Physical interpretation of the hysteresis parameters in the theory of hysteresis (abstract)

D. C. Jiles
Ames Laboratory, Iowa State University, Ames, Iowa 50011

One of the most important remaining issues in the theory of hysteresis is a complete description of the physical meaning of the parameters that define the model equations.[1] In common with the Stoner–Wohlfarth theory of rotational processes, the theory of hysteresis provides one of the few theories of hysteresis based on underlying physical mechanisms, rather than curve fitting models. In this paper, it is shown that the parameter a, which governs the orientation of the anhysteretic curve, is related to the density of domains and the absolute temperature $a=k_BT/\mu_0\langle m\rangle$, where $\langle m\rangle$ is the magnet moment of the average domain in the material, measured in A m^2. In fact, the magnetic material can be treated thermodynamically as an assembly of pseudodomains, each with identical magnetic moment $\langle m\rangle$, and each interacting with all the other domains via the coupling coefficient α, leading to a mean coupling field of αM. The pinning coefficient k is simply a measure of the energy dissipation caused by movement of domain walls. The dissipation energy is proportional to the change in magnetization, $dE=\mu_0 k dM$. Finally, the reversible component of magnetization is due principally to domain wall bending, and the bending coefficient c is related to the domain wall surface energy γ, the average domain magnetization $\langle m\rangle$, and the spacing between pinning sites l, according to the equation $c=(\langle m\rangle p l^4/4\gamma)\cdot F_{\max}$, where $F_{\max}$ is the maximum force exerted on the domain wall by a typical pinning site. This means that the amount of domain wall bending increases with the strength of pinning sites ($F_{\max}$) and decreases in inverse proportion to the domain wall surface energy. In conclusion therefore it is possible to give an exact physical meaning for all of the parameters used in the theory of hysteresis.

[1] D. C. Jiles, J. B. Thoelke, and M. K. Devine, IEEE Trans. Mag. **28**, 27 (1992).

Measurement of the switching properties of a regular 2D array of Preisach-type particles (abstract)

M. Pardavi-Horvath
Institute of Magnetics Research, The George Washington University, Washington, D.C. 20052

G. Vertesy
Central Research Institute for Physics, H-1525 Budapest, P.O. Box 49, Hungary

The original Preisach model of magnetic hysteresis assumes an assembly of single domain particles, each having a rectangular hysteresis loop. The loops are characterized by up and down switching fields. The halfwidth of the loop is the coercivity H_c of the given particle. The loops might be shifted depending on the magnetic state of the environment, described by an effective interaction field, H_i. In the present work the switching properties of an artificially structured, highly uniaxial, magneto-optic garnet film (courtesy of R. Belt, AIRTRON), corresponding to the assumptions of the original Preisach model, are investigated. In this case the parameter identification is straightforward. The garnet film is etched into 42 μm rectangular pixels, separated by 15 μm grooves. Each pixel has a rectangular hysteresis loop. Up and down magnetized pixels give a black and white contrast due to Faraday effect. Magnetization can be measured by counting the number of pixels switched in a given field. The distribution of the coercive field has been obtained by measuring individual loops on each of several hundred pixels in an optical magnetometer. The average $H_c=265\pm 99$ Oe, $H_i=0\pm 26$ Oe. The interaction field has been measured on the same pixel, depending on the magnetization state of the nearest neighbor pixels. The contribution to H_i of oppositely magnetized pixels is $dH_i/dn=26$ Oe/pixel. These data are compared to macroscopic hysteresis loops measured in VSM.

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