Magnetization Reversal in \( \mu \text{m}\)-size antidot Permalloy arrays


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Polarization modulation is used to separate the components of M during a MOKE measurement.

P. Vavassori; *APL* 77, 1605 (2000)
Antidot Arrays

- Permalloy 40 nm DC-sputtered on the native oxide of a Si substrate
- $H_{\text{ext}} = 100$ Oe during deposition - uniaxial anisotropy
- Patterning by optical lithography
- Square, rectangular, hexagonal, and oblique hole mesh
- Study of the magnetization reversal

AFM images 16×16 µm²
Vector Magnetometry 1

- In-plane magnetization
  - parallel to $H_{ext}$ (solid dots)
  - perpendicular to $H_{ext}$ (open dots)
- Anisotropy dominated by the dot pattern, with hard axes along the directions connecting nearest neighbor holes

Longitudinal hysteresis loop for the continuous Py film: (1) easy, (2) hard
Vector Magnetometry 2

- Anisotropy reflects the symmetry of the hole lattice
Magnetization Reversal Process

• Spike domains form around voids (Cullity) with walls at \( \sim 45^\circ \) to the field, \( M_d \) perpendicular to the field

• Domains elongate with increasing field

• When the field is applied along nearest neighbor holes, spins rotate 90° to connect holes along the field direction. These loops exhibit a hard axis-like shape.
Modulus of Magnetization

- Highly coherent domain nucleation and expansion process
Magnetic Force Microscopy

- MFM images at remanence (16×16 μm²)
- Domain structures periodic and commensurate with the hole array
- Domains joining nearest neighbor holes are in qualitative agreement with the magnetization reversal mechanism hypothesized
Conclusions

• MOKE with polarization modulation has been used to study the magnetization reversal process of Permalloy anti-dot arrays

• Patterning induces:
  – increase of the coercive field
  – generates easy and hard axes with the symmetry of the hole array
  – hard axes are in the direction of the nearest neighbor holes

• Formation of spike domains and rotation of spins defines the hard axes in the direction of nearest neighbor holes