Sensitivity analysis explains quasi-one-dimensional current transport in two-dimensional materials

We demonstrate that the quasi-one-dimensional (1D) current transport, experimentally observed in graphene as measured by a collinear four-point probe in two electrode configurations A and B, can be interpreted using the sensitivity functions of the two electrode configurations (configurations A and B represents different pairs of electrodes chosen for current sources and potential measurements). The measured sheet resistance in a four-point probe measurement is averaged over an area determined by the sensitivity function. For a two-dimensional conductor, the sensitivity functions for electrode configurations A and B are different. But when the current is forced to flow through a percolation network, e.g., graphene with high density of extended defects, the two sensitivity functions become identical. This is equivalent to a four-point measurement on a line resistor, hence quasi-1D transport. The sensitivity analysis presents a formal definition of quasi-1D current transport, which was recently observed experimentally in chemical-vapor-deposition graphene. Our numerical model for calculating sensitivity is verified by comparing the model to analytical calculations based on conformal mapping of a single extended defect.

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