Graphene Ferroelectric Field-effect Transistors: Up-scaling and Practicality

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Graphene is a two-dimensional material with many foreseen promises for opto-electronic applications. Chemical vapor deposition (CVD) of graphene on top of metallic foils is a technologically viable method of graphene production. Conventional photolithography and deposition of metal contacts on top of the transferred graphene layer to fabricate microelectronic devices is potentially invasive for graphene, and yields large spread in device parameters, and can inhibit up-scaling.
In this contribution, we demonstrate an alternative process technology in which both lithography and contact deposition on top of graphene are prevented. First a pre-patterned substrate is fabricated that contains all the device layouts, electrodes and interconnects. Then CVD graphene is transferred on top. Processing parameters are adjusted to yield a graphene layer that adopts the topography of the pre-patterned substrate. The metal–graphene contact shows low contact resistances below 1 kΩ µm for CVD graphene devices. The conformal transfer technique is scaled-up to 6” wafers with statistically similar devices and with a device yield close to unity. Conformal transfer is a generic process and can be applied for the transfer of any two-dimensional material.

Next, we demonstrated functional graphene devices, namely graphene ferroelectric field-effect transistors (GraFeFET) using the conformal transfer technique. As ferroelectric gate we used ferroelectric polymer, poly(vinylideneflouride-trifluoroethylene) (P(VDF-TrFE)). Device processing was optimized to obtain robust, highly reproducible GraFeFETs that operates at both electron and hole accumulation regimes. We present further dual-gated GraFeFETs wherein the on/off ratio can be controlled by a second non-ferroelectric gate.

Finally we present a model that captures the device physics of (dual-gate) GraFeFETs by incorporating the polarization of the ferroelectric gate. We predict, based on the model practicality of the graphene ferroelectric field-effect transistors.