Variable-temperature micromagnetic study of epitaxially grown MnAs films on GaAs(001)

Shpyrko Research Group. UCSD

May 27th 2010

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Introduction

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- Objective
  - Variable-temperature magnetic force microscopy (VT-MFM) studies
- Material
  - Epitaxially grown MnAs layers on GaAs(001)
- Conditions
  - Temperature range : 17 ~ 39°C
    - Up to phase transition temperature

Measurement

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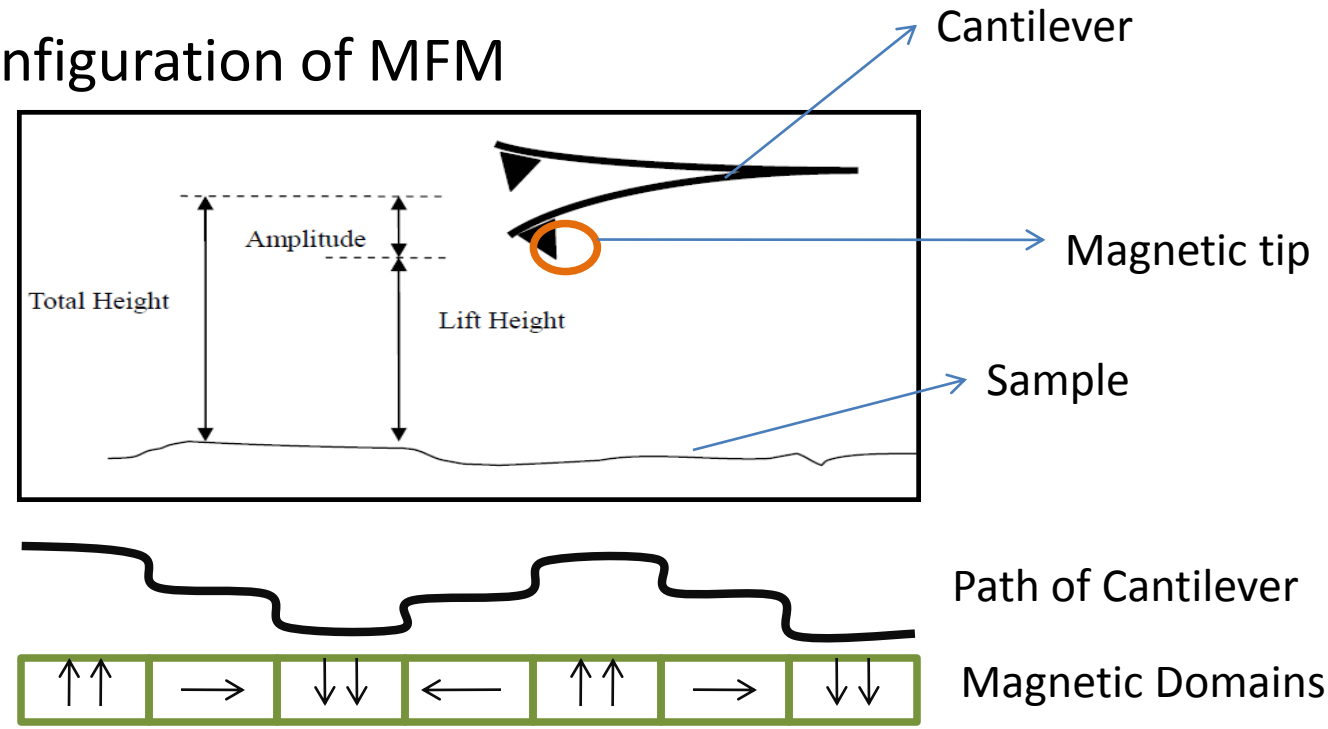
- Magnetic Force Microscopy(MFM)
  - The configuration of MFM



  - How it works : detecting changes in the resonant frequency of the cantilever induced by the magnetic field

Materials

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- Epitaxially grown MnAs film on GaAs(001)
  - Spin Injection

    : Ferromagnetic MnAs is a promising candidate for electrical spin injection into GaAs based semiconductor structures
  - Coexistence of Ferro-/Non-Ferromagnetic phases

    : Due to the epitaxial constraints, the ferromagnetic and the non-ferromagnetic phase coexist over a wide temperature range of 10–40°C.

Materials

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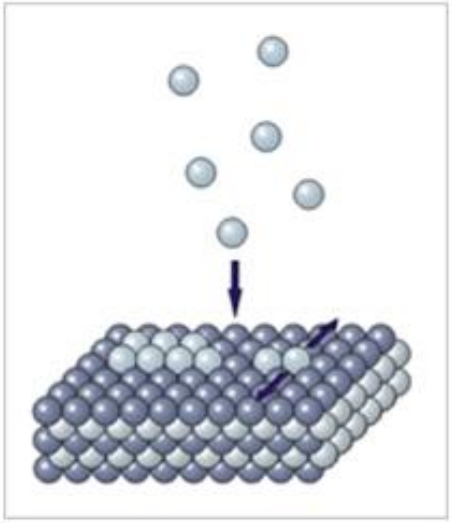
- Low-temperature molecular beam epitaxy (MBE)



Epi (=upon) + **Taxis (=arranged)**

Epitaxy = The arrangement of atoms on an ordered substrate

- Every atom reaching the surface has enough time to migrate around and find his place to build up a new crystal lattice.

Experiment

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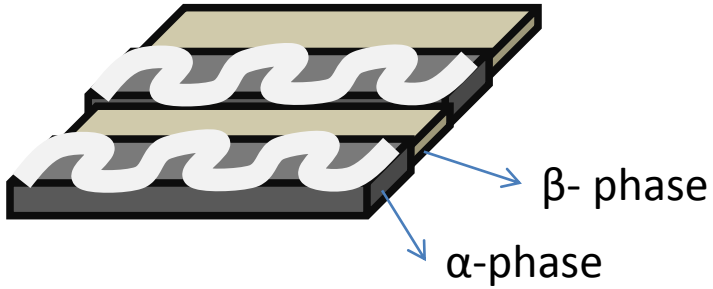
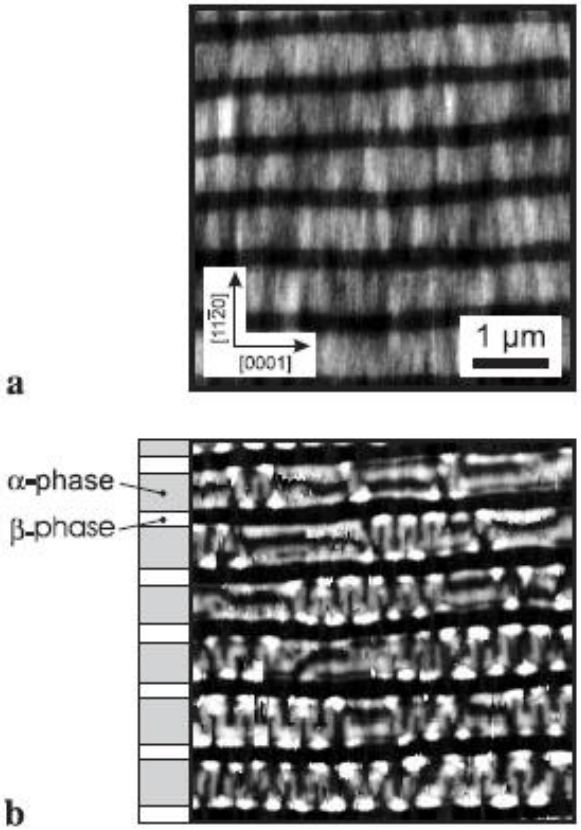
- 180nm-thick MnAs films were grown by MBE
- Two domain configurations
  - α-phase : ridge, a meander-like structure
  - β-phase : groove, more elongated structure





Experiment

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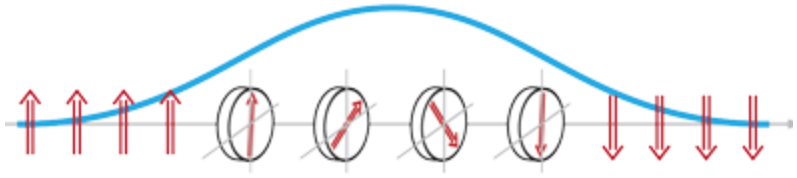
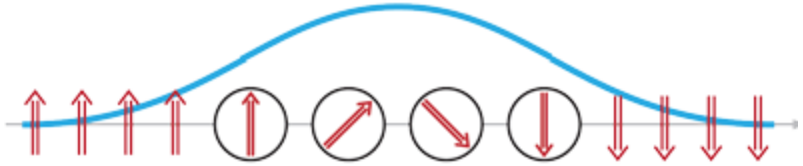
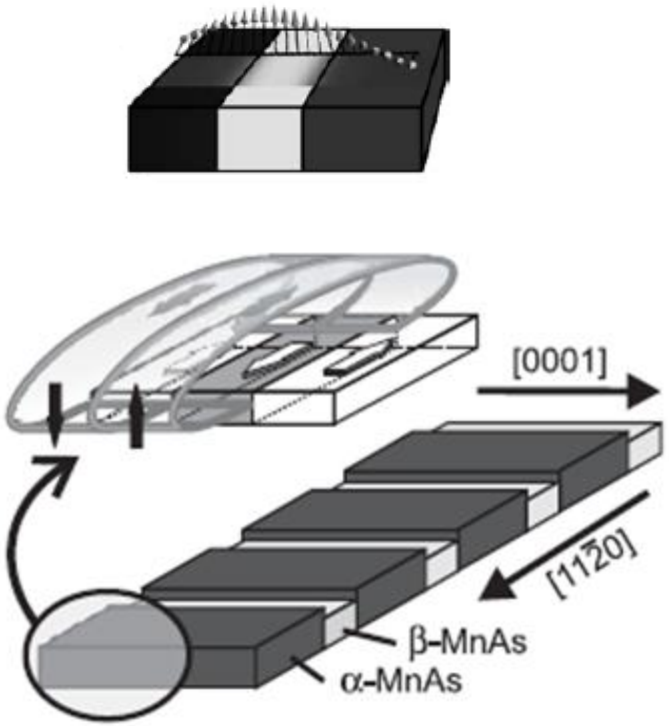
- What happened with α-phase?



Bloch Wall



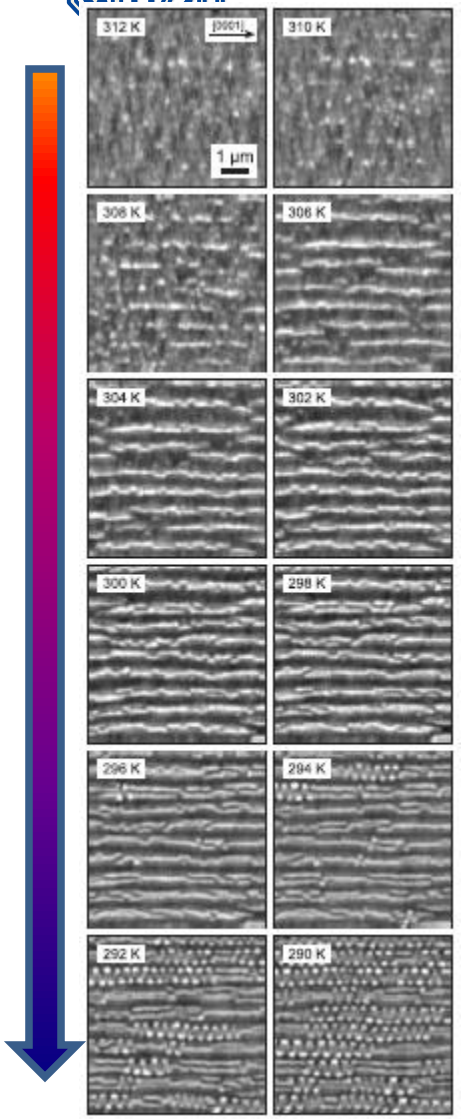
Neel Wall



Results

- Variable-temperature studies
  - Sample spot : 7 X 7 μm^2
  - Temperature range : 312K ~ 290K
  - Temperature step : 2K
  - Time distance : 14min

- Transformation of domains
  - Dot-like structure → chain-like structure
  - Get more ordered, meaner-like domain appear and grow



Results

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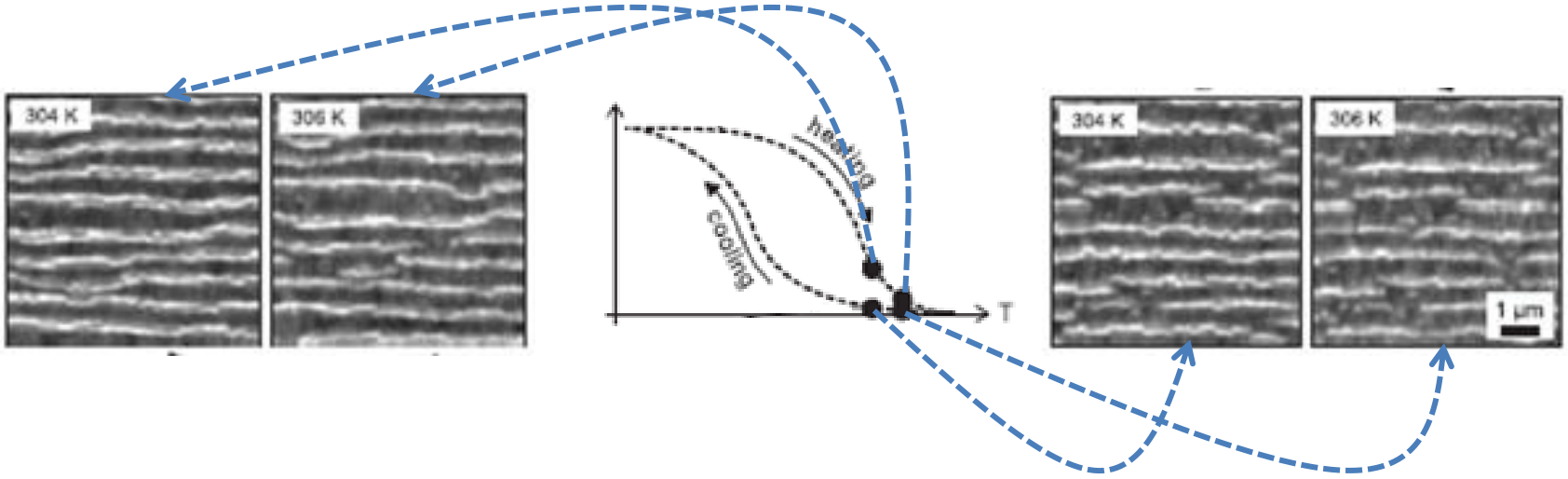
- Temperature Hysteresis
  - Domain arrangement depend on temperature history
    : α–phase contribution is larger during heating
    Ferromagnetic stripes are well connected



Conclusion

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- The origin of the magnetic contrast of the meander-like domains was explained
- Dot-like domains grow with decreasing temperature to become elongated, ferromagnetic domains
- Magnetic contrast exhibits a temperature hysteresis

References

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- Mohanty et al. Appl. Phys. A **77**, 739–742 (2003)
- Mohanty et al. Appl. Phys. A **81**, 1359–1362 (2005)