Gate electrostatics and quantum capacitance in ballistic graphene device

We experimentally investigate the charge induction mechanism across gated, narrow, ballistic graphene devices with different degrees of edge disorder. By using magnetoconductance measurements as the probing technique, we demonstrate that devices with large edge disorder exhibit a nearly homogeneous capacitance profile across the device channel, close to the case of an infinitely large graphene sheet. In contrast, devices with lower edge disorder (< 1 nm roughness) are strongly influenced by the fringing electrostatic field at graphene boundaries, in quantitative agreement with theoretical calculations for pristine systems. Specifically, devices with low edge disorder present a large effective capacitance variation across the device channel with a nontrivial, inhomogeneous profile due not only to classical electrostatics but also to quantum mechanical effects. We show that such quantum capacitance contribution, occurring due to the low density of states (DOS) across the device in the presence of an external magnetic field, is considerably altered as a result of the gate electrostatics in the ballistic graphene device. Our conclusions can be extended to any twodimensional (2D) electronic system confined by a hard-wall potential and are important for understanding the electronic structure and device applications of conducting 2D materials.

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