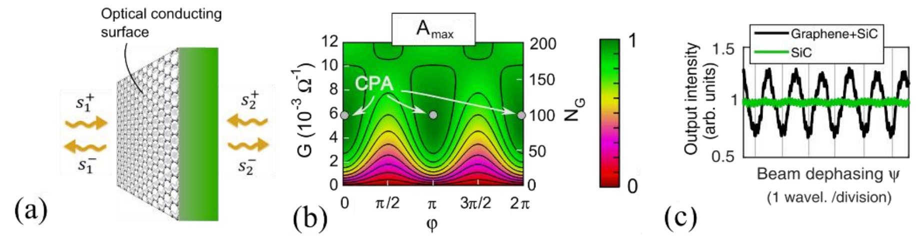

Figure 1. a) An optical conducting surface, here represented as a graphene sheet, lies on a transparent substrate. Plane waves excite the system from both sides. b) Theoretically predicted absorption enhancement A_{max} as a function of the optical path through the substrate (φ), the OCSs conductivity *G* and the corresponding number of decoupled graphene monolayers (N_G). c) Example of measured signal under double-beam illumination of the graphene on SiC (black line) and bare SiC (green line).