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FeCr Composites Processed by Multiple High-Pressure Torsion Steps

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The occurrence of a magnetic exchange coupling (exchange bias) effect is predicted for interfaces between ferromagnetic Fe and antiferromagnetic Cr. Exchange bias has been investigated to a greater extent for thin film materials but it also takes place in bulk materials. Therein, phase refinement results in a decreasing distance between ferro- and antiferromagnetic phases and an increased interface-to-volume ratio strengthens the effect. In total, this might result in a horizontally shifted hysteresis and therefore in an increased energy product, improving the magnetic performance.

In this study, the deformation behavior of binary, equiatomic Fe-Cr samples during severe plastic deformation by high-pressure torsion (HPT) is investigated. Processing Fe-Cr samples remains a challenge due to a strong increase in hardness, limiting HPT-deformation. The formation of the undesired sigma-phase has to be avoided. In a simple, one-step HPT process, the formation of supersaturated solid solutions was found instead. To impede the formation of a single phase material, a multi-stage HPT technique is developed by consecutively using two HPT devices of different size. Between the deformation stages, the deformed and refined microstructure is maintained and stabilized against intermixing by long time annealing treatments. The influence of the multistage process on the resulting microstructures is extensively studied by hardness measurements and electron microscopy investigations. Magnetic measurements are linked to the microstructure of the deformed Fe-Cr samples to establish a complete understanding of the HPT-deformation process, the resulting microstructures as well as their influence on magnetic properties.

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