Capacitance Studies of GaMnAs / GaAs Esaki diodes

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The GaMnAs / GaAs Esaki diode is an interesting system, in which the electrical properties of GaMnAs may be investigated in a non-standard way. In a typical parallel transport configuration current is passed in the plane of the layer and resistivity tensor is measured, which allows to find fundamental magnetic properties of the layer (e.g. the Curie temperature, magnetic anisotropies, etc.) [1, 2]. In this case the carriers participating in the transport are close to the Fermi energy. For GaMnAs being a part of a diode the situation is quite different. In this case, due to a possibility of tuning band alignment with voltage, different valence band states may contribute to the current, leading to such fine effects like tunneling anisotropic magnetocurrent [3-5].

In our previous studies of (Ga,Mn)As diodes with different Mn content [6] we have observed a qualitative difference between the I(V) curves of ferromagnetic and paramagnetic samples. In particular, ferromagnetic ones showed puzzling biexponenial dependence for forward bias, missing for paramagnetic samples where the current rise was much faster.

To understand these observations, we investigated electrostatic state of the samples by means of capacitance studies. The capacitance was measured as a function of bias at room temperature. The investigations provided us with basic parameters of the diodes, e.g. depletion layer width (DLW) and a built-in potential. The measured bias evolution of the DLW, showed a rapid decrease of the DLW with polarization for ferromagnetic samples, revealing the origin of the biexponenial I(V) curve. Moreover, the evaluation of the built-in potential allowed to estimate the position of the Fermi level in (Ga,Mn)As for different Mn contents. The results enabled to discuss the competing models of GaMnAs valence band structure.

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