Group Seminar

Theorie magnetischer Materialien

TECHNISCHE UNIVERSITÄT DARMSTADT

MATERIAL-WISSENSCHAFT

Dienstag, 20. Dezember 2022, 14 Uhr, L6|01 Raum 417

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A mechanically strong and ductile soft magnet with extremely low coercivity

Abstract:

Soft magnetic materials (SMMs) serve in electrical applications and sustainable energy supply, allowing magnetic flux variation in response to changes in applied magnetic field, at low energy loss1. The electrification of transport, households and manufacturing leads to an increase in energy consumption owing to hysteresis losses2. Therefore, minimizing coercivity, which scales these losses, is crucial3. Yet meeting this target alone is not enough: SMMs in electrical engines must withstand severe mechanical loads; that is, the alloys need high strength and ductility4. This is a fundamental design challenge, as most methods that enhance strength introduce stress fields that can pin magnetic domains, thus increasing coercivity and hysteresis losses5. Here we introduce an approach to overcome this dilemma. We have designed a Fe–Co–Ni–Ta–Al multicomponent alloy (MCA) with ferromagnetic matrix and paramagnetic coherent nanoparticles (about 91 nm in size and around 55% volume fraction). They impede dislocation motion, enhancing strength and ductility. Their small size, low coherency stress and small magnetostatic energy create an interaction volume below the magnetic domain wall width, leading to minimal domain wall pinning, thus maintaining the soft magnetic properties. The alloy has a tensile strength of 1,336 MPa at 54% tensile elongation, extremely low coercivity of 78 Am-1 (less than 1 Oe), moderate saturation magnetization of 100 A m2 kg−1 and high electrical resistivity of 103 μΩ cm. The microstructure of the MCA is also investigated using density functional theory (DFT) + finite-difference discretization micromagnetic simulation program (Mumax3) to understand the underlying physics of MCA.

Alle Interessierten sind herzlich eingeladen