Enhanced Valley Splitting in Silicon Nanowires and Point Contacts

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Splitting between equivalent valleys larger than the spin splitting is reported in a laterally confined electron system in thin Si films grown on SiGe substrate. We demonstrate that the enhanced splitting can be explained within a simple model of the conduction band structure in silicon. Our results are in good agreement with recent first-principle calculation data.

Due to the weak spin-orbit coupling and long spin lifetime silicon, which is the main material of modern microelectronics, is becoming attractive for spin-driven applications. However, in order to separate the spin degree of freedom from the valley quantum numbers, valley degeneracy between the equivalent minima must be lifted controllably. Valley splitting in a Si film grown on a SiGe substrate is found to be smaller [1] than predicted theoretically [3]. This is attributed to a slight misalignment of the SiGe/Si interface from the (001) direction [1,3]. However, in a point contact the valley splitting is enhanced [1]. This is attributed to the presence of atomic steps [1,3] at the quantum well interface between the plateaus of (001) orientation. If an electron system is laterally confined within a plateau, the large valley splitting at (001) interface is recovered [3].

We demonstrate that there is another contribution to large valley splitting in a laterally confined electron system in silicon. This contribution is due to a peculiarity of the conduction band structure well captured within the two-band **k·p** model [4]. The valley splitting dependence on thickness in a [110] oriented square nanowire with (001) and (-110) interfaces is shown in Fig.1 and is in good agreement with the recent results of first-principles calculations [2]. Interestingly, the valley splitting in a [100] nanowire is predicted within our model to be significantly lower than in [110] nanowires, in agreement with [2]. Therefore, a comparison between the values of the valley splitting measured in [110] and [100] oriented point contacts formed by an additional lateral confinement of the electron system at the (001) silicon interface will reveal which of the two contributions to the enhanced valley splitting in the point contact is most important.

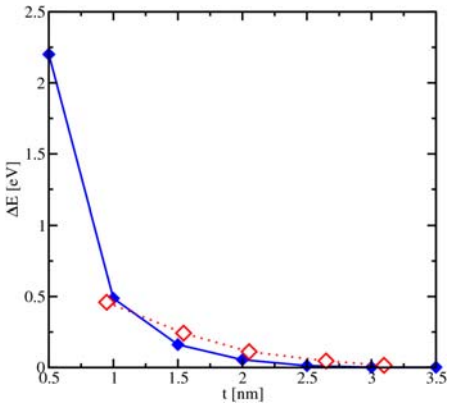

Fig.1*:* Calculated valley splitting in a [110] square nanowire as function of the wire thickness (filled symbols). Open symbols are from [2]

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