Polymer coating and stress test for carrier density stabilization in epitaxial graphene on SiC

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Homogeneous monolayer epitaxial graphene (EG) grown on SiC is an ideal candidate for the development of the quantum Hall resistance (QHR) standard [1]. A clean fabrication process [2] has been used to produce EG-QHR devices with EG free of contamination from photoresist, but exposed to ambient air after the fabrication. Compared to ungated EG devices produced by other methods, the as-fabricated EG devices have a reduced n-type doping level of $<10^{12}$ cm^{-2} due to a p-type molecular doping process initiated by the nitric acid treatment during the last fabrication step, and thus can provide precise metrological accuracy at the v=2 plateau in a moderate magnetic field (< 9 T). However, the v=2 plateau value may deviate from $h/(2e^2)$ if the carrier density shifts close to the Dirac point ($<10^{10}$ cm^{-2}) due to the p-type dopants adsorbed from the air. Here we report the first results on polymer coating methods that preserve a stable level of carrier density in chemically-doped EG, as shown by controlled environmental conditioning, along with measurements of longitudinal resistivity, carrier density and mobility at low temperatures in a 9 T superconducting magnet cryostat and measurements of surface conductance in a resonant microwave cavity at room temperature. At 1.5 K, the carrier densities of our EG devices coated with 720-nm-thick parylene C were stabilized at (5-10) x 10^{11} cm^{-2} after the first 24-hour 60°C-85% cycling in an environmental chamber, while the resistivity typically stabilized between 3 and 5 kΩ. Consistently, the room-temperature surface conductance of EG also stabilized near $\sigma_{xx} \approx 2 \times 10^{-4}$ S ($\rho_{xx} \approx 5$ kΩ) after the same 24-hour temperature-humidity cycling. Furthermore, we will present results on parylene C, Cytop and PMMA coating and show how each polymer encapsulation method affects the problem of carrier density instability caused by atmospheric doping.

References

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