Enhanced mobility of semiconducting graphene nanoribbons in nonlinear transport regime

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Abstract

The calculated electron mobility for a graphene nanoribbon as a function of applied electric field has been found to have a large threshold field for entering a nonlinear transport regime. This field depends on the lattice temperature, electron density, impurity scattering strength, nanoribbon width and correlation length for the line-edge roughness. An enhanced electron mobility beyond this threshold has been observed, which is related to the initially-heated electrons in high energy states with a larger group velocity. However, this mobility enhancement quickly reaches a maximum due to the Fermi velocity in graphene and the dramatically increased phonon scattering. Super-linear and sub-linear temperature dependence of mobility seen in the linear and nonlinear transport regimes. By analyzing the calculated non-equilibrium electron distribution function, this difference is attributed separately to the results of sweeping electrons from the right Fermi edge to the left one through the elastic scattering and moving electrons from low-energy states to high-energy ones through field-induced electron heating. The threshold field is pushed up by a decreased correlation length in the high field regime, and is further accompanied by a reduced magnitude in the mobility enhancement. This implies an anomalous high-field increase of the line-edge roughness scattering with decreasing correlation length due to the occupation of high-energy states by field-induced electron heating.