SPIN-SPLIT ONE-DIMENSIONAL SURFACE STATES ON VICINAL Si SURFACES

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Nanostructures that are supposed to be used in spintronics applications have to fulfill several conditions. Among most important is spin splitting of electronic bands at the Fermi level that is large enough at room temperature to prevent mixing of electrons with the opposite spins. In the present contribution we report on the existence of one-dimensional spin-split metallic states on vicinal silicon surfaces that reveal the largest splitting reported to now at room temperature.

A perfectly regular distribution of steps on a vicinal surface is prerequisite for a good quality of (quasi) one-dimensional nanostructures. The Si(553) surface has been used for this purpose as known to form an array of ordered steps even without any adsorbates [1]. However, in this case the electronic structure does not reveal dispersive and metallic bands, beside the surface state bands similar to those observed on Si(111)-(7x7). Quite different scenario occurs for the surface with the adsorbed Au or Pb atoms. They form either double atomic chains [2] (Si(553)-Au) or nanoribbons [3] (Si(553)-Pb) on each terrace of the vicinal surface.
The presence of the Au or Pb chain-like structures introduces parabolic-like one-dimensional surface states crossing the Fermi level. Due to the strong spin-orbit coupling the bands reveal considerable spin splitting of about 0.2 eV and 0.05 $Å^{-1}$ in case of Si(553)-Au [4] and much larger - 0.6 eV and 0.2 $Å^{-1}$ in case of Si(553)-Pb [5] at the Fermi level. The reason for the difference is a significant anisotropic electron charge distribution around Pb nuclei in the latter case which is caused by the unusual arrangement of the Pb atoms on terraces of vicinal surface [5,6]. It introduces a strong in-plane potential gradient what increases spin splitting of the surface states and the appearance of the out-of-plane component of the polarization vector. The weak interaction between Pb and Si atoms makes the spin-split states well-decoupled from the substrate what should assure pure spin currents in future spintronic devices.

Keywords: Spintronics; vicinal Si; Rashba effect

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