THz EMI Shielding in Graphene/PMMA Multilayers

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***Abstract*— The electromagnetic interference (EMI) shielding mechanisms of graphene/PMMA multilayered structures are experimentally investigated by using time domain spectroscopy (TDS) in the THz range. Stacked plates of similar thickness (~ 5µm), starting from a single layer up to 100 layers, were produced by a novel approach combining ultra-thin polymer casting and wet deposition techniques. These nano laminates show enhanced electrical conductivity (~ 100 S/cm) and superior specific shielding effectiveness (~ $2{\cdot}10^4$ dB cm^2 g^{-1}).**

I. INTRODUCTION

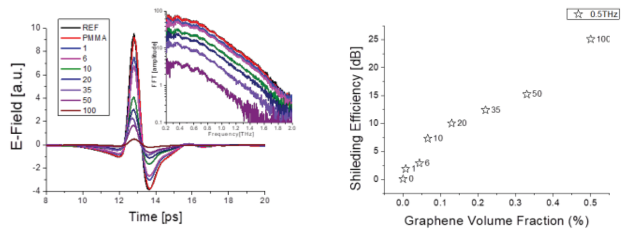
Electro Magnetic Interference (EMI) is the undesired interference effect in between the conducted or radiated electro-magnetic field with the surrounding media or electronic devices leading to the system performance decrease or malfunctioning of the device [1]. The quest for novel materials with high efficiency to mitigate EMI has become a mainstream field of research, motivated not only by environmental issues but also by a large variety of applications. Shielding in the terahertz region may have applications in homeland security and defence to protect information acquired by imaging and sensing techniques or personnel involved in ground operations, e.g. in airport body scanners or in the spectral detection of CBRN (Chemical, Biological, Radiological and Nuclear) materials. For this reason, research on large area, light weight, high strength composite materials with a superior shielding efficiency is mandatory for the development of high performance, low cost, novel THz systems.

II. RESULTS

Self standing, large surface area (few cm^2) CVD graphene/polymer nano laminates are produced by using a novel bottom-up approach based on the combination of ultra-thin polymer casting, “lift off-float on” process and wet deposition. Samples are characterized using a THz time domain spectrometer (Tera K15, Menlo Systems) based on photoconductive antennas driven by a sub-100 fs fiber laser. All measurements are carried out at room temperature and in dry atmosphere to minimize THz absorption by water vapor.

EMI shielding efficiency (SE) is evaluated in terms of the total attenuation in the incident electric field upon transmission through the barrier media [2] . SE_{TOT} in dB measures the total attenuation, given by the shielding decomposition due to reflection (SE_R), absorption (SE_A) and multiple internal reflection (SE_M) terms respectively. TDS transmission and specular reflection measurements for each sample with a different number of layers are acquired separately and the conductivity, absorbance, and the complex dielectric function are extracted. The retrieved conductivity shows very high values (up to ~ 100 S/cm), similar to what is measured using a simple four-point probe technique.

A gradual decrease in the E-field pulse amplitude is clearly observed with the increased number of stacks (Fig.1) revealing the effect of the graphene volume fractions on the SE. We directly measure SE_{TOT} and SE_R, and from here we extract the contributions from SE_A and SE_M taking into account the effect of the corresponding penetration depth in the stratified media. As expected, SE_A shows a gradual increase with the number of layers and consequently with the graphene volume fractions. SE_M is in direct correlation with the absorption losses, however it first gradually increases with the number of stack layers (1 to 50 layers) and then becomes practically negligible when SE_A is $\geq$ 10 dB [3].



(a) (b)

Fig. 1. (a) THz time domain signal for the different graphene/PMMA samples. Inset shows the corresponding frequency domain spectrum acquired from the fast Fourier analysis. (b) Total Shielding Efficiency calculated at 0.5THz vs graphene volume fraction (different stack layers number).

III. SUMMARY

Graphene/PMMA multi stack shields have been experimentally investigated by using THz-TDS technique. We directly measured the total shielding and the SE_R term from signal transmission and specular reflection experiments respectively. A very high specific shielding effectiveness is achieved (~ $2{\cdot}10^4$ dB cm^2 g^{-1}) with minute amounts of graphene content due to the ultrathin and the low weight nature of the stacked shields. Furthermore we have investigated the contributions from the absorption (SE_A) and the multiple internal reflections (SE_M) varying the number of graphene layers.

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