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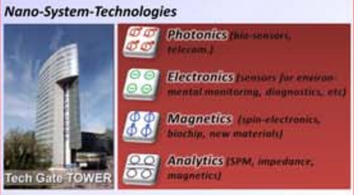

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SPIN TORQUE EFFECTS IN EXCHANGE BIASED SPIN-VALVE NANOCONTACTS

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Abstract

In this work we will report on spin torque experiments on point contact devices patterned by a combination of UV and e-beam lithography on top of spin valve multilayers. These were sputter-deposited and have the following structure: Cu(25)/IrMn(15)/Co$_{70}$Fe$_{30}$(5)/Cu(7)/Co$_{70}$Fe$_{30}$(2)/Ni$_{80}$Fe$_{20}$(5)/Ta(2)/Au(3).

The magnetic properties of the spin valves were optimized for large exchange bias of the bottom hard electrode and minimum magnetostatic coupling. The magnetoresistance in the current perpendicular-to-plane geometry is measured approximately 0.2 %.

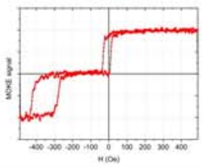
The magnetization precession is studied upon dc current excitation and applied magnetic field as a function of shape and size of the contacts. The latter consist of single circles with 80 or 100 nm diameter.

The results are compared with micro magnetic simulations using the OOMMF code.

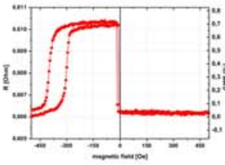
Spinvalve

Sputter deposited on Si/SiO$_2$(50): /Cu(25)/IrMn(15)/Co$_{70}$Fe$_{30}$(5)/Cu(7)/Co$_{70}$Fe$_{30}$(2)/Ni$_{80}$Fe$_{20}$(5)/Ta(2)/Au(3)

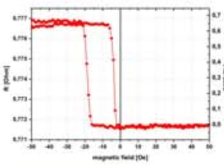
MOKE



CIP transport major



CIP transport minor

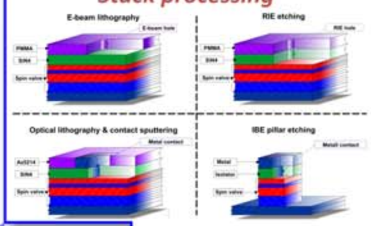


- Annealing at 270°C; 15min; H=250 Oe
- Large exchange bias field for the fixed layer: Hex=350 Oe
- Free layer coercivity: H_c=5 Oe
- Neel coupling: H_N=10 Oe
- CIP GMR 0,7 %

Point Contacts

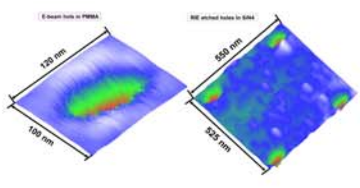
SiN$_x$ PCVD deposited, RIE etched and metal sputter deposited on spin valve : SiN$_x$(70)/Ta(10)/Al(150)/Ta(10)/Au(150)

Stack processing



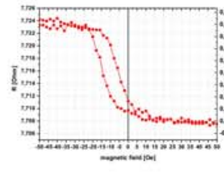
Point contacts patterned by a combination of UV and e-beam lithography on top of sputter deposited spin valve multilayers.

AFM measurements



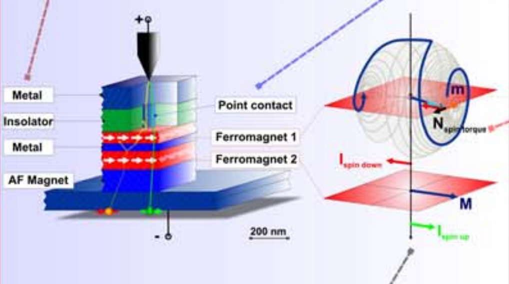
Contacts were characterized by AFM. They consist of single ellipses with an aspect-ration of 1 to 3 and short axis length of 10-100 nm, as well as arrays of ellipses.

CPP Transport measurements



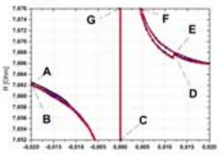
CPP transport measurements on the structure shows a resistance of ~ 7-8 Ohm and a magneto resistance change ~ 0.2 %. The present sample shows orange Peel coupling of ~10 Oe.

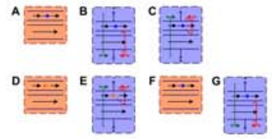
Basic Principle



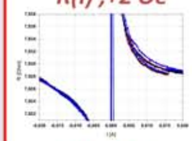
Switching & Excitation

R(I), 80 nm contact

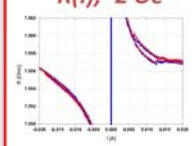




R(I) ,+2 Oe

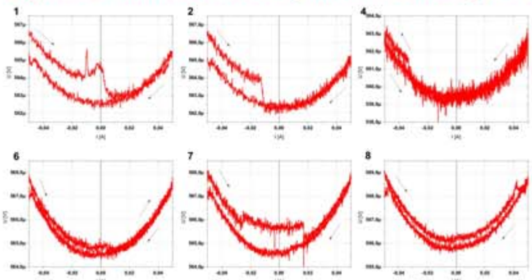


R(I), -2 Oe

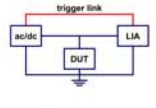


- Background hyperbola curve is an multimeter artefact for low bias
- Resistance jumps observed for positive current of I=12 mA - current density 2.4E12 A/m²
- Distinct jumps are not observed for negative current - gradial switching?
- Position of jumps for positive current depend on external field

dV/dI lockin measurements, 100 nm contact, 0 Oe



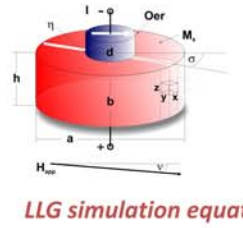
Lockin setup



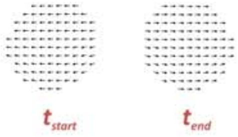
dV/dI measurement setup with ac/dc source and lockin-amplifier

- Successive measurements from the same nanocontact show distinct dynamic resistance rumps at different current densities
- Resistance changes in the order of 0.1-0.3% corresponding to the measured MR vs field

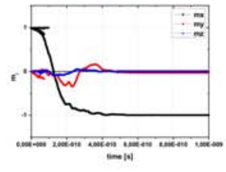
OOMMF Simulations



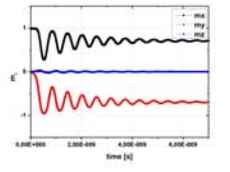
Magnetization dynamic $\vec{M}(t)$



M(t), 80 nm contact diameter



M(t), 100 nm contact diameter



LLG simulation equation

$$\frac{d\mathbf{m}}{dt} = -\gamma_0 M_s\left\{\mathbf{m}\times\left[\mathbf{h}_{exch}+\mathbf{h}_{mas}+\mathbf{h}_d+\mathbf{h}_{Oe}+\frac{\tau^{-1}}{\gamma_0 M_s}\mathcal{P}(\mathbf{m}\times\mathbf{p})\right]\right\}$$

$$\tau^{-1}=\frac{g|\mu_B|}{M_s}\frac{1}{d}\frac{I_e}{|e|} \qquad \eta=\frac{n_\uparrow-n_\downarrow}{n_\uparrow+n_\downarrow} \qquad \mathcal{P}=\mathcal{P}(\eta,\mathbf{m}\cdot\mathbf{p})$$

$$\mathbf{m}=\mathbf{M}/M_s \qquad \mathbf{h}=\mathbf{H}/M_s$$

- OOMMF Simulation parameters: xy-cellsize 3.6E-9 nm, z-cellsize 3E-9 nm, element diameter 80 nm and 100 nm, layer thickness 7 nm, current -0.012 A and -0.001 A, Happ 0 Oe, layer magnetization 1.1E6 A/m², coupling parameter A 2E-11 J/m, spin polarization 0,5669, theta 1°
- The magnetization of d=80 nm circles can be switched @ 12 mA
- Magnetization precession occurs for low currents for discs of d=100 nm

Acknowledgements

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