Influencing interface related magnetic properties of NiO and (Fe)Ni by tailoring nanostructures with Severe Plastic Deformation

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The exchange bias(H_{eb}) was first discovered by Meiklejohn[1] on Co-CoO nanoparticles in 1956 and was introduced as a new magnetic anisotropy. H_{eb} was related to a coupling of spins over phase interface of an antiferromagnetic and ferromagnetic material. A large variety of studies was done to get a better insight into this phenomenon, but still a good general theory for a detailed description is missing. One can say, that H_{eb} has its origin truly in the nanoscale region and is not observed, if phase dimensions get too large.
Nevertheless, H_{eb} coupling between two different magnetic phases is used in a variety of magnetic sensors like giant-magnetoresistive (GMR) or tunneling-magnetoresistive (TMR) sensors made by thin film deposition, which are still largely used in magnetic hard drives.
Due to the nanoscale origin of H_{eb}, high pressure torsion (HPT) a method belonging to severe plastic deformation (SPD) techniques was used in this study to process bulk nanocomposites from initial powders of (Fe)Ni as ferromagnetic and Nickeloxid (NiO) as antiferromagnetic phase. With HPT it was not only possible to process powders with different initial compositions, but also to tailor the obtained nanostructure and magnetic properties via applied strain. Ball milling as an additional powder preparation step allowed to increase NiO content over 55 wt% for HPT processing.
SQUID-magnetometry revealed a significant H_{eb} at low temperatures of 8K. At room temperature (RT) thermal fluctuation causes a decrease of H_{eb}. According to reports from bilayer studies H_{eb} has a high sensitivity to the thickness of ferromagnetic phase and just at the lower end of nanoscale regime (<10nm) a significant H_{eb} was detected. The dimensions of HPT processed nanocomposites are in a similar range and therefore H_{eb} was also observed at RT for a variety of compositions.
Further a tailoring of the magnetic properties was realized and an increase of H_{eb} over applied strain even at RT was documented. Annealing of nanocomposites lead to an enlargement of FM-phase and therefore to a decrease of H_{eb} at 8K.

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[1] W.H. Meiklejohn, Phy. Rev. Vol.102 No. 5(1956) 1413-1414

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