FINITE ELEMENT SIMULATION OF DISCRETE MEDIA WITH GRANULAR STRUCTURE

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INTRODUCTION

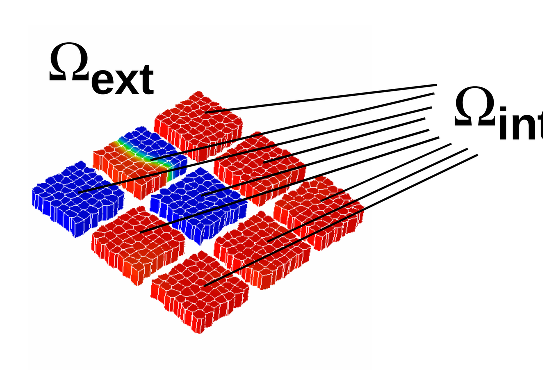
Discrete media [1] show great potential for future ultra-high density magnetic recording. A hybrid finite element / boundary element method [2] is used to compare the magnetization reversal process in a perpendicular granular film, a patterned media, and a single magnetic island. The results show that the influence of magnetostatic interactions on the switching field is comparable with the spread of the nucleation field due to the dispersion of the magnetic easy axes.

METHOD

Gilbert equation of motion

$$\frac{\partial \mathbf{J}}{\partial t} = -|\gamma|\mathbf{J}\times\mathbf{H}_{eff} + \frac{\alpha}{J_s}\mathbf{J}\times\frac{\partial \mathbf{J}}{\partial t}$$

$$\mathbf{H}_{eff} = -\delta E_t/\delta\mathbf{J} = \mathbf{H}_{exchange} + \mathbf{H}_{Zeeman} + \mathbf{H}_{anisotropy} + \mathbf{H}_{strayfield}$$



magnetostatics

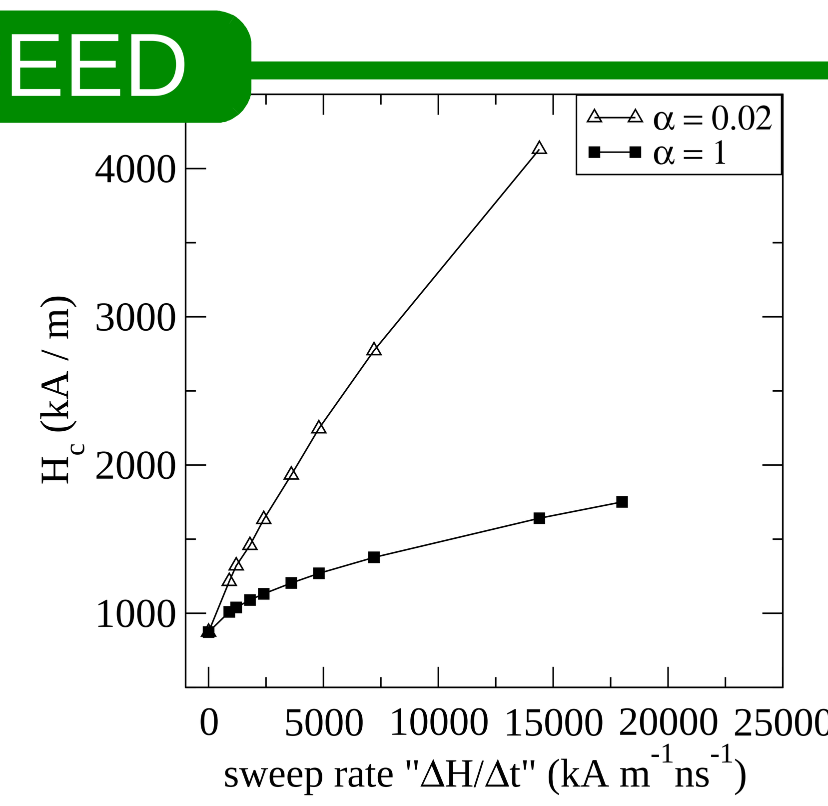
$$\mathbf{H}_{stray} = -\nabla U$$

- demagnetizing field $\mathbf{H}_{stray}$
- scalar potential U

$\Delta U(r) = \frac{\nabla J(r)}{\mu_0}$	solve with finite element method for **r** in Ω_{int}
$\Delta U(r) = 0$ $U \propto 1/\mathbf{r}$ for $\mathbf{r}\to\infty$	solve with accelerated boundary element method using a **treecode** [3] for **r** in Ω_{ext}

WRITING SPEED

Coercivity increases with increasing sweep rate of the external field. For low sweep rates H_c becomes independent of the damping constant.



HYSTERESIS

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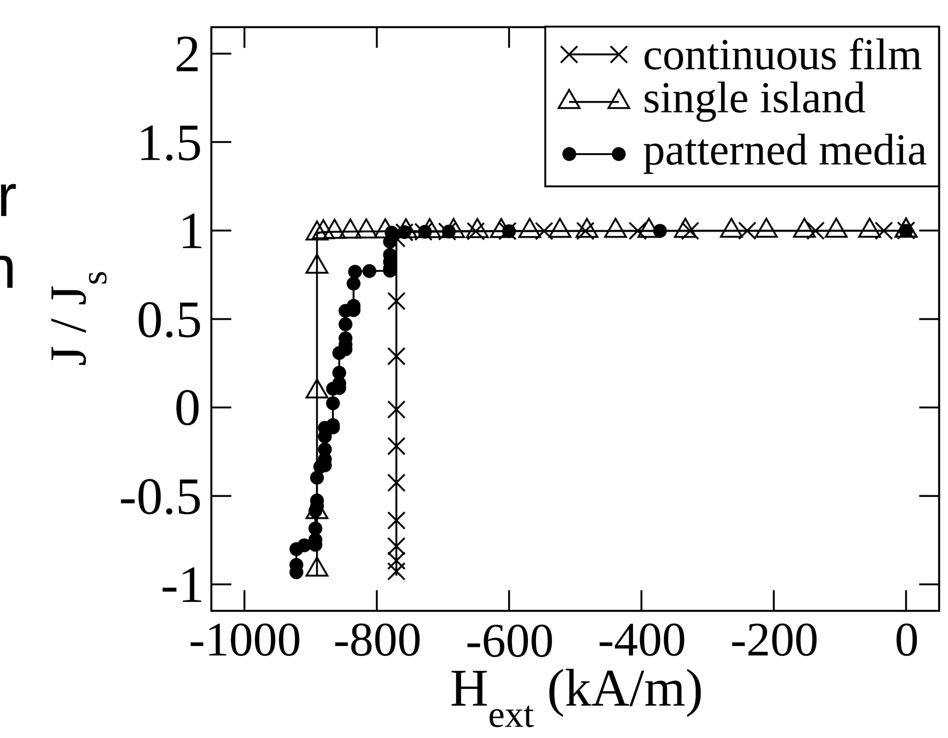
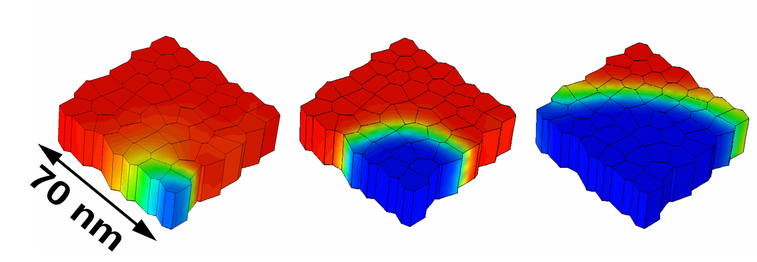
Islands have higher switching fields than unpatterned media.

- CoCrPt, ~10nm grains
- K_u = 0.3 MJ/m³
- A = 10 pJ/m
- J_s = 0.5 T





SINGLE GRANULAR BIT

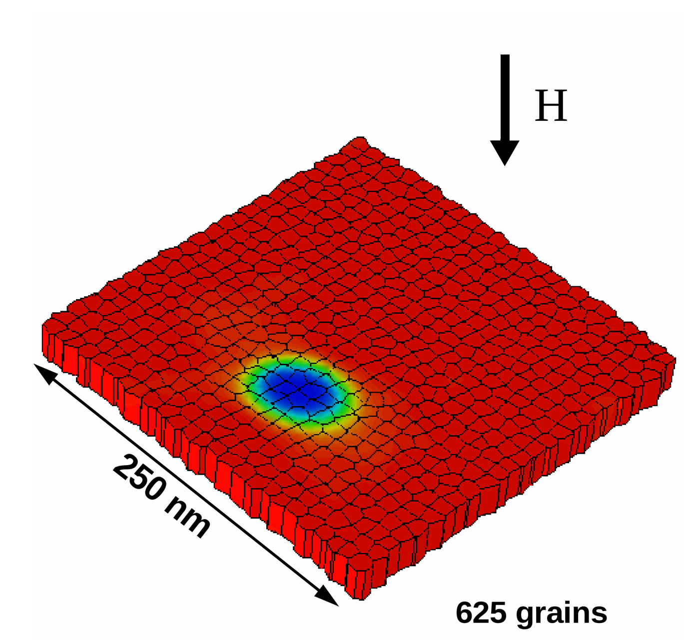
- reversal always starts at corners

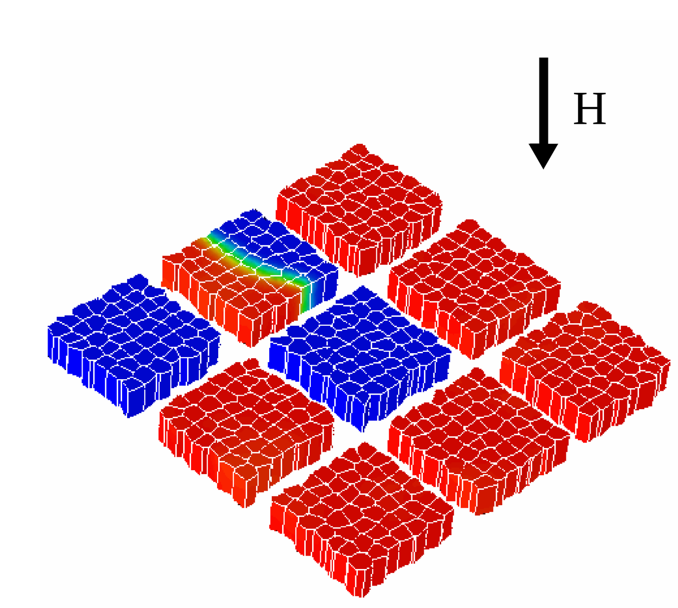
CONTINUOUS FILM

- nucleation of bubbles
- lower switching fields

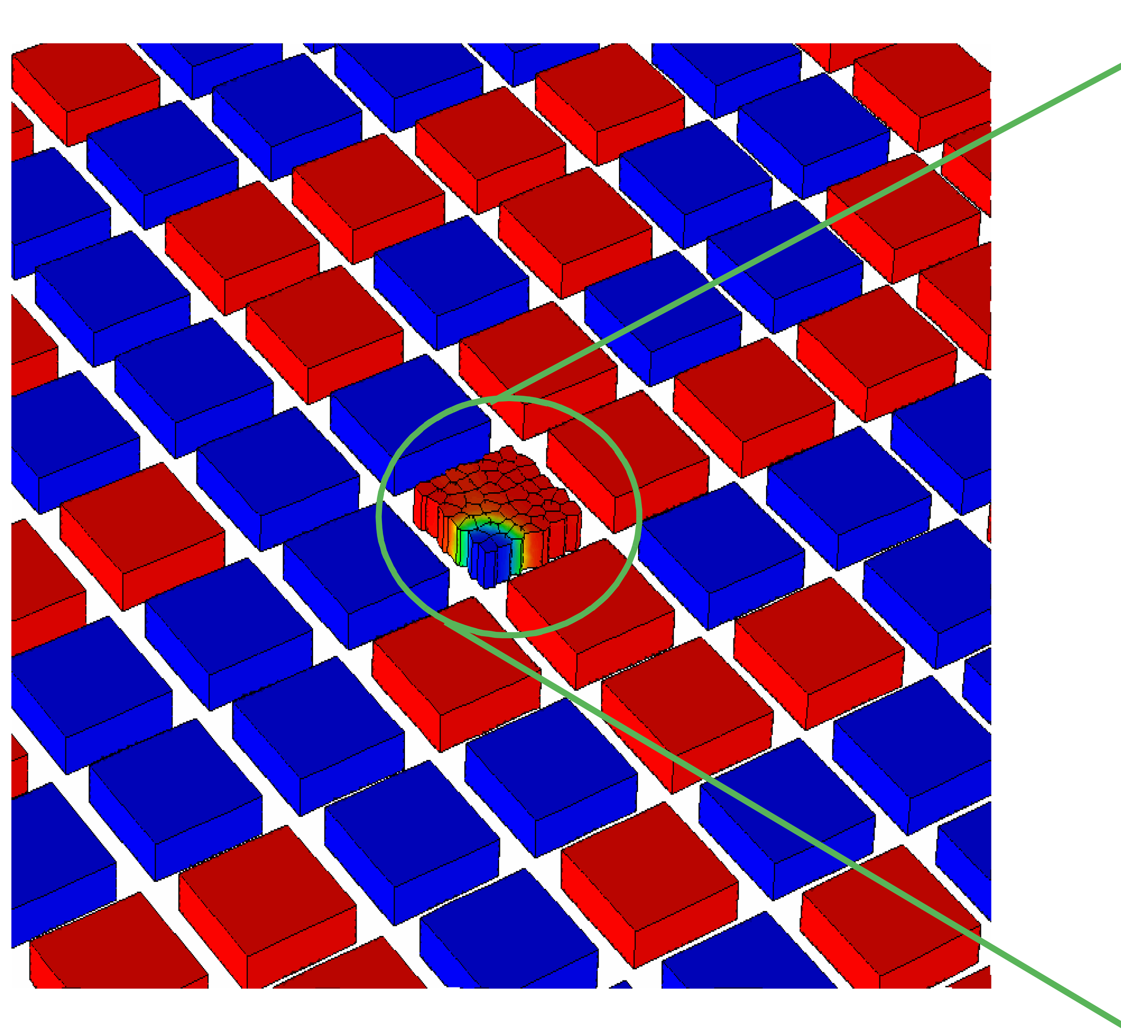
PATTERNED

- individual switching
- nucleation on corners or edges





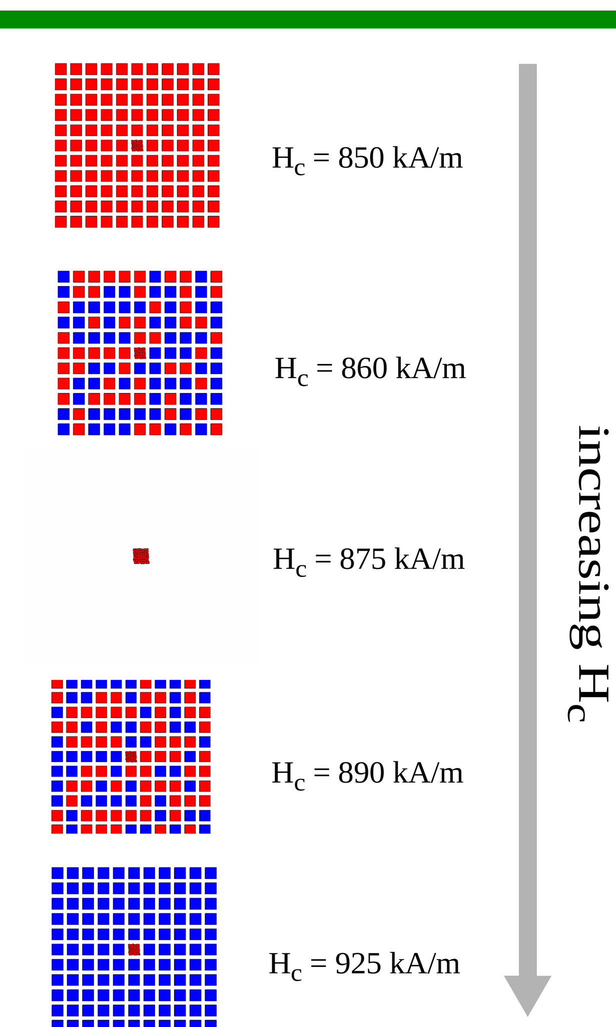
DIPOLAR INTERACTIONS



The switching field is dependent on the magnetization states (up or down) of neighboring bits. The hysteresis was calculated for several bit patterns (different data stored) in order to study the dispersion of the switching fields.

red.......magnetization up

blue......magnetization down



[1] C.T. Rettner, M. E. Best and B.D. Terris, IEEE Trans. Magn. 37,4,1649-1651 (2001)

[2] D.R. Fredkin and T. R. Koehler, IEEE Trans. Magn. 24 (1988) 2362.

[3] Josh Barnes & Piet Hut, A Hierarchical O(N log N) Force Calculation Algorithm, 1986. Nature 324, 446.

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