Positive and Negative Electric Field Sensing in Graphene

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Sensing lightning accurately and its early detection is of utmost importance to develop reliable lightning protection systems. Lightning is the discharge of charges accumulated on the cloud to the ground. This accumulation of opposite charges on the cloud and ground results in an electric field between them. Thus to detect lightning, we need to have an efficient electric field sensor. In this study, we develop an electric field sensor based on monolayer graphene for both positive and negative electric fields. The mechanism of electric field sensing is as follows. Under an electric field, electrons in the Si substrate redistribute and move either to the bottom of the Si or to the Si/SiO2 interface. The electrons at the interface induce holes in the graphene channel as a result of capacitive coupling. This results in an increase in the drain current in graphene under an external electric field [1-3].

Figure 1(a) shows the schematic representation of a graphene device under an external electric field. Here the plate is negatively charged and hence the field is directed towards it. The working distance between the top plate and the device is 2 cm. We used exfoliated graphene to have high carrier mobility. Figure 1(b) shows the effect of electric field on the drain current in graphene device. When the electric field is ON, the device shows a larger source-drain current compared to the case when the field is OFF. For a source-drain voltage of 1 mV, the current dropped for 915 nA when the field was ON to 890 nA when the field is turned OFF. Thus it can be said that the electric field induced a 2.8% increase in the source-drain current. Thus we performed measurements for various voltages and calculated the percentage increase in the drain current $((I_{field} - I_0)/I_0)$ under external electric field (Figure 1(c)). The percentage increase in the current increase linearly with applied voltage as anticipated. Similar results were also obtained for sub-kV measurements as well. We have also performed measurement for positive electric field. More details will be presented in the conference.

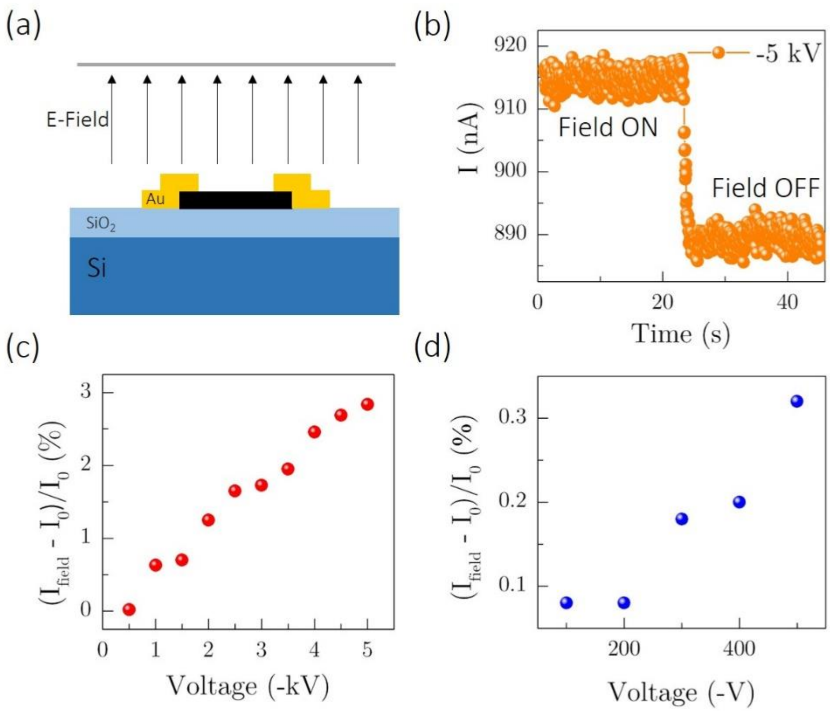

Figure 1: (a) Schematic diagram showing the graphene device under an external electric field. (b) The drain current increases when the electric field is turned ON and reduces immediately when the field is turned OFF. The source-drain voltage applied is 1mV. (c) and (d) The percentage increase in the drain current at various voltages.

References: [1] W. Wang *et al.*,IEEE Electron Device Letters, 38, 1136, 2017. [2] Xitao Guo *et al.*,Optica 3, 1066, 2016. [3] L. Tao *et al.*,IEEE Electron Device Letters, 39, 987, 2018.

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