The Random Anisotropy Model – A Critical Review and Update

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The *random anisotropy model* provides the theoretical basis for understanding the soft magnetic properties of amorphous and nanocrystalline ferromagnets. The present talk reviews the model including its extensions, its limits and its verification in experiment.

Basically, the *random anisotropy model* rationalizes the interplay of random magnetic anisotropies and exchange interaction within the framework of a relatively simple scaling analysis. The basic idea is as follows:

The actual microstructure leads to a distribution of magnetic easy axis varying their orientation over the scale of the structural correlation length (grain size) D. When these structural variations are randomly fluctuating on a scale smaller than the magnetic exchange correlation length $L_0 = (A/K_1)^{1/2}$ (A is the exchange stiffness and K_1 the anisotropy constant) the magnetization cannot follow the local anisotropy axis and will stay essentially homogeneous within L_0 due to the smoothing effect of exchange interaction. Thus, the anisotropy relevant for the magnetization process will be an average over the local random anisotropies. As a result it ultimately scales down as $(D/L_0)^6$ and the material will become soft magnetic for $D < L_0$ ($L_0 \sim 6$ nm for Co to about 20 - 40 nm for Fe-based alloys).

The original arguments were based on a single phase system. In real materials, however, we deal with various structural phases. Thus, in typical soft magnetic nanocrystalline materials the randomly oriented crystallites of about 10 nm in size are embedded in an amorphous matrix. The latter is made up again of structural units with magnetic easy axis randomly fluctuating on the much smaller scale of atomic distances. Moreover, real materials reveal additional anisotropies, such as magneto-elastic and field induced anisotropies which are uniform on a scale much larger than L_0. Such long-range

anisotropies ultimately determine the soft magnetic properties of optimized amorphous or nanocrystalline alloys where the contribution of the random anisotropies is negligible. The original model has been extended correspondingly. I will revisit and update these extensions and illuminate in more details the reasoning behind them. This is basically a question of understanding how to add up anisotropies which is illustrated by both a simple analytical model and numerical simulations. The corresponding arguments yield additional information about the symmetry and nature of the randomly averaged anisotropies as well as their interplay with long-range uniaxial anisotropies.