Weak antilocalization in HgTe quantum wells with inverted and normal energy spectra

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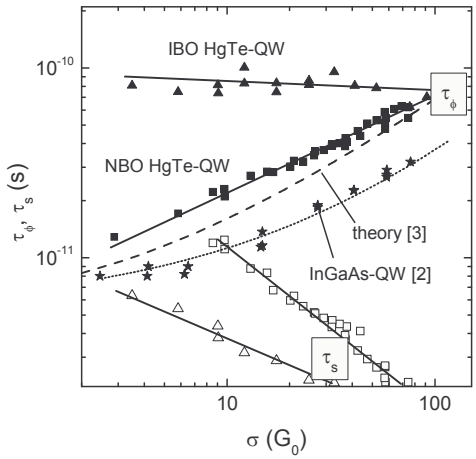
The energy spectrum of carriers in single CdTe/HgTe/CdTe quantum well depends drastically on the quantum well width (d) [1]. When thickness is small, $d < d_c \simeq 6.5$ nm, the energy spectrum is characterized by normal band ordering (NBO). It is analogous to that in conventional narrow-gap semiconductors; the highest valence subband at $k = 0$ is formed from the heavy hole Γ_8 states, while the lowest electron subband is formed both from the Γ_6 states and light hole Γ_8 states. For thicker HgTe layer, $d > d_c$, the quantum well is in inverted-band-ordering (IBO) regime; the lowest electron subband is formed from the heavy hole Γ_8 states, whereas the Γ_6 states sink into the valence band.

We present the results of experimental study of the magnetoconductivity of 2D electron gas caused by suppression of the interference quantum correction to the conductivity in HgTe single quantum well heterostructure both with inverted ($d \simeq 9.0$ nm) and with normal ($d \simeq 5$ nm) energy spectrum. Analyzing the shape of the magnetoconductivity curves on the gated Hall bars we obtain the temperature and conductivity dependences of the phase and spin relaxation times (τ_ϕ and τ_s, respectively) over the wide conductivity range, $\sigma = (3 - 130)\, G_0$, where $G_0 = e^2/\pi h$. We have found that the temperature dependences of τ_ϕ and τ_s demonstrate reasonable behavior independently of whether the quantum well is in IBO or NBO regime. The spin relaxation time is constant in the temperature as it should be for the degenerate electron gas. The T dependence of the phase relaxation time is close to $1/T$ that corresponds to inelasticity of electron-electron interaction as the main mechanism of the phase relaxation.



The key result of the report is the conductivity dependence of τ_ϕ shown in the figure. In the quantum well with NBO, it is analogous to that observed in conventional A_3B_5 based 2D system [2] and accords well with theoretical prediction [3]. In the quantum well in the IBO regime, the τ_ϕ value remains practically independent of the conductivity, indicating that the electron interference and/or dephasing processes in the 2D electron systems with inverted band ordering differs significantly from that in conventional systems.

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