Carrier transport in heavily Sb-doped Si layers near the Mott transition

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We studied spin-resolved components of resistivity tensor ρ_{xx}(T,B) and ρ_{xy}(T,B) and magnetization M(T,B) on temperature T and magnetic field B in thin epitaxial Si layers heavily doped with Sb which were initiated by spins arised on paramagnetic “dangling bonds” at the Si<Sb> layers surface when epitaxial growing process. The Si<Sb> 10-12 nm thick layers were epitaxially grown on the p-Si(001) 12 Ω×cm substrate covered with 100 nm thick lightly-doped buffer and capping Si layers [1]. Studies have shown the following 3 features of ρ_{xx}(T,B) and ρ_{xy}(T,B) dependences in Si<Sb> layers: (1) ρ_{xx}(T,B) and ρ_{xy}(T,B) dependences in samples without capping Si layer includes 2 contributions: (1) from Sb impurity in Si<Sb> layer bulk and (2) from “dangling bonds” on Si<Sb> layer surface. As a result, the Hall resistance component is described by the relation ρ_{xy}(T,B) = R_oB + R_aM, where R_o and R_a are the ordinary (OHE) and anomalous (AHE) Hall effect constants, respectively, M is the magnetic moment of paramagnetic centers and ρ_{xx}(T,B)$\sim B^2$. (2) Below 10-15 K, our measurements have shown a linear change of σ_{xx} with L_n(T) that is typical for weakly disordered two-dimensional (2D) semiconductors and metals and is described by the interference quantum corrections (QC) to the Drude conductivity in weakly-localized systems [3]. The QC contribution to low-T ρ_{xx}(T,B) is also confirmed by its suppressing at low values of B ∼ 0.1 T. (3) The estimation of the appropriate Thouless lengths L_{TH} from fitting of σ_{xx}(T,B) dependences has shown a power-like function $L_{Th}\sim T^{-p/2}$, where p is constant depending on the scattering mechanism of carriers [2]. The best agreement with the experimental data was achieved with p values close to 1 that corresponds to the 2D quantum corrections theory [3].

References:

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