Scrolled Si/SiGe heterostructure as a building block for a tube-like field-effect transistor

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Rolled-up structures fabricated due to self-scrolling of a sequence of Si and SiGe layers detached from the Si substrate by selective etching, are fascinating nano-objects with complex strain distribution that might demonstrate unique transport phenomena in both conduction and valence bands [1]. Recently, *p*-type modulation doping has been demonstrated in those structures [2], which could be used to create a 2D hole gas in the Ge_xSi_{1-x} layer with a density controlled via a perpendicular electric field.

Here, we report on a Monte Carlo study of the low-field hole mobility along the axis of scrolled SiGe heterostructures. We consider a scrolled tube formed by a bilayer consisting of Si and $Si_{1-x}Ge_x$ layers grown on (001) Si-substrate (see Fig. 1). For the modeling of the hole transport, we first determine the strain in a stationary configuration using linear elasticity theory and minimizing the strain energy of the bilayer. Second, we calculate the valence band structure by solving coupled Poisson and Schrödinger equations within the envelope function and effective mass approximations. Third, we employ the one-particle Monte Carlo method to simulate hole motion in a static electric field applied along the tube axis and take into account the most relevant scattering mechanisms, namely acoustic and optical phonon scattering and interface roughness. We calculate the low-field hole mobility at low lattice temperature (10 K) as a function of Ge content and Si/SiGe layer widths. We find that the interface roughness scattering substantially reduces the hole mobility and acts as the main scattering mechanism. However, increase in the width of the SiGe layer is accompanied by substantial increase in the hole mobility, which reaches the value of 10^4 cm^2/Vs.

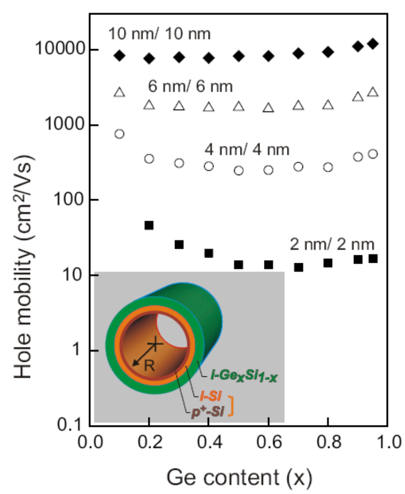

FIG. 1. Low-field hole mobility *vs*. Ge content *x* for the different thicknesses of Si and $Si_{1-x}Ge_x$ layers. Doping of the Si layer ensures the hole density in the SiGe of 10^{11} cm^{-2}; inset shows sketch of a Si/GeSi scrolled structure.

1. V. Ya. Prinz *et al*., *Physica E* **6**, 828 (2000).
2. J. Yukecheva *et al*., *Semicond. Sci. Technol.* **23**, 105007 (2008).