Magnetoresistive and Magnetostrictive Properties of Nanocrystalline, Severe Plastically Deformed Materials

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High pressure torsion (HPT), a method of severe plastic deformation is a well-known method to refine the microstructure of bulk materials. Starting from either bulk materials or powder mixtures of binary or ternary compositions nanocrystalline, single phase materials or multi-phase nanocomposites are produced. Metastable supersaturated states might also be the outcome. In this case, the thermal stability is of especial importance. In general, HPT-processed materials show interesting functional properties due to their refined microstructure. Focussing on magnetic properties, strong microstructural influences can e.g. be found for the coercive field dependence or the occurrence of exchange coupling phenomena between phases of different magnetic properties.

For this study, HPT-processed and annealed materials, bulk materials as well as binary and ternary powder mixtures with varying fractions of ferromagnetic and non-ferromagnetic elements were processed. Besides microstructural investigations, the room temperature magnetoresistive and magnetostrictive properties were investigated in magnetic fields up to 2.2T, using purpose-made experimental setups.

Regarding the resistive properties: Nanocomposites involving small and non-percolating ferromagnetic particles result in giant magnetoresistance. With increasing ferromagnetic content and consequently percolating ferromagnetic phases, there is a transition towards anisotropic magnetoresistance. Adequate thermal treatments are able to increase the giant magnetoresistive effect.

Magnetostrictive measurements show the capability to produce on the one hand low-magnetostrictive materials (Fe-Cu, ~0ppm) and on the other hand materials of increased magnetostriction (Fe-Cr, up to 21ppm), when compared to pure Fe.

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