Technological approach to vertical transport structures based on GaN epilayers

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Theoretical prediction suggest large spin filtering capabilities of spin filters and resonant tunneling diodes involving insulating ferromagnetic barriers. The tunneling spin-filter effect in a metal/ferromagnetic insulator/metal tunnel junction take place when electrons with randomly oriented spins tunnel from the Fermi level of the nonmagnetic metal through the spin-dependent barrier. The spin-split conduction band of ferromagnetic part creates a lower barrier height for spin-up electrons and higher barrier for spin-down electrons, giving rise to a highly spin-polarized current (Fig. 1).

In our approach to spin filtering concept we want to employ devices made of structures containing GaN:Si/(Ga,Mn)N/GaN:Si, where (Ga,Mn)N is a thin ferromagnetic layer and the whole stack is epitaxially grown on sapphire substrates. On the other hand the lattice mismatch between sapphire and GaN results in a sizable number of vertically oriented misfit-related threading dislocation which are highly conductive so they are shortening the researched nonlinear characteristics. One of the way to reduce this detrimental effect is to shrink the active area of the device to a micrometer-size range. Our current approach is schematically drawn in Fig. 2. We employ a mask made of a dielectric oxide (Al_2O_3 or HfO_2) deposited on the free surface of the structure by the atomic layer deposition method. In this ~50 nm thick insulating layer windows of 5 to 10 micrometers are defined by the lift-off method. These windows are now covered by a larger in diameter gold contacts which make only a local electrical contact with the GaN-based structure, yet they constitute a sufficiently large conductive platform to which electrical wires can be conveniently bonded. This technological effort is the first step towards elaboration of fully operational submicrometer devices.

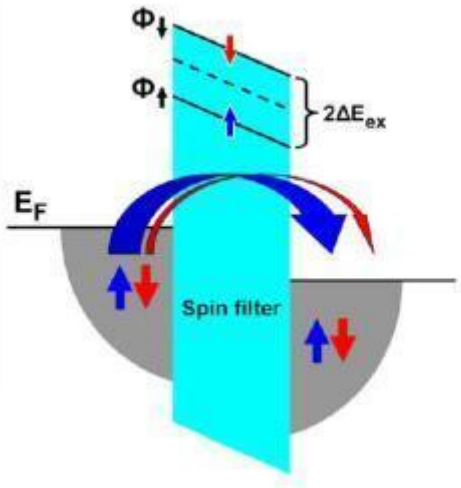

Figure 1: Scheme of the spin filter, tunneling through a spin dependent barrier.

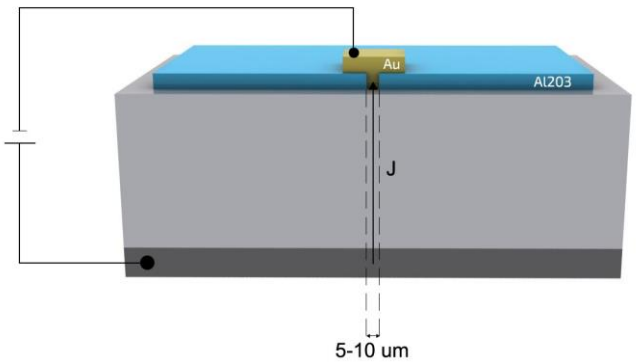

Figure 2: Scheme of the contacting of micrometer size vertical transport devices using an insulating oxide mask (gray-sample, blue-aluminum oxide, yellow-gold contact pads).