Electrodeposited Epitaxial CoPt films

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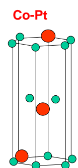
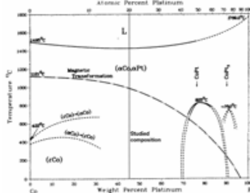
Motivation/Background



MEMS devices containing magnetic elements for field generation or actuation need a high anisotropy and a crystal structure that minimizes wall motion or rotation. A candidate material is Co-rich, CoPt $Co_{75-80}Pt_{20-25}$ K_u 1-3 MJ/m3, μH 1.2 T, T_c 1050 These properties are obtained without any post-deposition thermal processing.



In order to tailor the magnetic properties, the microstructure and the orientation of the electrodeposited CoPt must be controlled. One method for controlling both the orientation and the grain size is to use an epitaxial seed layer.

Earlier work used (100) and (111) copper seed layers deposited on (100) and (110) Si wafers. These enabled mixed FCC and HCP CoPt (on (100) Cu seed layer) and (002) CoPt (on (111) Cu seed layer). The (002) CoPt films showed a decrease in FWHM (~0.73°) with increasing thickness to 1 μm. These films required thickness over 100 nm to exhibit hard perpendicular anisotropy.

Template Fabrication (MINT)

Silicon (110), hydrogen-terminated using a 25:1 dilution of a 6:1 NH3F:HF BOE solution
(111) Cu deposition DC sputtering 100W 200 nm
(002) Ru deposition DC sputtering 10W 20 nm
Base Pressure ~5e-7 torr, Ar pressure 5 mTorr, ambient deposition

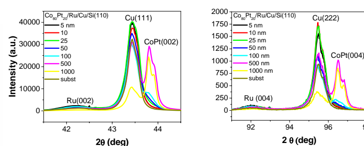
Electrochemical Deposition (UVa)

$E_{0,Co} = -0.44\ V_{SHE}$, $E_{0,Pt} = 1.2\ V_{SHE}$
Need to reduce the metals at similar voltages:
decrease Pt activity by selective binding in solution

Electrolyte: Pt-p-salt 0.01 M
Co-sulphamate 0.1 M
ammonium citrate 0.1 M
Glycine 0.1 M
sodium hypophosphite 0.1 M

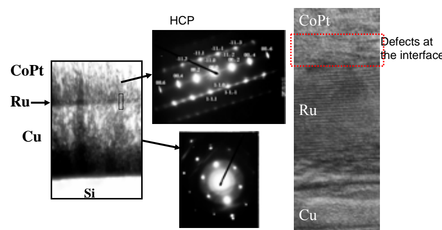
Deposition conditions
Current control, 10 – 50 mA/cm^2
pH 8, 60°C

Structure (XRD)

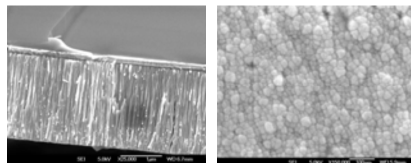


X-ray measurements show epitaxial deposition of the CoPt on the Ru/Cu templates. Only the CoPt (002) and (004) peaks are observed

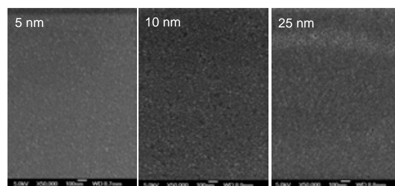
Structure (X-TEM)



Structure (SEM)

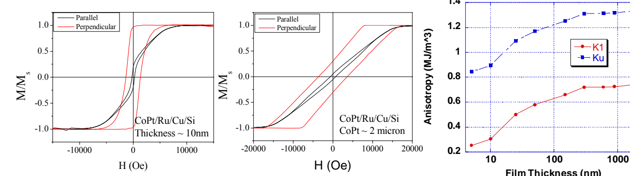


Columnar microstructure – cellular growth
20-50 nm grain size at the surface

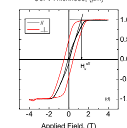


Continuous layers at small thicknesses

Results (Magnetic)



- High B_r, H_c at small thickness
- Possible application in perpendicular magnetic recording



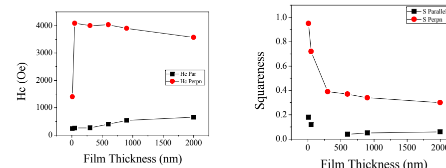
K_{eff} determined by low field susceptibility:

$$K_{eff} = H_{k,eff} M_s/2$$

$$K_u = K_{eff} + 2pM_s^2$$

(an upper limit to the actual value, $N_d = 1$)

K_u values similar to those reported for Co_3Pt



Highest coercivity is achieved at the 50 mA/cm2 current density

Conclusions/Future work

We have demonstrated that a Ru seed layer can be used produce an electrodeposited CoPt film with a perpendicular anisotropy in a thickness range thinner than observed using solely Cu seed layers.

The properties of these films show properties obtained without the need of additional processing that could be useful in MEMS devices.

Future work will focus on e-beam patterning a layer of PMMA spun onto the Ru-templates. The patterned PMMA will be used as a mask to allow the deposition of nm-sized perpendicular anisotropy CoPt elements.

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Zana ESSl 6 C153 (2003)

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