Self-organised hexagonal patterns of independent magnetic nanodots

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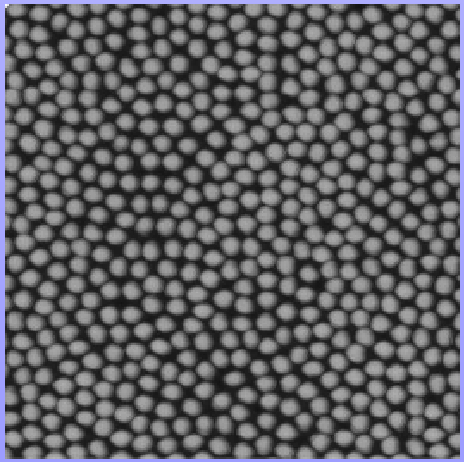

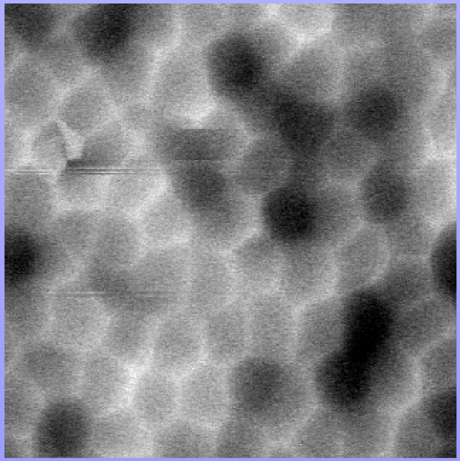

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"NAMASOS: Nanomagnets by self-organization"

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Pattern formation by ionic bombardment

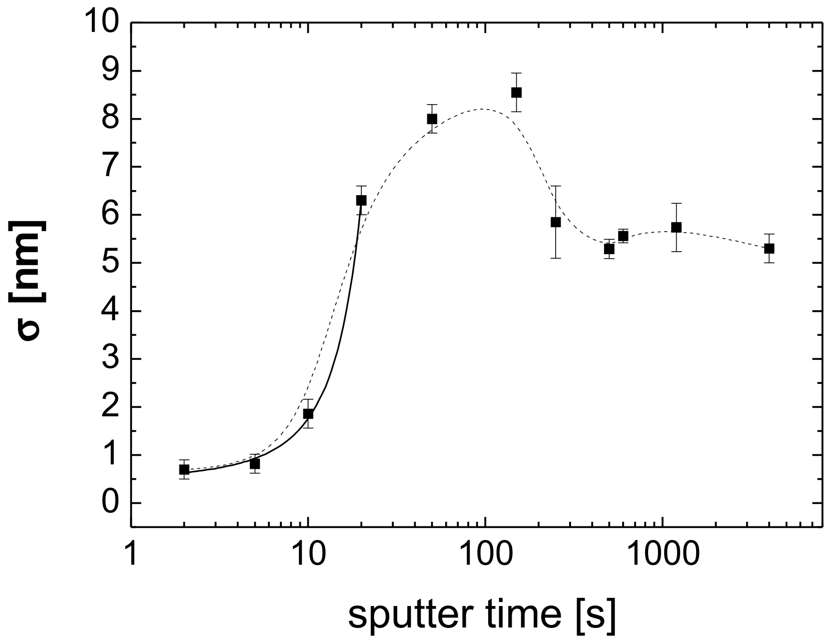
Erosion under normal incidence

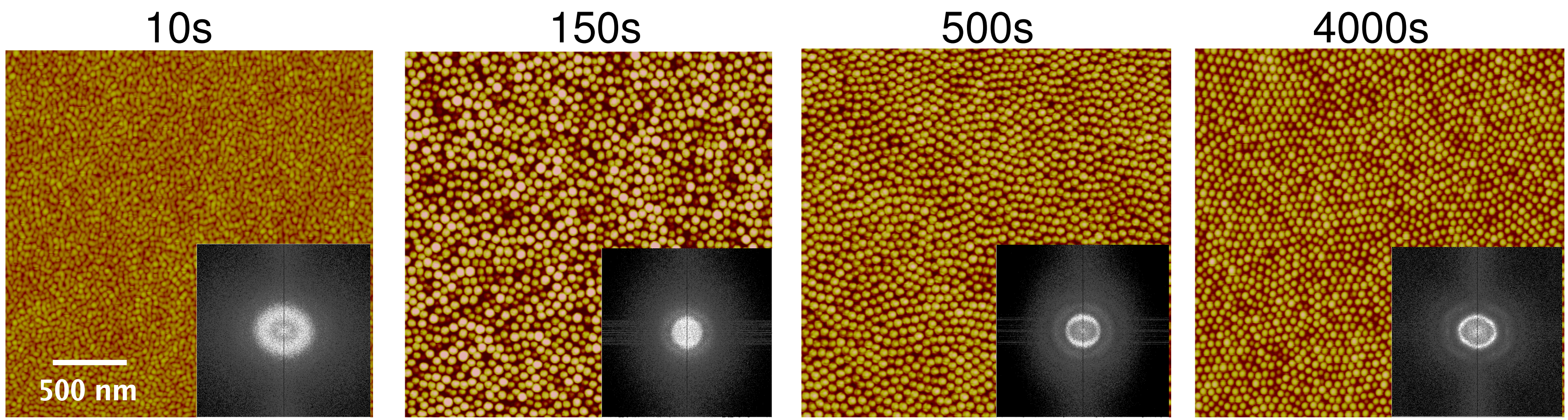
Three stages of morphological evolution:

- Exponential increase of roughness
- Maximum roughness reached
- Reduction of roughness and saturation

Only stable motives survive, but

Unsuccessful on metal surfaces

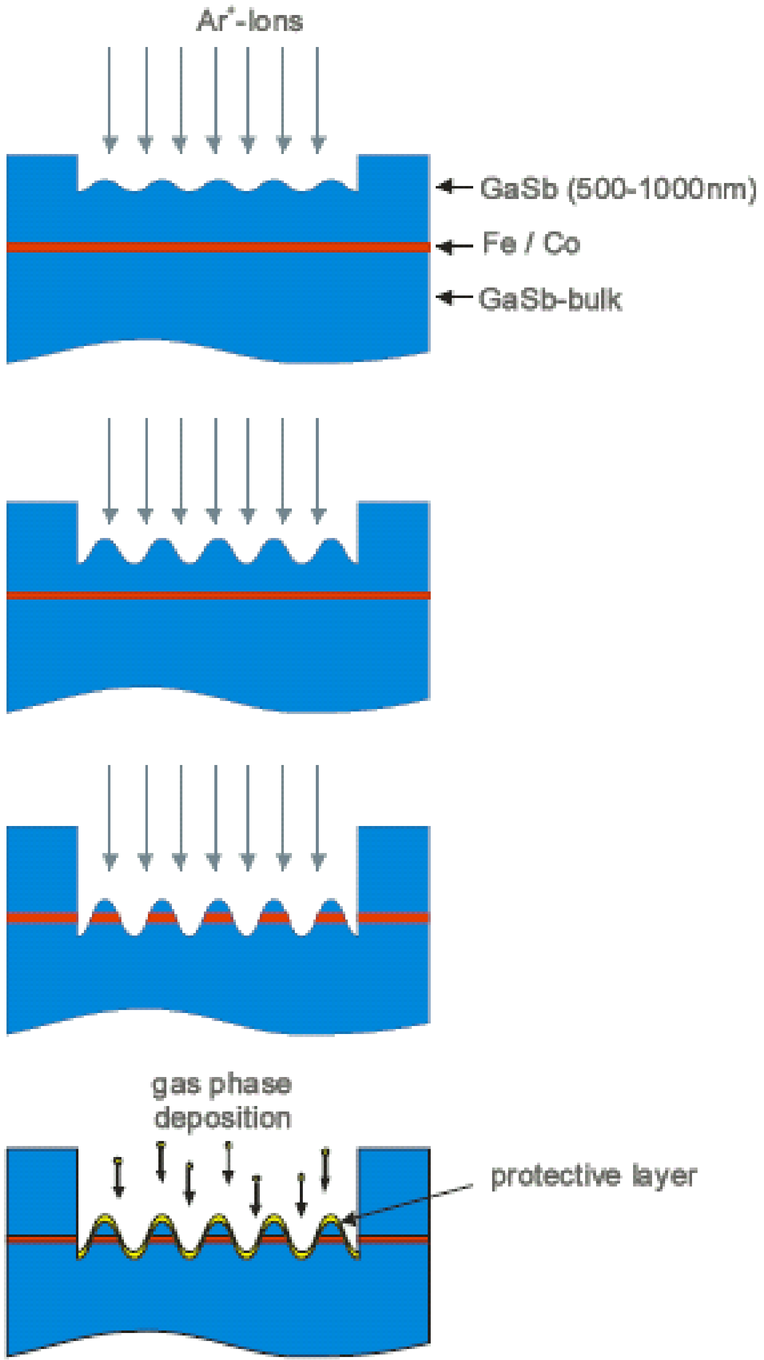




GaSb(100) 500eV (Ar^+)

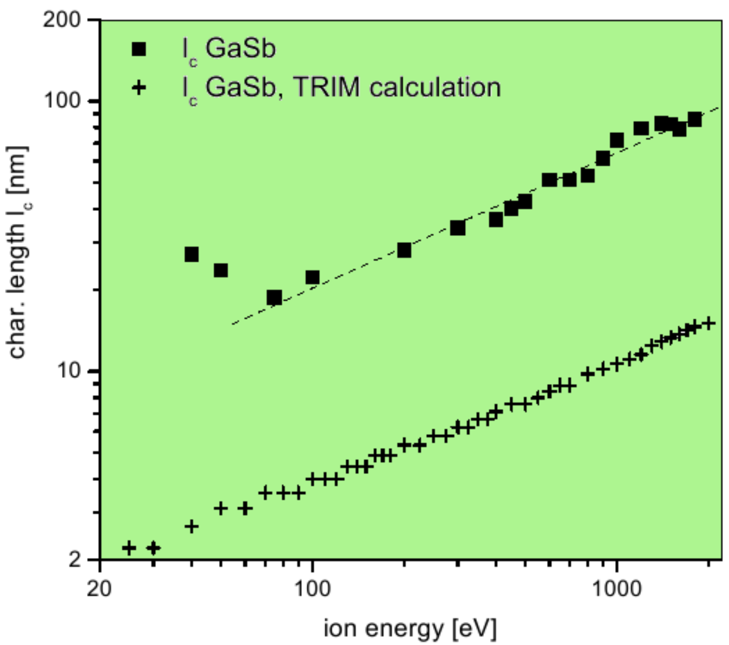
Z scale = 25nm

Patterning of intercalated metallic layers



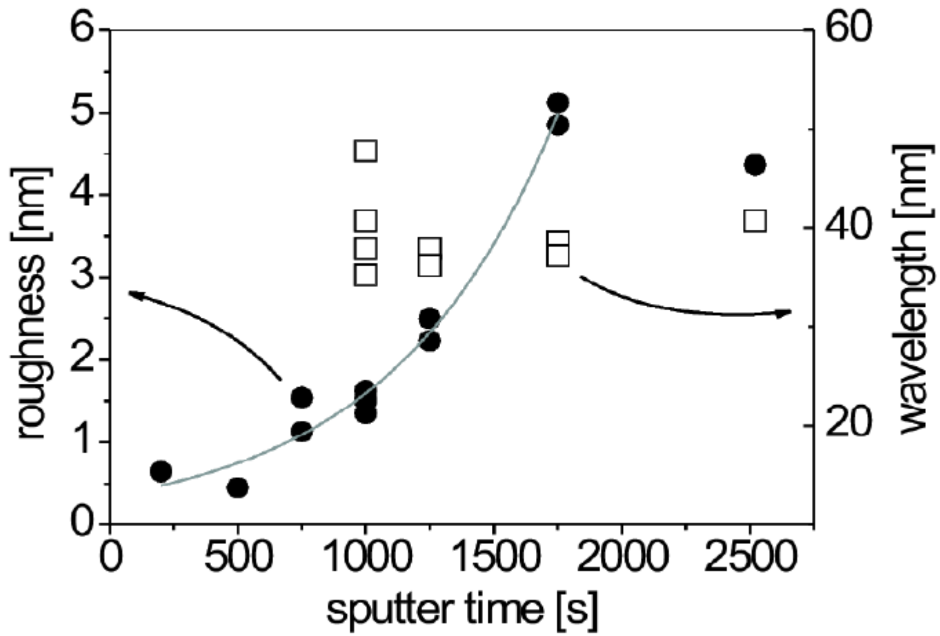
Procedure:

- Sputtering deposition of a magnetic layer (5 – 10 nm) capped with a semiconductor film
- Production of a nanodot pattern (10 – 80 nm) by ion sputtering of the semiconductor
- Transfer of the self-organized pattern to the buried metallic layer

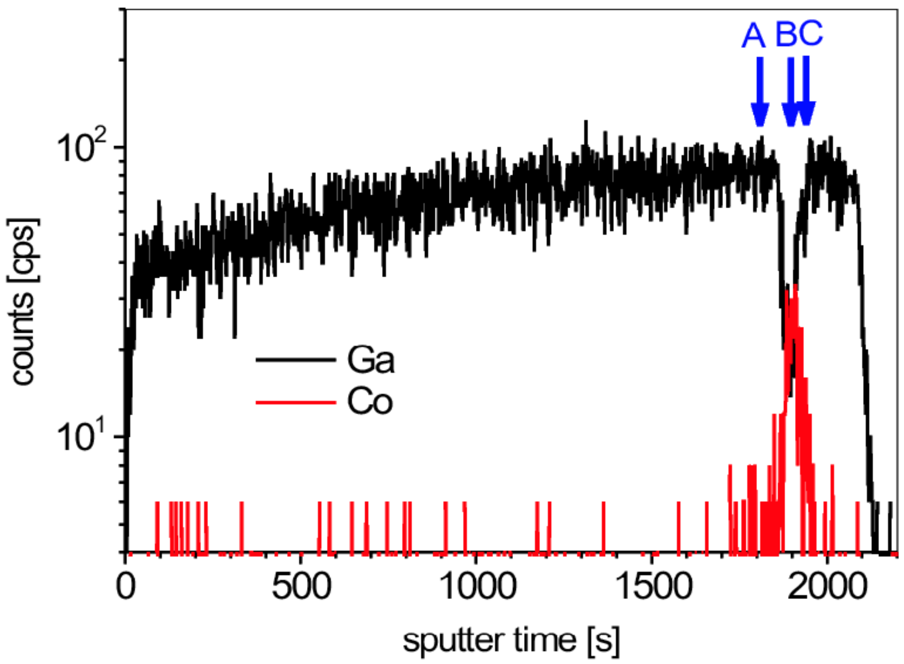


Pattern formation by ion bombardment

1000 nm GaSb capping layer / 5 nm intercalated Co film



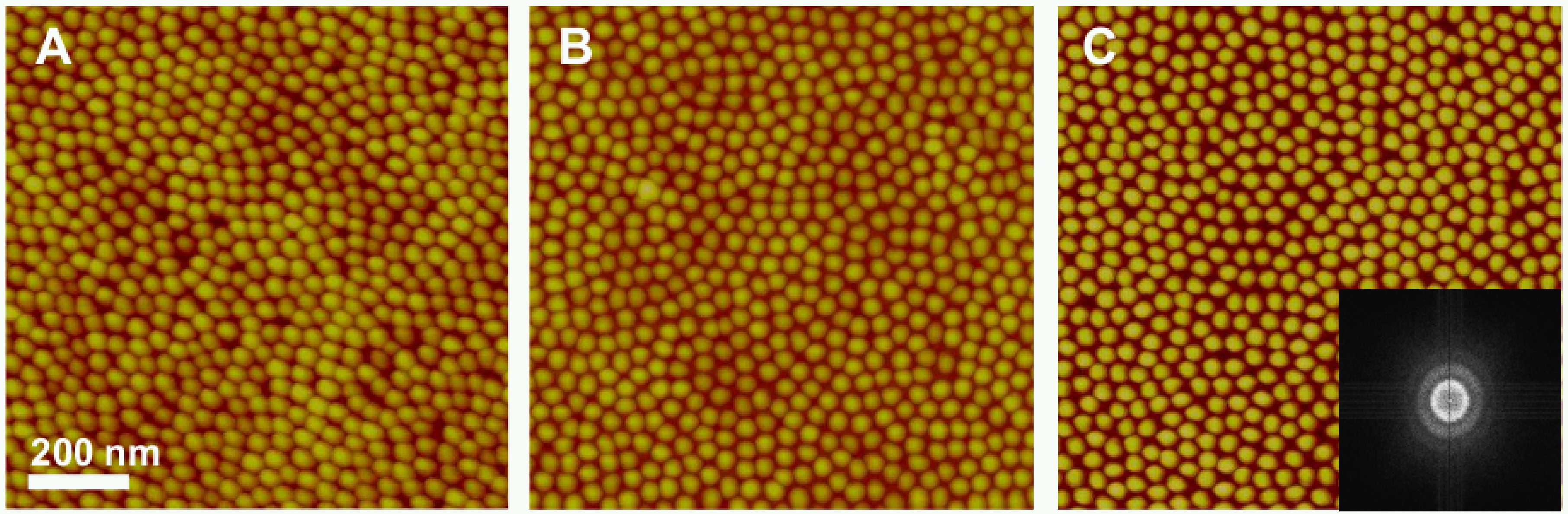
Time evolution of surface roughness and wavelength during sputtering with 400 eV Ar^+ ions

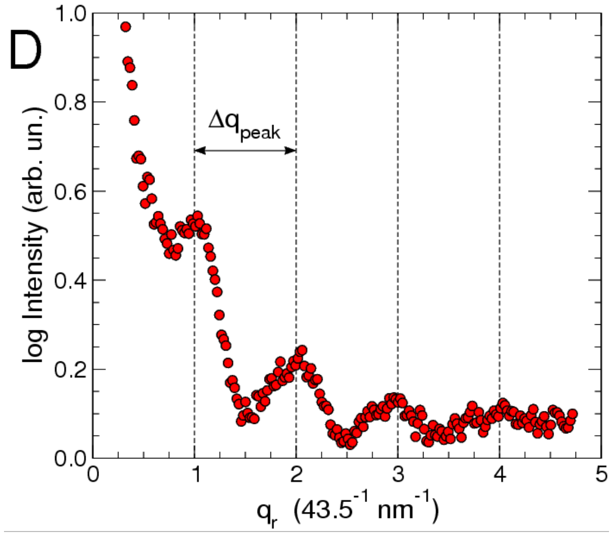


Secondary Neutral Mass Spectrometry depth profiling during sputtering.

Co nanodot pattern formation by ion sputtering

AFM snapshots during patterning





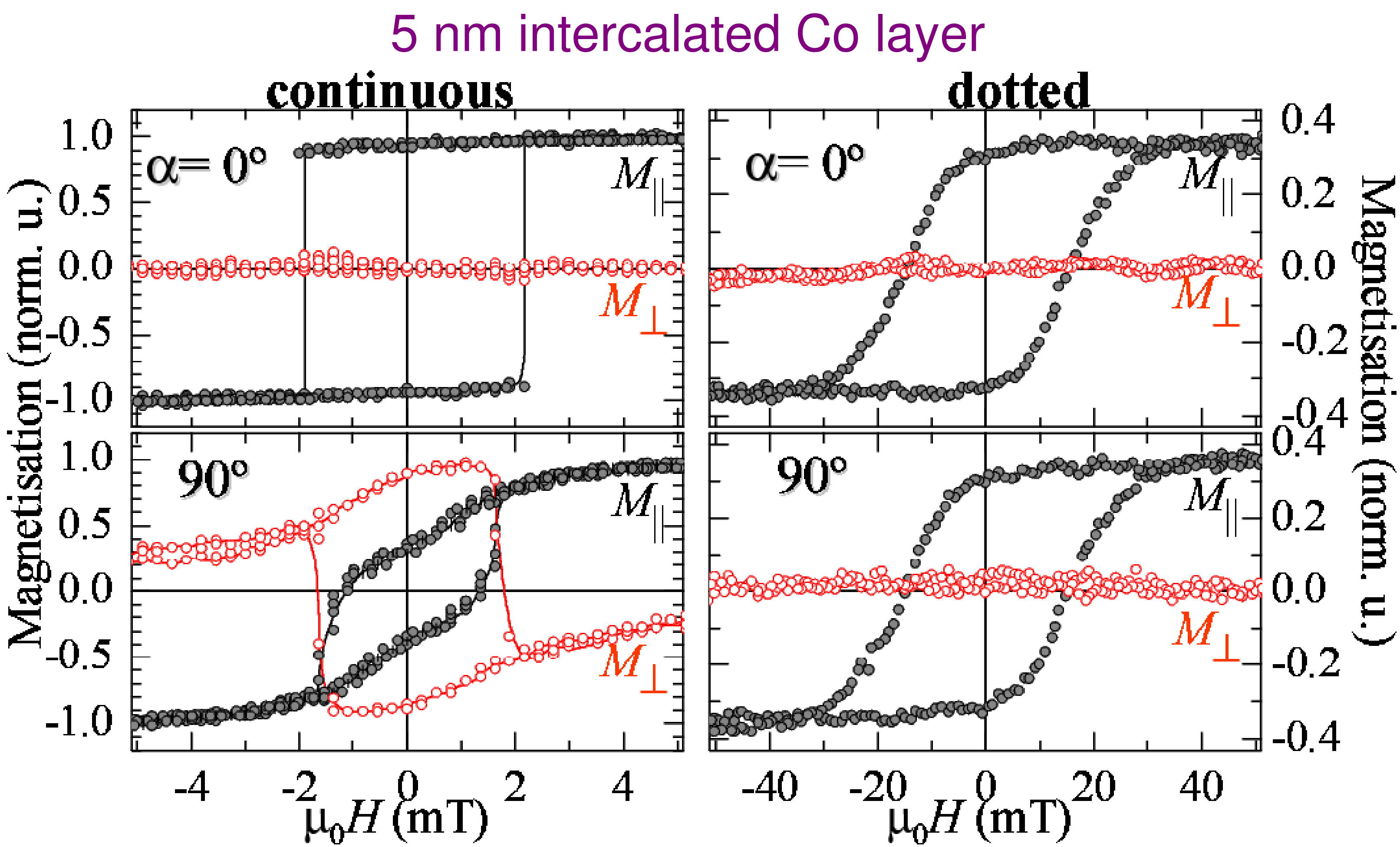
A: Above the Co layer;

B: In the middle of the 5 nm Co film;

C: At the bottom edge of the Co.

The 2-D power spectrum of image C reveals short-range order up to fourth neighbors

Co nanomagnets produced by ion bombardment



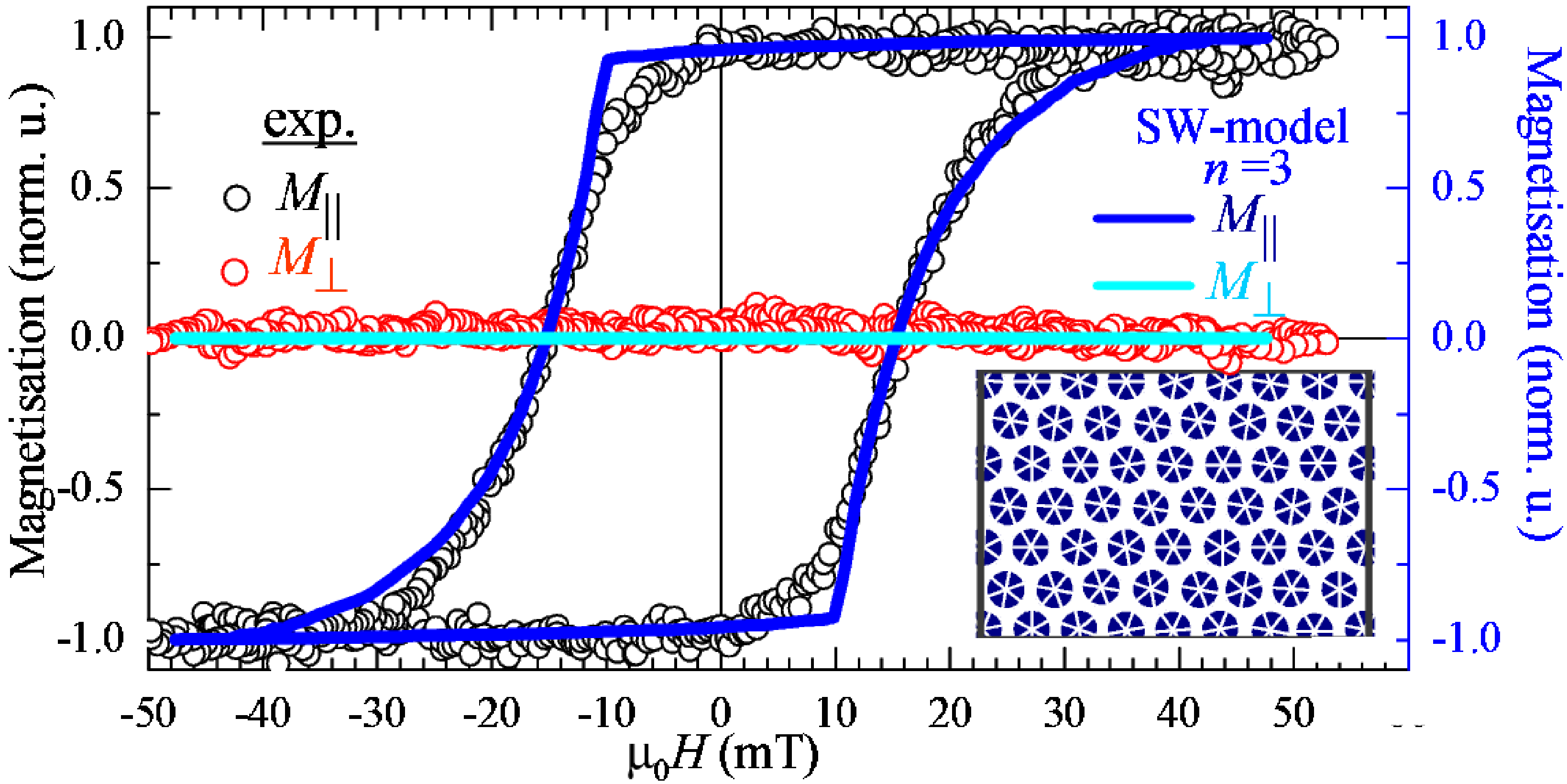
Continuous film before patterning: Growth-induced uniaxial anisotropy, magnetization reversal by domain nucleation and growth

Patterned sample: Isotropic, magnetization reversal by coherent rotation

Magnetization reversal in sputtered Co dots

Theoretical fits to MOKE data on sputtered area

Stoner-Wohlfahrt model: Energy mimimized as a function of applied field, system of nanoparticles with randomly oriented 3-fold anisotropy.

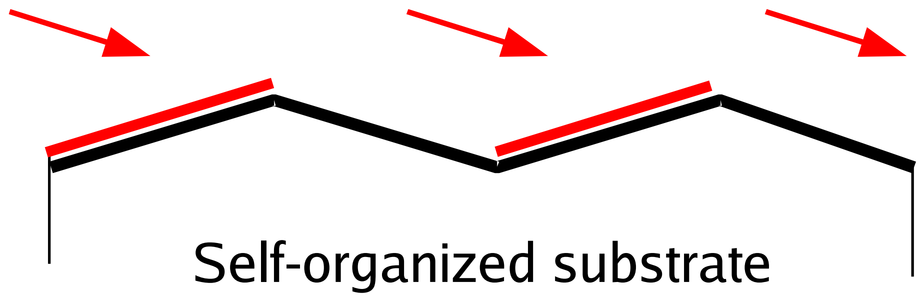


Weakly interacting, SW-like magnetic particles

Bobek *et al.*, Adv. Mater. **19**, 4375 (2007)

“Shadow deposition” method

Evaporation under Ultra High Vacuum onto self-organized substrates



- Take advantage of the surface relief to expose only certain facets to the incoming beam of deposited material

- Accurate control of deposition angle and thicknesses is required

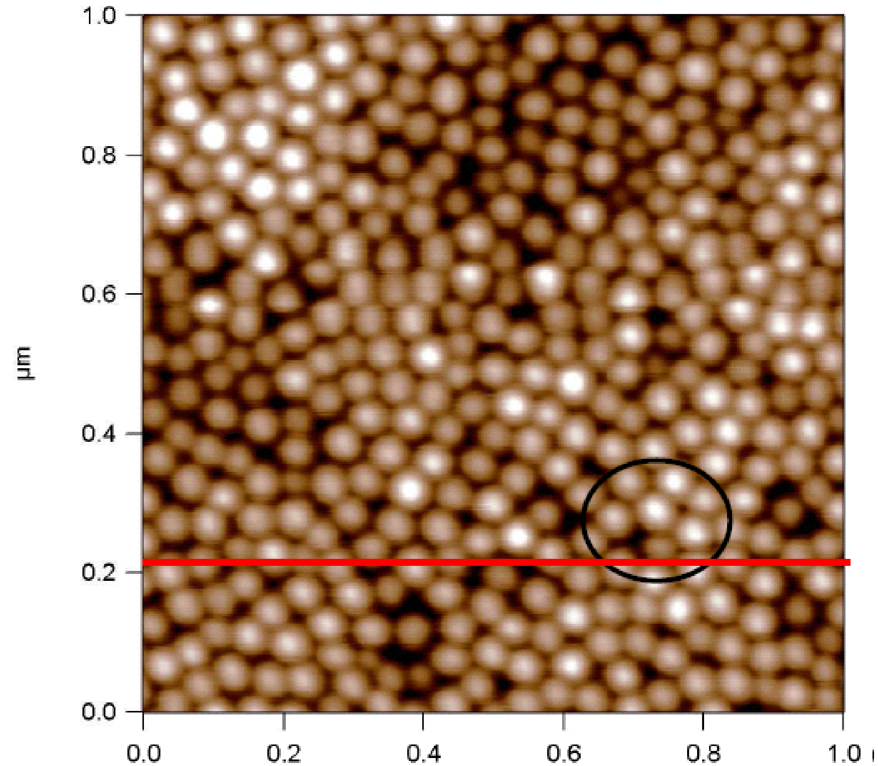
(Co/Pt) multilayers:

Strong perpendicular magnetic anisotropy (high coercivity favors independent alignment of nanodots magnetization)

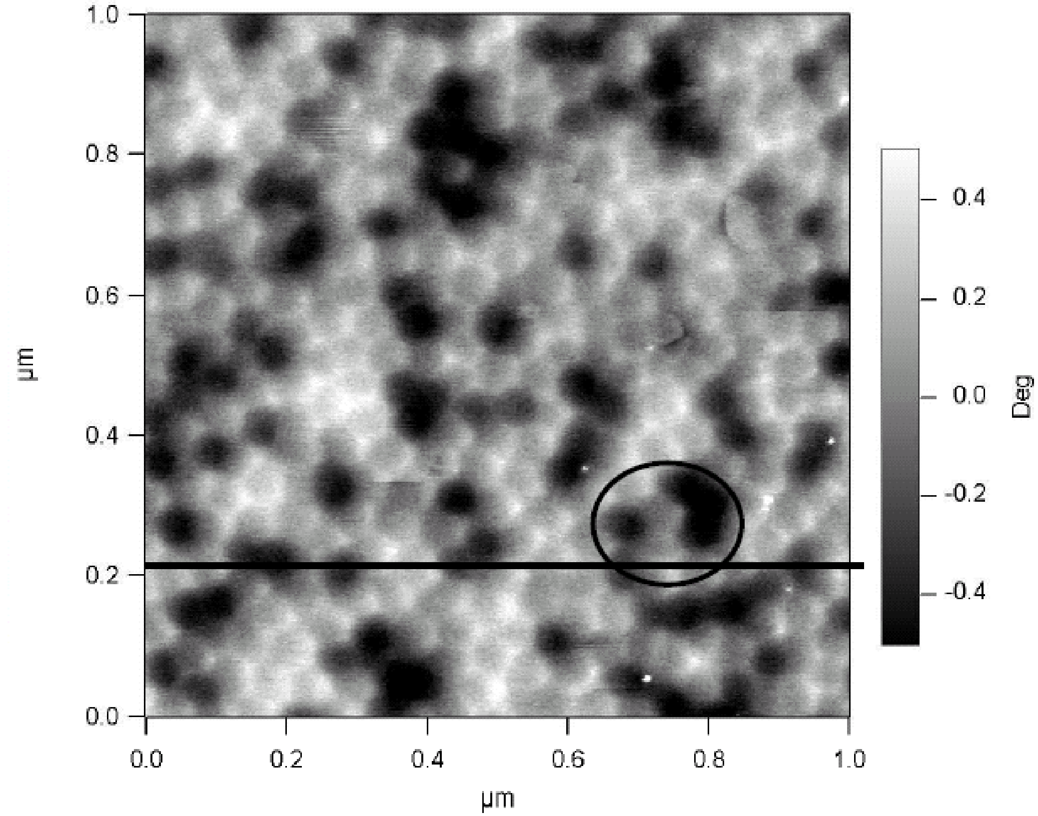
Shadow deposition of {Co/Pt} nanomagnets

15 ML Pt / 18 ML Co / 15 ML Pt / GaSb

AFM topography



MFM phase



GaSb substrate patterned by ion bombardment

Co deposition angle: 20°

Pt deposition angle: 45°

Random alignment of magnetization directions: independent nanomagnets.

Conclusions

- Magnetic nanodots with stable remanence at room temperature have been obtained and imaged, using different production methods

- The magnetic correlation between neighboring particles can be reduced by introducing a spacer with different magnetic anisotropy (Co/Pt).

- Both production methods are completely general and could be used with other, non-magnetic, metallic or semiconducting materials to produce ordered arrays of nanoparticles with a wide variety of potential applications