INVESTIGATION OF A HIGH ANGLE GRAIN BOUNDARY IN FE2.4WT.%SI BCC MICROPILLARS

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Iron-silicon sheet steel is the most widely used material for the iron cores of electrical machines like generators, motors or transformers. Although already ubiquitous, the demand will nevertheless rise in the future since electro-mobility is spreading rapidly. For this reason, even small improvements of efficiency have a huge energy saving potential. Currently, hysteresis losses are one of the main limiting factors for efficiency, resulting from the movement of domain walls, which may be pinned by dislocations. Even though electrical sheet steel is generally used in a fully recrystallized state, it is the final stages of production involving cutting that introduce large plastic strains, and hence high local dislocation densities. These have been shown to cause significant loss in performance.

The aim of this work is to understand the evolution of deformation structures on a fundamental basis taking grain boundaries, size effects and different strain-rates into account. To this end, single- and bi-crystalline-micropillars of 1, 2 und 4 µm in diameter were investigated. 158 micropillars were deformed in order to provide a statistically-relevant dataset. In addition, macroscopic single- and bi-crystal-samples with a diameter of 2.5 mm were deformed as a reference for the size effect. The considered grain boundary has an angle of about 50° and a very high geometrical transmission factor (m'=0.89). Regarding the strain-rate-sensitivity three different strain rates were used for the deformation of the micro-/macroscopic single- and bi-crystals, with strain rate jump tests additionally conducted for the single-crystals. To visualize the deformation structure, selected micropillars were lifted out of the sample, thinned to the middle and analyzed utilizing EBSD.

For most micropillars a clear slip system could be determined. Regarding one orientation the active slip system changed from the single- to the bi-crystal, likely because the newly-activated slip system was better aligned relative to the slip system of the other half-crystal. The bi-crystal-micropillars showed a higher resolved shear stress despite direct slip transmission across the grain boundary. Furthermore, a pronounced strain-rate sensitivity and size effect was found.