Charge transport properties of semiconductor nanowires within the Kubo-Greenwood and Landauer-Büttiker approaches.

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Semiconductor nanowires are promising building blocks for one-dimensional physics and nanoelectronics. They have indeed shown remarkable properties. Ballistic transport has for example been achieved in Si/Ge core-shell nanowires [1]. Various devices such as resonant tunnelling diodes [2], biological sensors [3] and single-electron transistors [4] have moreover been realized in just a few years using these nanowires. However, little is known about the physics of these devices. The effects of disorder for example have not yet been assessed in detail.

We are computing the transport properties of semiconducting nanowires using the Kubo-Greenwood and Landauer-Büttiker formalisms in a semi-empirical tight-binding framework. Both formalisms have previously been sucessfully applied to carbon nanotubes [5,6]. In the Kubo-Greenwood approach, a wave packet is propagated along an infinite (disordered) nanowire. The spread of the wave packet gives access to the "intrinsic" transport properties of the nanowire, such as the mean free path, the localization length and the mobility as a function of the Fermi energy. The Landauer-Büttiker approach yields the transmission through a nanowire connected to source and drain electrodes. The combination of both approaches will ultimately allow to distinguish between intrinsic and contact-related effects in the $I(V)$ characteristic of a nanowire-based transistor. We are also comparing the results of both approaches on disordered nanowires.

We are presently studying the effect of surface roughness on the transport properties of silicon nanowires. This disorder is characterized by the rms of the radius fluctuations, $<\delta R^2>^{1/2}$, and by the typical length scale L_0 of these fluctuations along the nanowire (see Fig. 1). We have computed the mean free path and mobility as a function of these parameters. We will later consider other kind of relevant disorders (trapped charges, dopants).

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Figures:

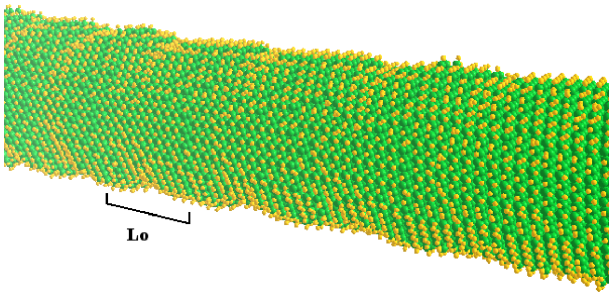

Fig. 1 : A nanowire (average radius R = 2 nm) with surface roughness.