

Estimation of a parameter from a metastable magnetic image by machine learning

Toyota Technological Institute,

Kenji Tanabe, Shiori Kuno, Shinji Deguchi, and Hiroyuki Awano

E-mail: tanabe@toyota-ti.sc.jp

In the field of magnetism and spintronics, determining material parameters of deposited magnetic films is the most important experiment to evaluate them. Some parameters such as the Dzyaloshinskii–Moriya interaction (DMI) constant, however, are difficult or time-consuming to measure. Therefore, in order to establish a simpler method for estimating parameters, research is being conducted to estimate parameters from magnetic domain images by machine learning[1-3]. In general, ferromagnetic materials have hysteresis in the M-H curve, indicating that the magnetic domain state is not necessarily in the most stable state, but often in a metastable state. In previous studies[1-3], experiments have been conducted with the most stable magnetic state, or without any particular control on whether it is the most stable or metastable state. In this study, we artificially created several metastable states, and conducted to estimate the Tb concentration in TbCo alloy films from the images[4].

Multilayers of Si_3N_4 (10 nm)/ $\text{Tb}_x\text{Co}_{1-x}(t)$ / Si_3N_4 (10 nm) were fabricated on Si substrate by sputtering method. Compositions were selected under conditions that resulted in perpendicularly magnetized films, and nine different composition films were fabricated. The AC demagnetization method was used to fabricate the magnetic domain structures. By modulating the rate of decay of the amplitude of the AC magnetic field, multiple metastable states of magnetic domain structures were fabricated (Figure (a)). Figure (b) shows the relationship between the experimentally measured Tb concentration and the value estimated by machine learning. The estimated values are almost proportional to the measured values, suggesting that the Tb concentration can be estimated from the metastable state images.

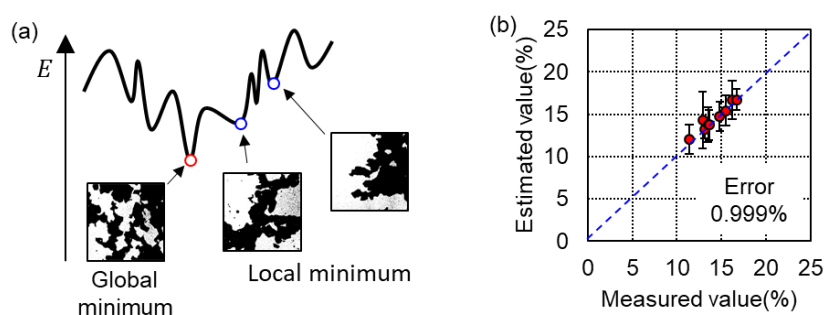


Fig. (a) Images of the most stable and metastable states. In a magnet with hysteresis, the shape of the potential has a multi-valley structure. (b) Relationship between experimentally measured values and values estimated by machine learning. The dotted line is the straight line with slope 1.

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