Design of Materials with Low Magnetic Hysteresis: the Unexpected Role of Magnetostriction

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Owing to the development of a quantitative theory of hysteresis, phase transforming crystals with record low hysteresis are now being synthesized worldwide. We present a brief review of the state-of-the art, and then turn attention to magnetic materials. Are the same ideas used for phase transformations applicable to magnetic hysteresis? The answer is no, but the way of thinking is promising. Numerous studies in the 1950-1970s based on linear stability analysis of the single domain state on the shoulder of the hysteresis loop show that this method fails to predict the size of the loop, a conclusion referred to as the 'coercivity paradox'. Using careful studies of numerical micromagnetics with well-designed critical nuclei, we identify the important role of magnetostriction. In particular, we find that the widely used alloy design criterion of minimizing the anisotropy constant(s) is incorrect, and we predict that materials with large anisotropy constant will have extremely low coercivity as long as the magnetostriction constants are tuned to special values. The research is joint work with Ananya Renuka Balakrishna (UCSB), is partly supported by the NSF-DMREF program.