Control of the Optical transmittance in Multilayer Graphene using a bias Voltage

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The search for new materials, particularly nanomaterials, has been intensively studied in the last two decades. Due to the fascinating physical properties that the family of materials based on carbon present, graphene, a two dimensional crystalline arrangement in the shape of honeycomb, is one of the most studied. The physical properties such as optical, electronic and thermal properties of this material become ideal for a wide range of applications. The optical absorption of graphene at normal incidence is 2.3% in the frequency range from visible to infrared (1). However, the optical absorption of graphene can be controlled by a gate voltage, enabling the construction of electro optical modulators (2).

In this work, the modulation of the optical transmittance of the multilayer graphene (MG) through a bias voltage of the form across two coplanar electrodes (3) is studied (see figure 1). The multilayer graphene is synthesized by CVD technique, and later, placed on glass substrates. The experiment consists in passing light through the MG while the sample is biased with an electrical signal at frequency using a function generator (see figure 1b). For illumination, different laser and white light sources were used. The transmitted light is detected by a photodiode and an electrometer which provides a direct physical measurement of transmittance, it is also important to mention that experiments have been done in reflection mode. The measurements were made in vacuum.

One of the results can be seen in figure 2a, the variation of the modulated transmittance respect to the background is small and the values varie from 1% to 5 % depending on the experimental conditions. This was obtained from the numerical Fast Fourier Transform (FFT) (figure 2b) to know the frequencies present in measurement signal. In the Fourier analysis, we found that the fundamental frequency appears and also higher harmonics, in all cases the second harmonic is the most intense. The observed effect appears to be a universal phenomenon because it works with monochromatic and white light, with a DC bias, and in the reflection mode as well. Due to optical conductivity of graphene is a function of temperature, there is a possibility that modulation in optical transmittance in MG is a consequence of Joule effect. The electric field generated by the bias voltage is not discarded either.

The observed phenomenon opens the possibility of using this effect in the transmission of information by optical means and for the generation of electrical signals with higher frequencies than that of the excitation signal.

References

[1]. R. R. Nair, P. Blake, A. N. Grigorenko, K. S. Novoselov, T. J. Booth, T.Stauber, N. M. R. Peres, and A. K. Geim.,Science **320**, (2008)1308 .

[2]. Liu Ming, Yin Xiaobo, Ulin-Avila Erick, Geng Baisong, Zentgraf Thomas, Ju Long, Zhang, Feng Wang and Xiang Zhang. Nature **774**,(2011) 64.

[3]. J.L. Benitez and D. Mendoza, Appl. Phys. Lett. **103**, (2013) 083116.

Figures

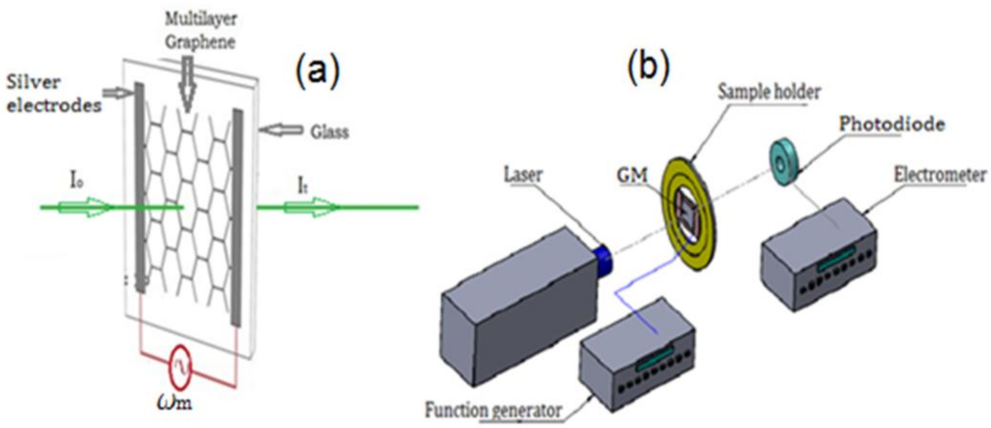

Figure 1. (a) Schematic of the electrical connections and (b) illustration of the set-up for the experimental measurements.

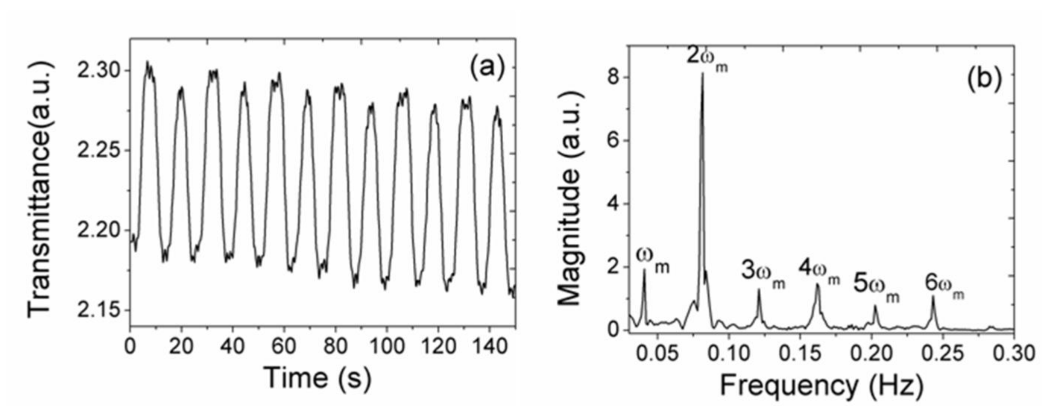

Figure 2. (a) Transmitted light intensity modulated using an amplitude of 11.2 V and a frequency of , (b) FFT frequency spectrum obtained from the transmittance measurements.