

The effect of strain on the magnetization process

Mehrija Hasicic¹, Spyros Angelopoulos³, Aphrodite Ktena^{2,3}, Evangelos Hristoforou³

¹International Burch University, Bosnia and Herzegovina

²Energy Systems Laboratory, National & Kapodistrian University of Athens, Greece

³Sensors Laboratory, National Technical University of Athens, Greece

Residual stress in magnetic materials is linked to deformations at the cell and grain level as a result of composition, fabrication processes, thermo-mechanical treatment, aging or the history of the material. The dependence of magnetic properties on stress is well established and has been demonstrated by a number of experimental techniques at the macroscopic level, such as major and minor hysteresis loops, permeability and magnetic Barkhausen noise measurements, as well as at the grain or atomic level, such as EBSD or XRD measurements. The present work aspires to contribute to the discussion on the relationship between macroscopic measurements and microstructure on the way towards establishing a methodology that will allow the quantitative assessment of the effect of strain on magnetic properties in the plastic deformation regime. In particular, we study the effect of strain on the magnetization process as a result of a varying anisotropy profile at the grain level [1]. Results on micromagnetic calculations of hysteresis loops for various configurations of magnetic anisotropy are shown and discussed against experimental loops on a series of strained electrical steel samples as well as magnetic Barkhausen noise measurements on the same samples.

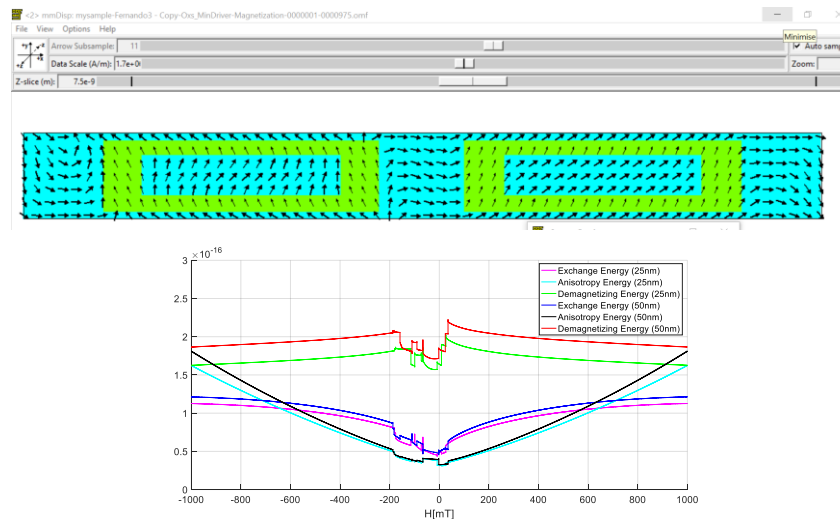


Figure 1: Micromagnetic model of soft grain with hard magnetic boundaries (top) and energy plots for two different thicknesses of hard magnetic boundaries

We postulate that the magnetic Barkhausen noise energy [2] may be used as a measure of the irreversible processes in the magnetization process, which are favored as plastic strain levels increase, whereas the hysteresis loop or magnetic permeability measurements reflect both reversible and irreversible processes. This is also reflected on the interplay between the energy terms involved in the calculations, namely anisotropy, demagnetizing and exchange. The results are in line with previously obtained results using vector Preisach modeling with the Stoner-Wohlfarth model acting both as a switching and rotation mechanism. Establishing a relationship between stress and local anisotropy profiles, obtained through a combination of EBSD and magnetic anisotropy measurements, may provide a link between macroscopic magnetic phenomenology and microstructural changes due to induced strains.

References

- [1] A. Ktena, M. Hasicic, F. J.G. Landgraf, E. Moudilou, S. Angelopoulos, E. Hristoforou: On the use of differential permeability and magnetic Barkhausen Noise Measurements for Magnetic NDT Applications, *Journal of Magnetism and Magnetic Materials*, Volume 546, 168898 (2022).
- [2] B. Ducharne, Y.A. Tene Deffo, P. Tsafack, S.H. Nguedjang Kouakeuo: Directional magnetic Barkhausen noise measurement using the magnetic needle probe method, *Journal of Magnetism and Magnetic Materials*, Volume 519, 167453, (2021).