New materials and applications for magnetic tunnel junctions

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The discoveries of the Giant MagnetoResistance by Fert and Grünberg and a large tunneling magnetoresistance at room temperature by Moodera have triggered enormous research on spin dependent tunneling resistance, where a strong dependence of the tunneling current on an external magnetic field can be found. Within a short time, the quality of magnetic tunneling junctions (MTJs) increased dramatically as illustrated in fig.'s 1a and 1b by comparing results from 1999 and 2002.

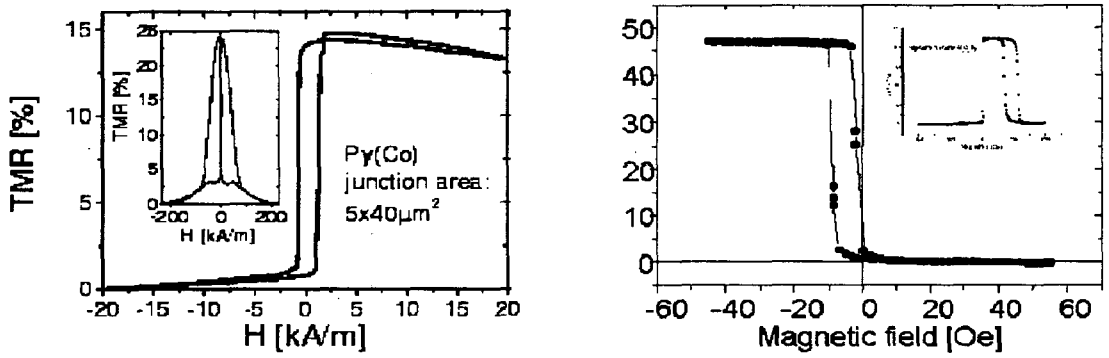

Figure 1: Resistance as a function of an external magnetic field (minor loops) for a tunneling junction Co/Cu/Co/Al_2O_3/$Ni_{80}Fe_{20}$ (left, 1999) and IrMn/CoFe/Ru/CoFe/Al_2O_3/$Ni_{80}Fe_{20}$ (2002). The TMR increased from about 15% to 45% (the insets show the corresponding major loops).

We will briefly address important basic properties of these junctions depending on the material stacking and then show new results obtained with the full Heusler alloy Co_2MnSi as one of the electrodes. A TMR value of larger than 80% at low temperature and 33% at room temperature with a barrier still not in an optimum state demonstrates the potential of theses alloys for MTJs. The last part will give a short overview on applications beyond the use of MTJs as storage cells in MRAMs. This concerns mainly field programmable logic circuits, where we demonstrate the clocked operation of a programmed AND gate. The second 'unconventional' feature is the use as sensing elements in DNA or protein biochips, where molecules marked magnetically with commercial beads can be detected via the dipole stray field in a highly sensitive and relatively simple way.