On the improvement of reliability in 2D devices for sensing

Carlos Marquez
Jorge Ávila, José-Carlos Galdon, María-Isabel Recio, Carlos Navarro, Luca Donetti, Francisco Gamiz
Nanoelectronics Lab, CITIC-UGR Dept. of Electronics, 18071, Granada, Spain
carlosmg@ugr.es

GRAPHENE and other 2D materials such as MoS_2 or WS_2 have received an exceptional attention due to their excellent electrical, optical, thermal and bendability properties [1], [2] . Thanks to their reduced thickness, they present an enhanced electrostatic control of the channel and an outstanding sensitivity to changes in the surroundings, which make them particularly attractive for sensing applications [3]. However, the operation conditions differ from the optimal ones as much as the experimental results do not match with the theoretical expectations. For example, for graphene biosensors, they should operate at or near physiological conditions, so it is essential to use them in aqueous solutions. The graphene–electrolyte interface is typically models as an electrical double layer capacitance (EDLC) [4], acting as a transistor gate stack. Nonetheless, due to the high sensitivity of graphene and the complex nature of the electrolyte solutions and transfer processes, the reproducibility among devices is challenging. For the case of gas sensing, 2D materials also have an important niche detecting species such as CO_2 or NH_3. However, non-passivated devices for a direct 2D material-gas interaction are addressed to improve the sensitivity while it increases the residual and superficial charge implications as counterpart [5]. In this work, we analyze the interface implications on our fabricated 2D devices and evaluate different approaches to improve their reliability when are used for sensing applications.
In this context, Figure 1 summarized how a liquid gated graphene transistor, despite presenting a more defective structure according to the Raman characterization, also shows an improvement of the inter-device Dirac voltage variability after a laser treatment on the graphene surface. On the other hand, the low-frequency noise characterization of the device follows a flicker trend which does not show important current spectral density variations after the leaser treatment.

References

[1] K. S. Novoselov *et al.*, *Science*, vol. 306, no. *5696 (2004)*, pp. 666–9.
[2] K. S. Novoselov et al. *Nature*, vol. 490, no. 7419 (2012), pp. 192–200,
[3] C. W. Lee et al. *Front. Chem.*, vol. 7 (2019), pp. 1–21.
[4] N. Liu et al. *Sensors*, vol. 19 (2019) 15.
[5] A. Lipatov *et al.*, *Appl. Phys. Lett.*, vol. 104 (2014), p. 013114.

Figures

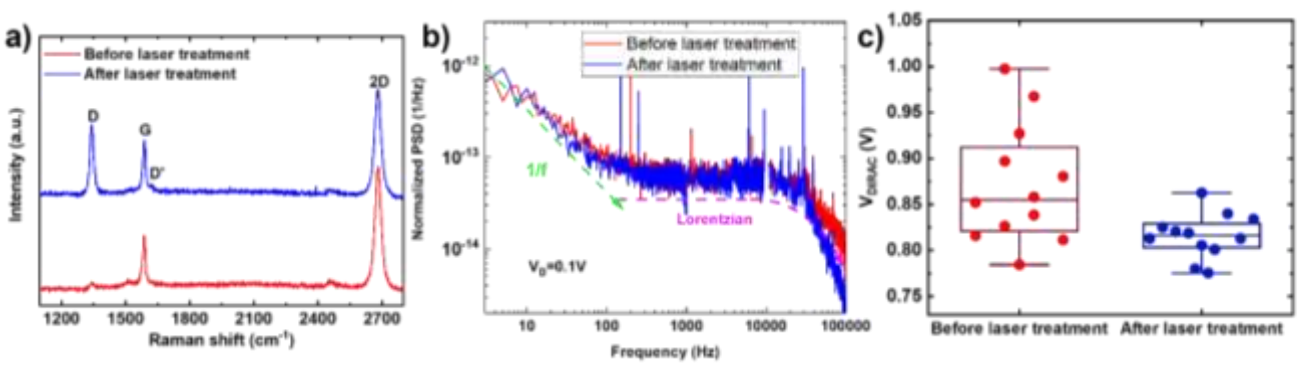

Figure 2: a) Raman characterization of a liquid-gate graphene sensor before and after a laser treatment on the graphene surface. b) Spectral density of the noise of the same device before and after the laser treatment. Inter device variability of the Dirac voltage.