Coercivity Analysis based on extended Landau free energy landscape

Masato Kotsugi

(Tokyo University of Science)

Microstructure is an important information that characterizes macroscopic function. The coercivity is a typical issue, and we have analyzed the magnetic domain structure and metallographic structure to discuss the origin of macroscopic coercivity. However, a rather problematic approach has been taken for a long time, in which the results of pinpoint local structural analysis are used to discuss the macroscopic function of the entire system. In other words, most of the information of image data has been discarded and the interpretation of the image data required expert knowledges.

Here, we propose a new energy model that can explain macro functions using entire information of microstructure. Spatial inhomogeneity, which could not be dealt with by the Landau model, is quantified and used as a feature using modern mathematical science. Feature extraction combines Persistent homology, Fourier transformation and Ising model to extract significant Physical Feature in multiscale. Selected features are used to draw the free energy landscape that can explain the magnetization reversal process, then analyze the behavior of the saddle point to discuss the origin of macroscopic coercivity. We design the extended Landau energy model that can handle spatial inhomogeneity and explain the macroscopic functions. The model can connect microscopic microstructure and macroscopic materials' function. Furthermore, the modeling the free energy landscape behind the material functions would allow for analysis that goes into the interpretation of the mechanisms. In this talk, we will introduce our recent research projects related to

(1) Feature extraction from magnetic domain structure using Persistent Homology.
(2) Drawing Extended Landau Free Energy Landscape for the analysis of magnetization reversal process and coercivity.

Reference
T. Yamada, M. Kotsugi et al. Vacuum and Surface Science 62, 153, (2019)
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