Optimizing Graphene Photolithography for Biosensing Applications

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Graphene is one of the most promising materials for the future electronic devices due to its unique optical properties, superb conductivity, excellent mechanical strength and vast specific surface areas, which make the graphene a highly sensitive candidate for biosensing applications [1]. However, the reproducibility among devices can be challenging [2]. In this work, we carry out the fabrication and characterization of graphene-on-insulator transistors to understand the instability phenomena affecting the sensor performance and to improve its reliability. The fabrication process consists of the evaporation of Cr/Au contacts on silicon substrates and the transfer of a graphene monolayer using a thermal release tape. Graphene is lithographed to design the transistors, and finally partially passivated using deposited Al_2O_3 to avoid any potential drain/source shortcut when using a liquid gate. The design of the wafers is shown in Figure 1.a. The devices fabrication and photolithography were performed following different strategies: 1) graphene transfer, wet etching for contact patterning and wet etching for passivation with a 50nm-thick Al_2O_3 layer; 2) HMDS treatment on SiO_2/Si wafer, graphene transfer, wet etching for contact lithography and wet etching for passivation with a 50nm-thick Al_2O_3 layer; 3) direct contact deposition using hard mask, graphene transfer and HMDS treatment before the lift-off process for passivation with a 30nm-thick Al_2O_3 layer. The electrical characterization of several sensors for the three strategies was performed employing PBS 0.001X as the front-gate, V_D=50mV, V_G from 2V to -1 V at ambient conditions (Figure 1.b, c and d). As observed, Dirac voltage (voltage at current minimum) has a significant dependence on the specific fabrication process. For example, using HMDS or lift-off can imply an increase in the total charge (higher Dirac voltage). Processing also seems to have influence on the inter-device variability. These results open the door to optimize the fabrication/lithography processes and strike the balance between variability or absolute V_{Dirac} values depending on the specific biosensing application.

References

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[2] A. Pirkle; J. Chan; A. Venugopal; D. Hinojos; C. W. Magnuson; S. McDonnell; L. Colombo; E. M. Vogel; R. S. Ruoff; R. M. Wallace, Applied Physics Letters, 12 (2011) 122108.

Figures

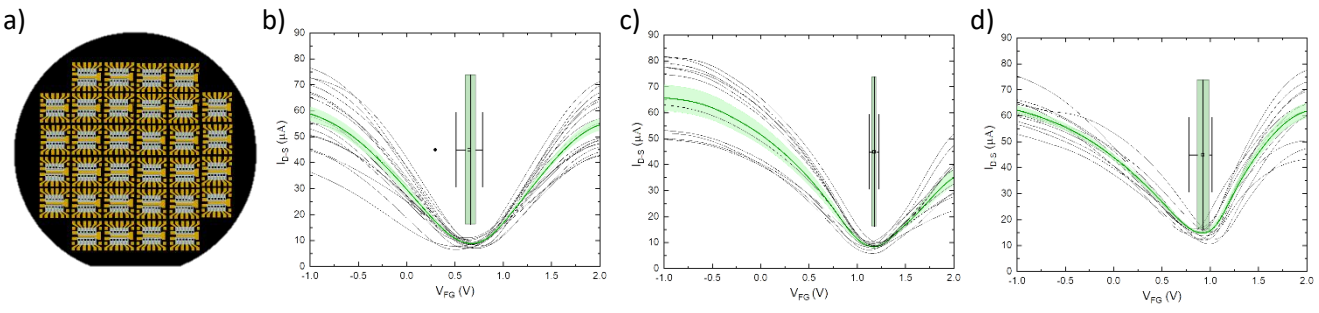

Figure 1: a) 100mm-wafer scheme with 24 dies and 12 sensors per die. Electrical characterization using liquid-front gate (V_{FG}) for strategies 1 **(b)**, 2 **(c)** and 3 **(d)**. Mean and standard error values of the current are presented in green, and of the Dirac point in the box chart.