Electrical spin injection into semiconductor nanowires

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Semiconductor nanowires (NWs) offer compelling properties for nanoelectronics and spintronics. Foremost, they provide an intriguing bottom-up based alternative to the conventional design of VLSI circuits. Recently, Yan *et al.* [1] have demonstrated basic conventional logic elements based on semiconductor nanowires. With regard to spin such quasi-1D objects suggest an enhancement of spin lifetime [2, 3] while maintaining such important advantages of semiconductors as carrier density control and tunable spin-orbit interaction. On the downside, their geometry, preparation and manipulation introduce new challenges. That is why we have developed a novel technique that enables thin magnetic contacts to such narrow nanostructures, overcoming shadowing effects during the metal deposition and preventing pinning from obstructing magnetization switching. Figure 1(a) illustrates the device preparation, including NW planarization in HSQ (hydrogen silsesquioxane) spin-coatable resist, dry-etching steps and multiple e-beam lithography steps for contact definition via lift-off patterning.

The objects of study are the low-bandgap III/V-semiconductors InN and InAs. One inherent property of these materials is the electron accumulation layer at the surface, which in principle facilitates ohmic contacts. In order to maintain current spin-polarization across the interface between the ferromagnetic Co contacts and the NW, the conductivity mismatch is compensated by introducing a tunnel barrier at the interface via *in-situ* deposition of Al_2O_3 or MgO via molecular beam epitaxy. Theoretical predictions are presented for the interface resistance, necessary in order to obtain a significant, detectable, nonlocal spin signal. The spin accumulation is probed in a four-terminal nonlocal measurement geometry, confirming spin accumulation in the NWs – see Fig. 1(b).

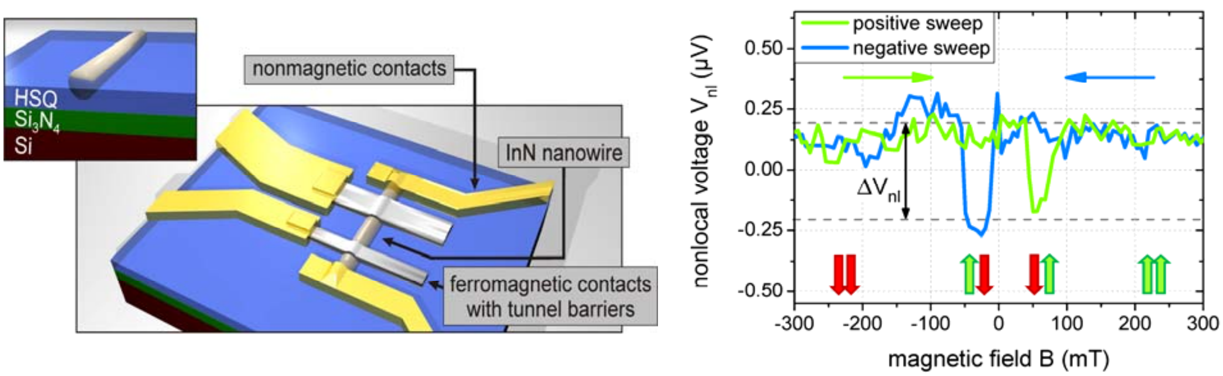

Fig. 1. (a) Illustration of the NW upon planarization (inset) and after contact deposition; (b) nonlocal spin-valve measurement on an InN nanowire (contact separation L = 200 nm).

1. H. Yan *et al.*, "Programmable nanowire circuits for nanoprocessors", *Nature* **470**, 240 (2011).
2. Th. Schäpers *et al.*, "Suppression of weak antilocalization in $Ga_xIn_{1-x}As$/InP narrow quantum wires", *Phys. Rev. B* **74**, 081301 (2006).
3. A. W. Holleitner *et al.*, "Suppression of spin relaxation in submicron InGaAs wires", *Phys. Rev. Lett.* **97**, 036805 (2006).