Spin relaxation in low dimensional Si structures.

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A spintronic device is a structure which allows to handle not only the electron charge but also the electronic spin. Effective spin manipulation, however, is possible only if the spin life time is long enough. In that sense the problem of spin relaxation is one of the basic aspects of spin electronics. Generally, there are two strategies which can lead to a long spin life time. The first one is based on the persistent moment of ferromagnetic structures. Physics and technology of insulating and metallic nano-ferromagnets are already well known. Unfortunately, such elements cannot be easily manipulated by the tools of classical electronics, *i.e.*, by electric voltages. There is a hope that ferromagnetic semiconductors will be more useful. Unfortunately, the critical temperature of ferromagnetic semiconductors is still to low to think about any realistic application. The second spintronic strategy relies on nonmagnetic metals or semiconductors. In that case, in the absence of magnetic spins the spin life time of carrier can be long enough to think about a real application. Manipulation of the carrier is off course well developed by the classical electronics.

A very long spin relaxation time, of the order of milliseconds has been evidenced in III-V quantum dots (Kroutvar *et al.*, Nature 2004) and in various artificial single electron nano elements. There is also experimental evidence that a long spin relaxation can be found in 2d Si structures. These data indicate that two conditions are necessary to provide a long spin relaxation: a low density of states close to the ground state and a very weak spin orbit coupling. The long spin relaxation in single electron devices is related to the lack of states to which carrier spin can be scattered. Generally, long spin relaxation is expected to occur in low dimensional structures. The slow spin relaxation in Si structures originates from extremely weak spin-orbit coupling.

We undertake studies of the mechanisms of spin relaxation in low dimensional Si/SiGe structures. Detailed experimental and theoretical studies lead us to the conclusion that the D'yakono-Perel (DP) mechanism, caused by Bychov-Rasba spin-orbit field, is the dominant mechanism in high mobility 2D electron gas. The DP spin relaxation rate is proportional to the square of the BR field, which is caused by an asymmetry of the quantum well structure, and inversely proportional to the modulation of the electron velocity. In the classical DP mechanism the modulation frequency corresponds to momentum scattering. We show that for high mobility electrons the cyclotron motion can be also treated as an additional modulation frequency. Such a mechanism becomes effective when Landau quantization becomes effective, *i.e.*, when a gap in the density of sates occurs. Our analysis of spin relaxation in Si quantum dots shows that the wall scattering of electrons in quantum dots also contributes to the modulation of BR field leading to the suppression of the spin relaxation rate. Such contribution becomes effective when the confinement splitting is pronounced, *i.e.*, when the confinement energy is bigger than the natural energy width of the ground energy state.

In summary, we show that a simple classical mode of spin relaxation allows to follow spin relaxation with reduction of dimensionality from 3D to a single electron quantum dot.

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