Spin-Polarized LEEM Study of Co on Ru(0001)

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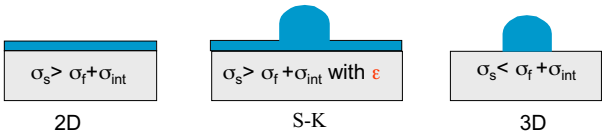
Motivation

- Study the growth mechanism of self-assembled ferromagnetic quantum dots
- Seek systematical control of the size and inter-dot distance of the system
- Explore the size-related magnetic domains

Spin-polarized LEEM

- High resolution (10 nm lateral, 0.1 nm vertical)
- Fast imaging process (1 frame/sec)
- All 3 magnetic components imaged individually
- In-situ, real time imaging during film deposition

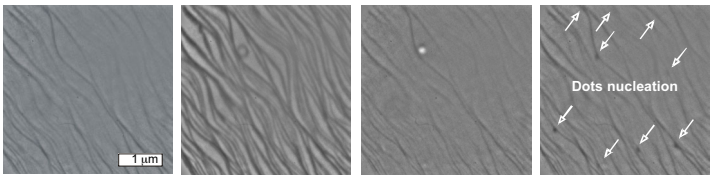
Growth mechanism



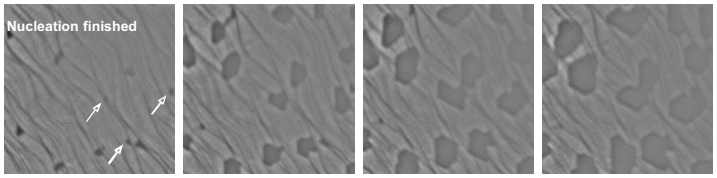
2D S-K 3D

Growth mode governed by surface energy σ_s, σ_f, interface energy σ_{int} and **elastic energy ε**

Co/Ru(0001): strain driven S-K growth



Substrate 0.35ML 0.98 ML 1.08±0.02 ML



1.16±0.02 ML 3 ML 6 ML 9 ML

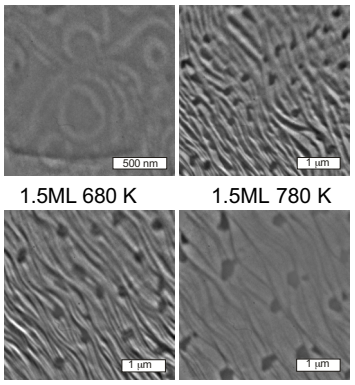
Strain driven S-K growth

- 1 ML wetting layer before the island nucleation.
- Abrupt island nucleation process around 1.1 to 1.2 ML.

Chentao Yu, J. Pearson, and Dongqi Li, J. Appl. Phys. 91, 6955 (2002).

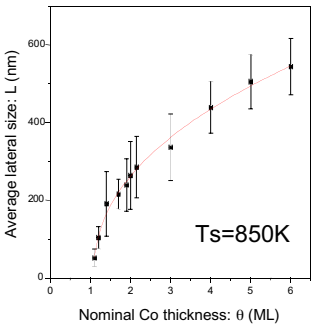
Control of size and inter-dot distance

Temperature dependence



1.5ML 680 K 1.5ML 780 K
1.5ML 820 K 1.5ML 850 K

Thickness dependence

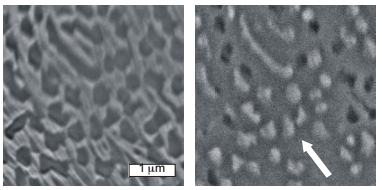


Dot size monotonously increase with Co nominal thickness.

- Both the dot size and inter-dot distance can be easily controlled with substrate temperature and the Co thickness.

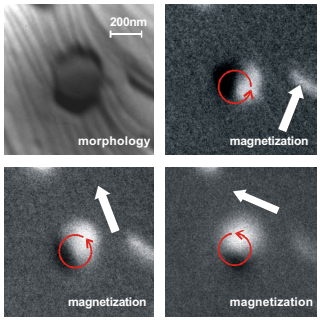
Temperature-driven magnetic domain transformation

- **Initial state: single domain**
- **Annealed at 940K: vortex**



morphology magnetic domain

Single domain —*anneal*→ **Vortex**



- Irreversible magnetic phase transition from single domain to vortex –– bi-stability between the two states, with vortex state more favorable. In good agreement with theoretical prediction.

Impact and future aspects

- Controlling the size and inter-dots distance of the dots enables systematic study of domains and magnetic interactions in confined geometry.
- Temperature-driven domain transformation between single-domain and vortex is discovered in magnetic dots. Such metastability of domains should be generic, and fundamentally important for nanomagnets.

BES - DOE

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