Croissance et propriétés magnétiques de réseaux planaires auto-organisés de nanofils de Fer

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INTRODUCTION – Context

Self-organization at surfaces: 2D regular arrays of similar nanostructures

**Stripes and wires** Co/Pt(997)

A. Dallmeyer et al., PRB 61(8), R5153 (2000)

**Dots** Co/Au(111)

D.D. Chambliss et al., PRL 66, 1721 (1991)
B. Voigtlander et al., PRB 44, 10354 (1991)
J. P. Bucher et coll.; S. Rousset et coll.;
O. Fruchart et coll.

What for?

- **Cheaper and beyond lithography**
- **Fundamental research**: weak distributions > reliable analysis
- **Applications?** lack of versatility (tunability; use no vicinal nor reconstructed surface)

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INTRODUCTION — Self-organization without reconstructions or steps

Demonstrated path: ion etching

**Stripes and wires**  
Ag

**Dots**  
GaSb(001)


**Magnetic wires**

Etched magnetic films (with or without mask)
Hills and grooves by kinetically-limited growth on bcc(110)

**Fe(110) homoepitaxy**


**W(110) homoepitaxy**


Any use for magnetic wires?

http://lab-neel.grenoble.cnrs.fr/themes/couches/ext/slides/
Pulsed Laser Deposition (DLP) in UHV

Nd:YAG pulsed laser

cc(110)/Al\textsubscript{2}O\textsubscript{3}(11-20)

cc=Mo, W, Nb, etc.

Analysis

• RHEED (Reflection High-Energy Electron Diffraction)
• STM (Scanning Tunneling Microscopy)
• AES (Auger Electron Spectroscopy)

Wedges

Mask

Substrate
Buffer layers for trenches

Deposition of bcc refractory metals along (110)

RT deposition

Uniaxial array of trenches (epitaxial)

Long-range orientational order
GROWTH – Trenches: Mo (2/2)

RHEED

Mo, RT, annealed

Mo, RT

200nm

50nm

[1-10]

[001]

STM

8nm

http://lab-neel.grenoble.cnrs.fr/themes/couches/ext/slides/
GROWTH — Trenches: atomic structure

Atomic structure of the facets

Facets of type \{210\} 
\[ \theta = 18.43^\circ \]

Lateral period \(~5\) nm
Depth of trenches: \(0.6-1\) nm

Figures for Mo

Lateral period \(~5\) nm
Depth of trenches: \(0.6-1\) nm
GROWTH — Trenches: W (1/2)

Process for W

STM

W deposited at 150°C

Lateral period ~5.5 nm

RHEED

Order is improved with W

Satellite streaks

> Lateral period ~5.5 nm

Lab Neel, Grenoble, France.
W deposited under decreasing temperature: 550°C ➔ 150°C

Well-defined facets

\{210\} is the limiting facet

[contrary to statement of Köhler et al.
On small trenches, \{310\} (2000)]

Period ~ 10-12 nm

Depth ~ 2-3 nm
Fe/W(110) with small period (5nm) at 150°C

Layer-by-layer growth
Forms a smooth surface
Some details about continuous films

- Residual corrugation across the trenches
- Zoology of misfit dislocations
Magnetism – Mo/Fe/W

Structure

2.5ML Fe/W(110) with large period (12nm) at 150°C

Capping for SQUID measurements

Magnetism

Fe stripes at the bottom of the trenches

Easy axis along in-plane [001]

Mean blocking temperature 100K
Fe/Mo surface anisotropy along [001] > Anisotropy increased
Mean blocking temperature 175K
**Current focus**

**Engineer further magnetic anisotropy**

By what means?
- Magnetic material
- Capping material
- Etc.

**What for?**

- Blocking temperature above 300K
- Get perpendicular anisotropy

**Fabrication of multilayers**

(Widespread for semiconductor QDs)

Q.Xie et al., PRL 75(13), 2542 (1995)

>>> RHEED Movie (Step: W)

**What for?**

- Unusual (not demonstrated?) for metals
- What becomes of strain, dislocations etc?
- Influence on magnetic anisotropy?
- Futuristic: trend of magnetic recording towards 3D (Cf S.S.P. Parkin, R. Cowburn)