**Graphene based microwave – THz devices: main principles**

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For frequencies up to 100 GHz, the sheet conductivity of graphene produced by conventional CVD is a sizable fraction of the intrinsic admittance of air. Thanks to this nice coincidence, stacking a few layers of graphene suffices to match the sum of the admittances of the media located on both sides, providing thereby the largest possible power absorption of electromagnetic radiations traveling from one medium to the other [1]. A low transmittance across the graphene stack can be achieved while keeping the reflectance low. Whereas conventional shielding layers reflect almost 100% of the incoming radiations, which maintains high the density of radiations in the environment, graphene planes can absorb about 50% power by Joule heating and only reflects a small fraction of incident power.

The intrinsic RF power transmittance of a five-layer graphene/PMMA stack is 0.25 (6 dB attenuation) for a thickness of 1 µm. In the same conditions, it absorbs 50% and reflects 25 % of the incident power. By comparison, good carbon-based paints can shield 30 dB at 15 GHz, over a 25 µm dry layer, with 10% absorption and 90% reflection. Similar characteristics can be obtained for thin conducting meshes. Graphene-based shielding multilayers are particularly well adapted to small-scale applications, such as optical windows of optoelectronic devices. A graphene-polymer multilayer can be deposited on a glass window and placed in the inner side of the device. In order to improve the shielding properties, the thickness of the window can be adjusted to half a wavelength of the radiations to be screened (2.6 mm at 30 GHz for $n$=1.9). In these conditions, a few-layer graphene stack can block 90% of the incident RF radiations while remaining optically transparent.

It has been checked that intrinsic defects of CVD graphene do not affect the electromagnetic properties of the multilayers [3,4].

We demonstrate theoretically and prove experimentally that microwave absorptance of graphene can be enhanced considerably by depositing graphene on a dielectric substrate. On the experimental side, we obtain 80% and 65% absorptance at 30GHz and 1THz, respectively [2]. Theory predicts that higher absorptance can be achieved with a suitable choice of the dielectric permittivity and the thickness of the substrate.

A thickness corresponding to a quarter wavelength indeed reduces the reflectance to almost zero in case the radiations comes from the substrate side and increases the absorptance to a maximum value. This property has been demonstrated experimentally and theoretically [2]. The transmittance is minimum when the substrate thickness is half a wavelength.

The simplest way to tune EM response is using different polarization of incident way. Moreover, absorption can also be maximized by choosing the optimum incidence angle for s- polarized waves in free space or by working in the vicinity of the cut-off frequency of the transverse electric mode in waveguide configuration.

The same propertis of graphene and its heterostructures (graphene/polymer sandwiches) can be used to design graphene based polarizer, filter and detector of microwave-THz radiation.

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