The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Numerical study of finite element based micromagnetic phase-field simulations of heterogeneous microstructures

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Keywords: *Micromagnetic Simulations, Finite Element Method, Microstructure*

With the advancing development of technical devices, the demand for powerful magnetic materials is increasing. A composition of magnetic grains and a decoupling non-ferromagnetic boundary layer can lead to an improvement in coercivity [1]. This shows the great potential of microstructure optimization. Micromagnetic simulations are often used to predict the magnetization distribution on fine scales and finite elements are particularly suited for the precise discretization of microstructures compared to other methods. To capture the correct material behavior of the magnet, the enthalpy functional needs to contain all necessary contributions, like the magnetostatic energy, the exchange energy, crystalline anisotropy and the elastic energy. The evolution of the magnetization vectors is described by the Landau-Lifshitz-Gilbert equation. This equation requires the conservation of the magnetization vector length during the simulation. Since this is not fulfilled intrinsically, different methods of conserving the constraint have been developed, such as the use of penalization strategies [2], exponential updates [3] or spherical coordinates [4]. All of the methods mentioned have advantages, but also disadvantages. In this contribution the results of finite element based micromagnetic simulations of heterogeneous microstructures are presented. Here, the focus lies especially on the analysis of their magnetic and mechanical material properties and how these can be tuned by an optimal microstructure composition.

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