Modification of graphene´s laminar resistance by a 10 keV electron beam

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Graphene has unique physical and chemical properties due to its sp2 carbons arranged in hexagons [1], [2]. This material is widely studied for applications in fields such as biology, biomedicine, bioengineering, and the industry [3].

However, sometimes it is required to modify the chemical structure of graphene to be used in specific applications. Several studies ensure that the properties of graphene vary due to electron beam irradiation when the energy is higher than 30 keV [4]. In this case, the carbon hybridization can change, the defects can vary, or other elements can be attached to broken bonds [4]-[6]. This method offers the opportunity to modify the graphene properties in situ.

In this work, graphene ink was obtained by an electrochemical method with edge and vacancy defects. The material was deposited on a glass substrate by spring coating and then irradiated by an electron beam in a range of energies between 1 and 10 keV for 30 minutes. We measured the laminar resistance of the films by the Van der Pauw´s method before and after irradiation. In figure 1 is presented the variation of graphene´s laminar resistance. It can be observed a reduction of about 6% for the films irradiated with energies higher than 8 keV. It was determined that the reduction of oxygen in the sample could be of the factors as shown in figure 2. The changes in the chemical structure were evaluated with techniques such as Raman spectroscopy, FTIR and XPS.

References

[1] M. E. Cayambe Guamán and C. A. Zambrano Vera, *Obtención de grafeno mediante exfoliación en fase líquida y optimización de la parte experimental a través de tratamiento hidrotérmico*. 2018.

[2] J. Narváez, “Obtención de grafeno monodisperso mediante exfoliación electroquímica y centrifugación en la cascada y su uso para la fabricación de películas delgadas.” 2019.

[3] P. Gulia, R. Brajpuriya, S. Kumar, and A. Tripathi, “Synthesis of graphene oxide thin film and effect of electron beam irradiation,” *AIP Conf. Proc.*, vol. 1832, 2017, doi: 10.1063/1.4980805.

[4] P. Adamson and S. Williams, “Effects of Electron-Beam Irradiation on Graphene Oxide,” *J. Undergrad. Reports Phys.*, vol. 29, no. 1, p. 100002, 2019, doi: 10.1063/1.5129242.

[5] Z. Huang, J. Fang, X. Zheng, X. Zhang, and X. Peng, “Evolution of the Raman spectra of electron beam irradiated graphene exposed in air,” *Second Int. Conf. Photonics Opt. Eng.*, vol. 10256, p. 1025634, 2017, doi: 10.1117/12.2257790.

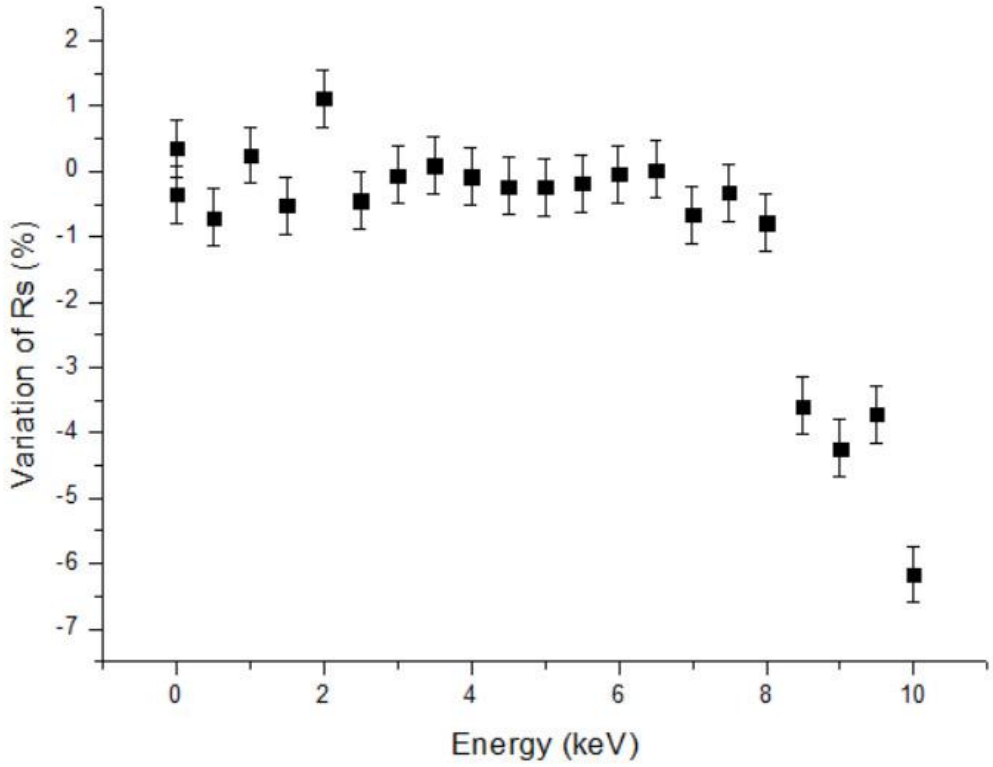

Figure 1 – Variation in the laminar resistance of a graphene film deposited on a glass substrate. A significant reduction of the laminar resistance is observed for incident electron energies higher than 8 keV.

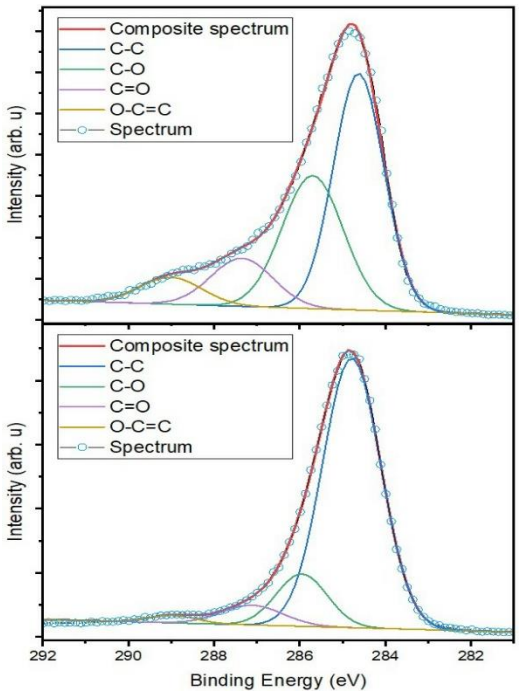

Figure 2 - The plot shows an XPS analysis of a graphene film before being irradiated (top), and one after being irradiated with 10 keV for 30 min (down). It can be seen how the intensity of the C-C bonds increases with respect to the other carbon bonds with other elements. This indicates that irradiation affects the chemical structure of graphene.