Ballistic mobility and saturation velocity in low-dimensional nanostructures

Abstract

Ohm's law, a linear drift velocity response to the applied electric field, has been and continues to be the basis for characterizing, evaluating performance, and designing integrated circuits, but is shown not to hold its supremacy as channel lengths are being scaled down. In the high electric field, the collision-free ballistic transport is predicted, while in low electric field the transport remains predominantly scattering-limited in a long-channel. In a micro/nano-circuit, even a low logic voltage of 1 V gives an electric field that is above its critical value εc (ε≫εc) triggering non-ohmic behavior that results in ballistic velocity saturation. The saturation velocity is an appropriate thermal velocity for a non-degenerate and Fermi velocity for a degenerate system with given dimensionality. A quantum emission may lower this ballistic velocity. The collision-free ballistic mobility in the ohmic domain arises when the channel length is smaller than the mean free path. The results presented will have a profound influence in interpreting the data on a variety of low-dimensional nanostructures.