GRAPHENE WEEK

Laser-induced inter-device variability improvement for liquid gated graphene sensors

J. Ávila, J.C. Galdon, N. Salazar, M.I. Recio, C. Marquez and F. Gamiz,

[1] *Nanoelectronics Research Group (CITIC-UGR), University of Granada, Spain.*

Introduction. Electrochemical gated graphene sensors employing electrolytes such as ionic liquids and aqueous solutions have been widely reported showing excellent performances [1,2]. Nonetheless, due to the high sensitivity of graphene and the complex nature of the electrolyte solutions, the reproducibility between devices can be challenging [3]. In this work, we have explored the laser irradiation of the graphene sheets as a rapid treatment to improve the inter-device electrical variability in graphene-based liquid gate sensors.

Experimental Setup. Low-pressure chemical-vapor deposited graphene was synthesized on polycrystalline copper foil using methane and then transferred to cleaned quartz substrates using the PMMA-based technique [4]. Graphene was annealed and optical lithographed to perform devices with liquid gate capability. Laser treatment consists of the radiation of graphene layers using a laser engraver (445nm-wavelength).

Results. An increase in the resistance of the device was observed, growing rapidly during the first laser cycles, and stabilizing around 2.8 kΩ after 6 cycles. (Figure 1a). The Raman spectroscopy comparison before and after the laser treatment (Figure 1b) shows that before laser exposure, the Raman spectrum fits the signature for pristine single-layer graphene, while after the laser treatment, an increase of the D peak and D´ peak, related to structural alterations, are detected. These results indicate that the laser treatment has an adverse effect on the structural order of graphene. When using the ion liquid gate (Figure 1c), the device current decreases with the successive laser cycles, while the Dirac point (minimum conductivity point) shifts to lower voltages (inset). This increase in the resistance agrees with the Raman interpretation, indicating that after the laser exposure the graphene could be degraded. However, when comparing the Dirac voltages of several devices before and after the laser treatment, a significant reduction of the electrical variability among devices is observed (Figure 1d), improving the inter-device variability, a critical constrain for sensing applications.

Conclusions. There is a trade-off between some grade of graphene degradation and an improvement at the liquid gate/graphene interface thus, the sensing performance. Finding the origin of this phenomenon seems critical to optimize the device performance for sensing using liquid gates.

Acknowledgment. This work has received funding from the EU H2020 under the Marie-Curie grant agreement (895322), from the Spanish Program (TEC2017-89800-R), SUPERA COVID-19 Fund and CRUE-Santander, Regional Program FEDER UGRVID (CV20-36685) and P18-RT-4826 projects.

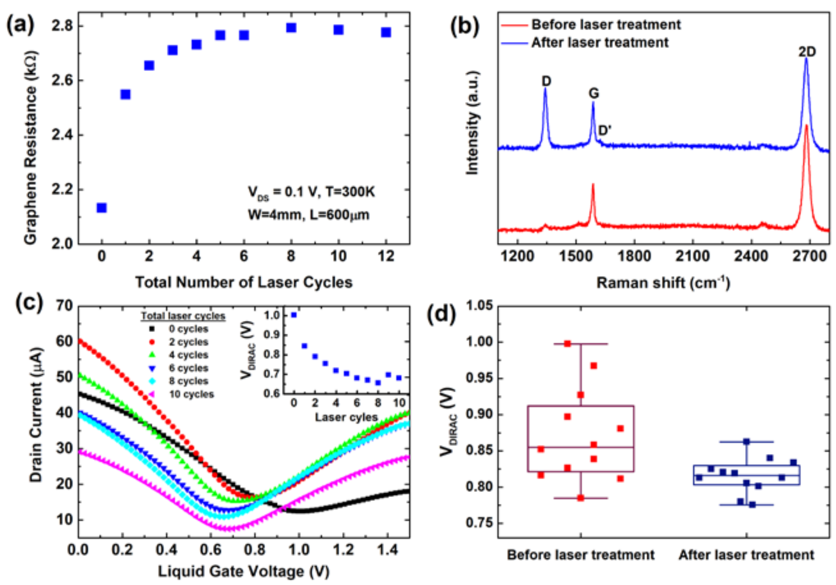

Fig. 1. a) The graphene device resistance measured without the liquid gate for different numbers of laser cycles, b) the graphene Raman spectra before and after the laser treatment. c) Drain current versus gate voltage for a graphene layer measured after different numbers of laser cycles. d) Dirac voltages distribution of 16 devices measured before and after laser treatment of 4 cycles.

[1] F. Chen et al., J. Am. Chem. Soc. 131, 9908–9909, (2009). [2] N. Liu et al., Sensors, 19 (2019). [3] A. Pirkle et al., Appl. Phys. Lett. 99, 122108, (2011). [4] G. Borin, et al., Carbon N. Y. 84, 82–9, (2015).