Microstructure Design of Advanced Multi-Domain Magnetic Materials under Applied Fields

Khachaturyan (Rutgers), Laughlin(CMU) and Wang (OSU), DMR (FRG) Award #9905725

Magnetic domain characterization

- Annealing experiments: the Fe55at%Pd alloy was annealed both above and below the Curie temperature (T_c).
- Microstructure: both polytwinned structure and tweed structure have been observed. Lorentz microscopy imaging techniques are used to image the magnetic domains.
- Trace analysis was developed to determine the surface orientation of the magnetic domain images; to analyze the magnetization direction and to determine the sample thickness.
- This trace analysis can be applied to many magnetic systems during Lorentz imaging. It provides crystallographic information without taking diffraction pattern and therefore without altering the magnetic domain pattern.

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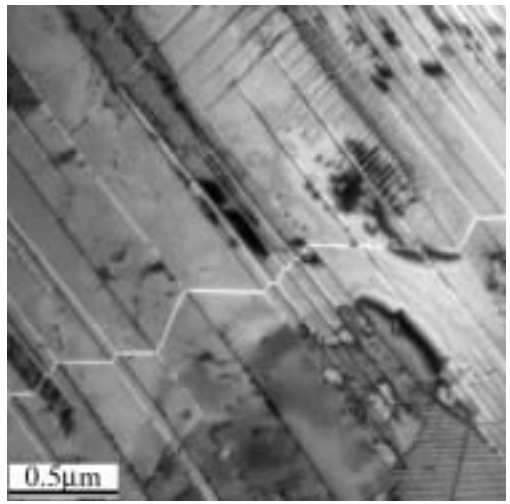
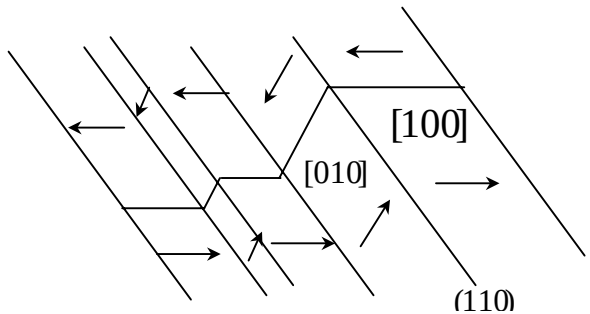
L. Wang, Z. Fan, D. E. Laughlin, "Trace Analysis for Magnetic Domain Images of $L1_0$ Polytwinned Structure ," submitted to *Scripta Materialia* (2002).



Magnetic domain wall image, the black and white lines are magnetic domain walls.



Arrows indicate magnetization directions.

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Microstructure Modeling

- According to experimental observations, the coupling between magnetic domain structure and polytwinned microstructures in FePt thin films is studied both theoretically and using computer simulations.
- Multilevel hierarchy in the magnetic domain structures is predicted, which agrees well with the observations.
- Parameters controlling the magnetic domain structure and domain wall orientations are analyzed.
- Insight gained to the design of specially tailored microstructures with improved magnetic properties.

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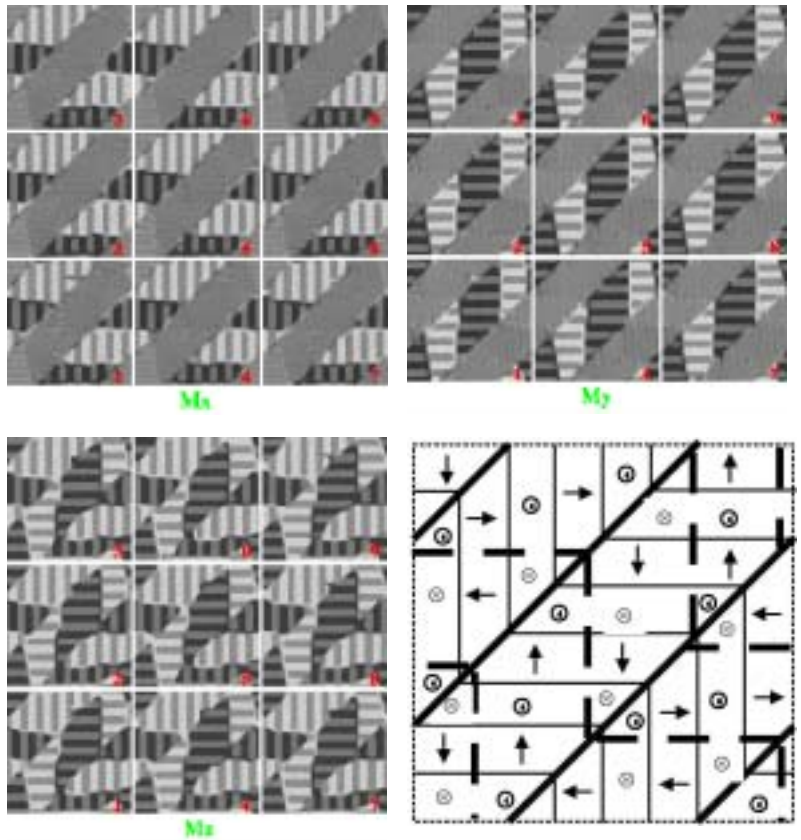
A. Kazaryan, Y. Wang, Y.M. Jin, Y.U. Wang, A.G. Khachaturyan and D.E. Laughlin, "Development of Magnetic Domain Structure in Highly Anisotropic Magnetic Thin Films of Polytwinned Microstructure" (submitted to *Journal of Applied Physics*, 2002).



Simulation prediction of complex magnetic domain structure and the corresponding schematic drawing in hard ferromagnetic thin films with polytwinned microstructure

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Structure-Property Relation

- Three different grain textures in hard magnetic thin films are simulated.
- Different magnetic properties are observed.
- Detailed spatial-temporal evolutions of magnetic domains reversal are recorded.
- Mechanisms controlling structure-property relation are revealed.
- Insight gained for advanced magnetic material design.

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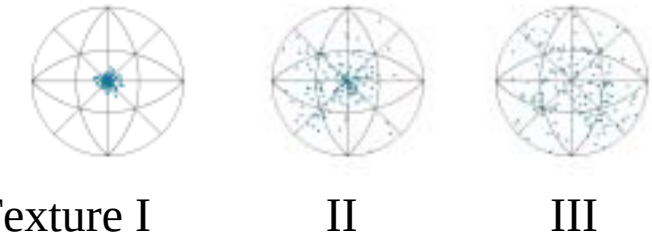
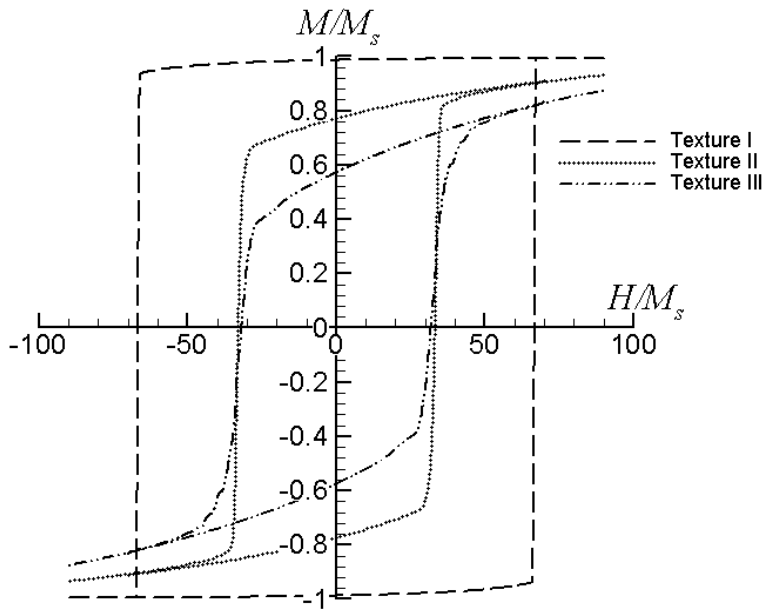
Y.M. Jin, Y.U. Wang, A. Kazaryan, Y. Wang, D.E. Laughlin, and A.G. Khachaturyan, "Magnetic Structure and Hysteresis in Hard Magnetic Nanocrystalline Film: Computer Simulation" (submitted to *Journal of Applied Physics*, 2002).



Texture I II III



Magnetic hysteresis loops of different textures

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Structure-Property Relation

- Two main mechanisms are associated with grain textures: nucleation and domain wall movement.
- Nucleation and domain wall movement exhibit different dependences on grain textures.
- It is possible to design magnetic property by tailoring grain texture.

Education:

Two graduate students (Yongmei M. Jin and Lisha Wang, Ph.D. candidates) and two postdoctoral research associates (A. Kazaryan and Yu U. Wang) have participated in this research.