Fabrication and Testing of Exchange Coupled Composite Media

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Outline

- Introduction to ECC media
- Fabrication of ECC media using CoCrPt-SiO_2
- Spin-stand recording performance of ECC media
- Switching mechanism of ECC media
- Conclusions

Exchange Coupled Composite Media for Perpendicular Magnetic Recording

- Perpendicular magnetic recording (PMR) is currently replacing longitudinal magnetic recording.

- However, the density limit of PMR is around 500 Gbit/in^2:
  - Writability
  - Side track erasure (STE)
  - Switching field distribution (SFD)

Kryder, et al, 2004

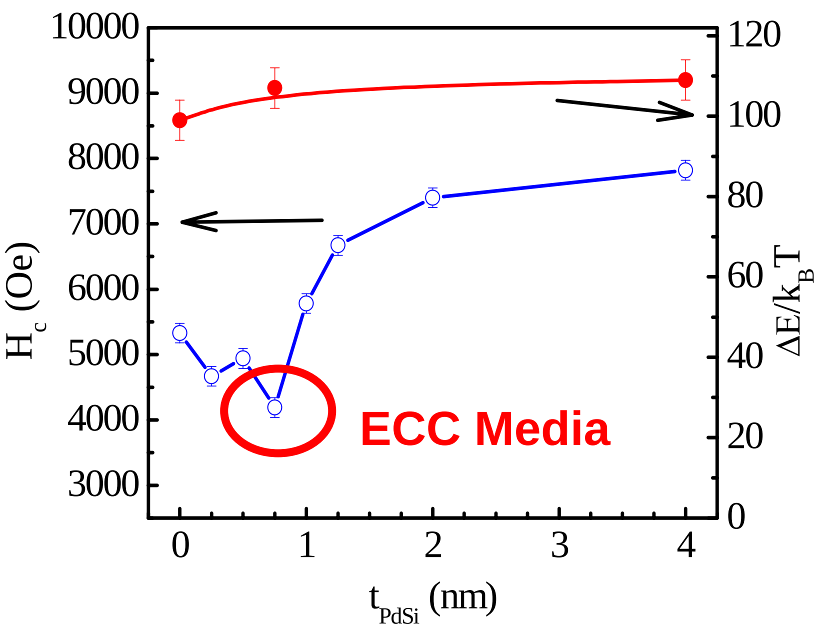
- Exchange coupled composite (ECC) media has been proposed and demonstrated to address above issues and extend the areal density of perpendicular recording.

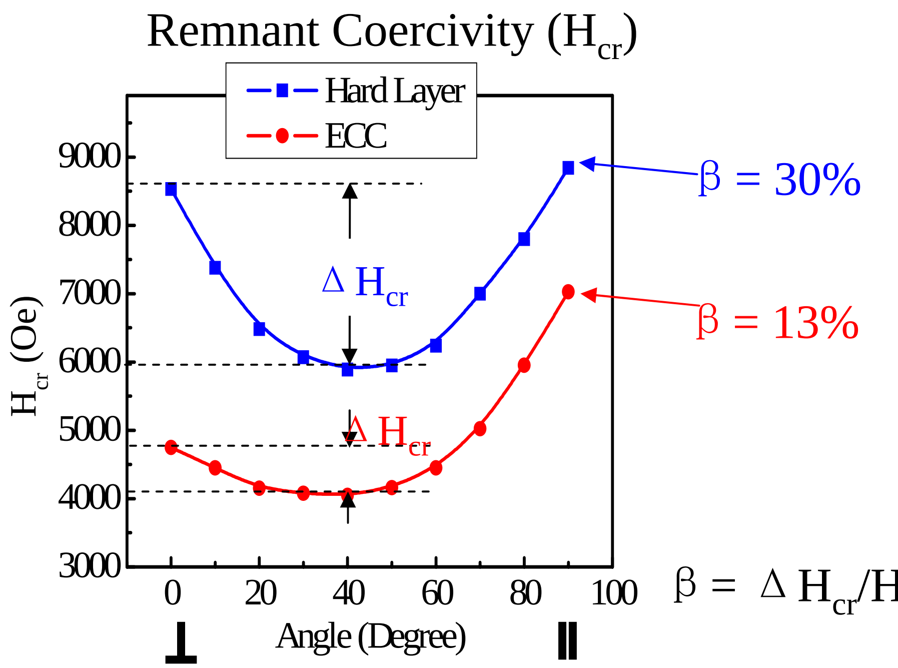
Victora, et al IEEE Trans. Magn. 2005

Wang, et al, Appl. Phys. Lett. 2005

Prototype ECC Media

Si(2 nm)/FeSiO(6.5 nm)/PdSi(t nm)/[Co/PdSiO]$_n$(18.2 nm)/UL & SL/GL





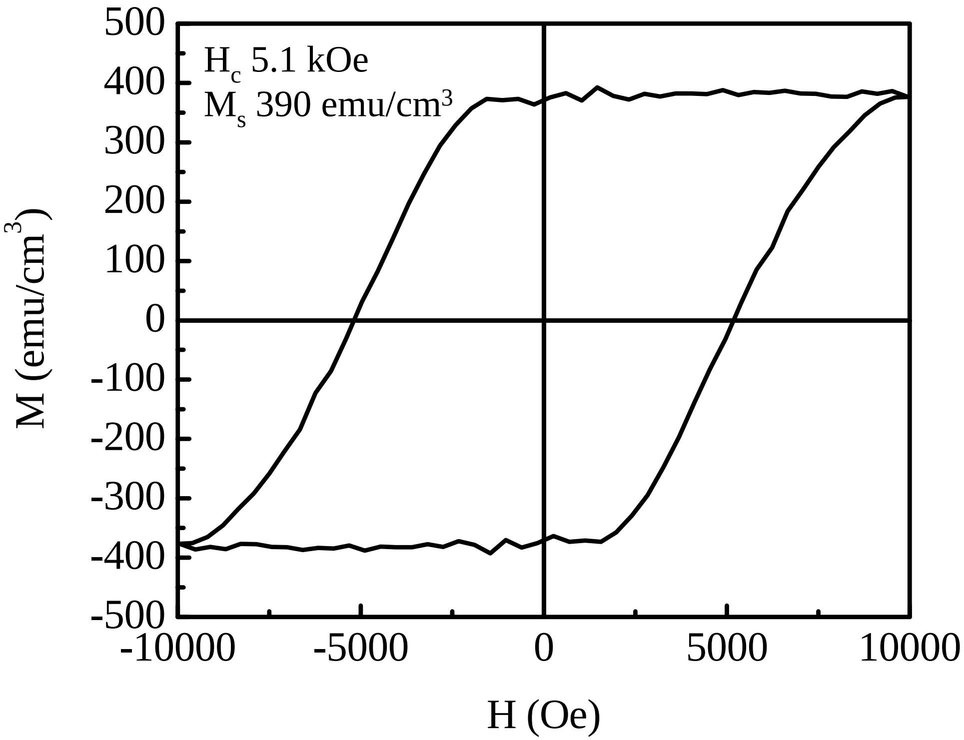
Lower switching field
→ Writability

Less angular dependence
→ STE & SFD

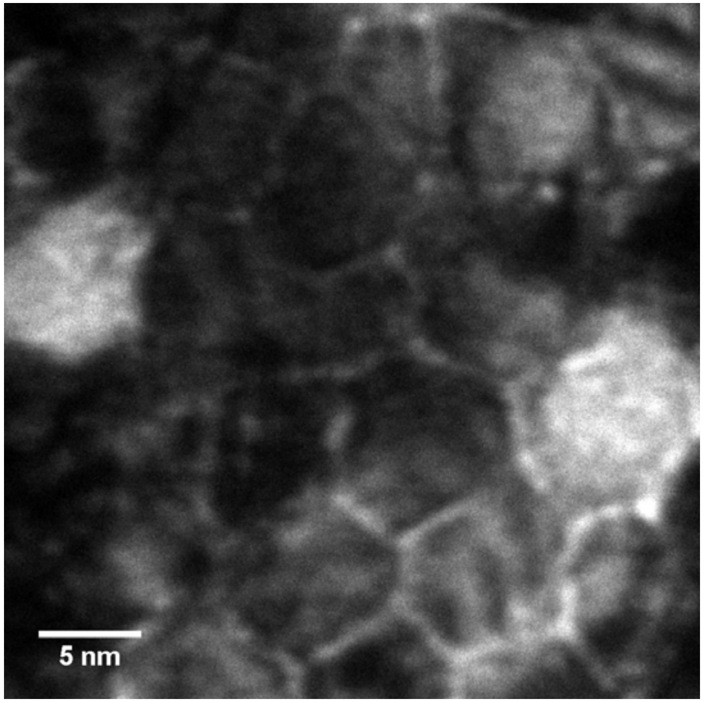
J. P. Wang, el al, Appl. Phys. Lett. 86, 142504(2005).

CoCrPt-SiO_2 Hard Layer for ECC Media

Si(2 nm)/CoCrPt-SiO_2(20 nm)/Ru(40 nm)/Ta(5 nm)/Glass

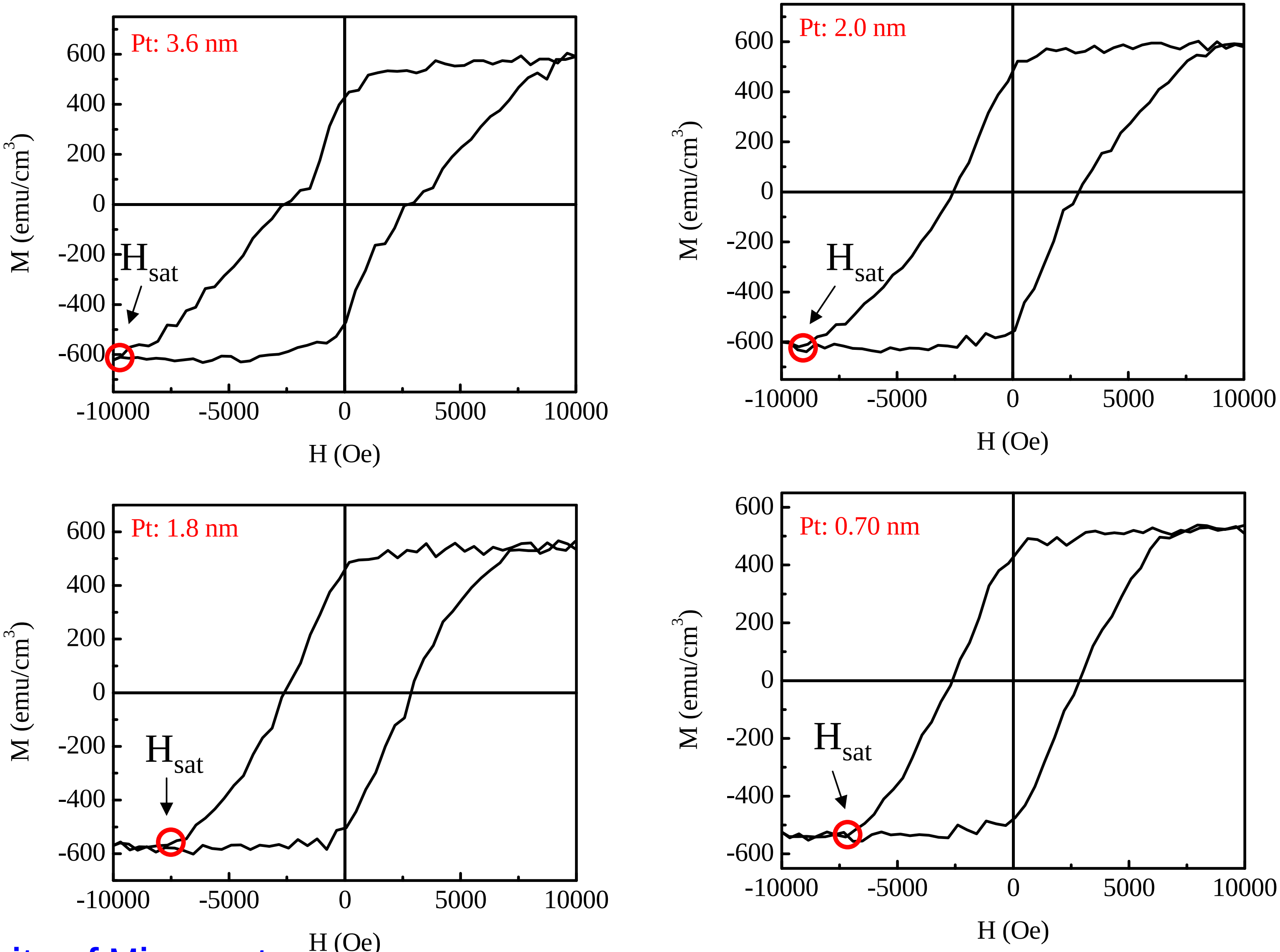


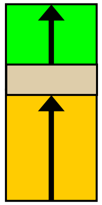
Grain size: 7.0 nm



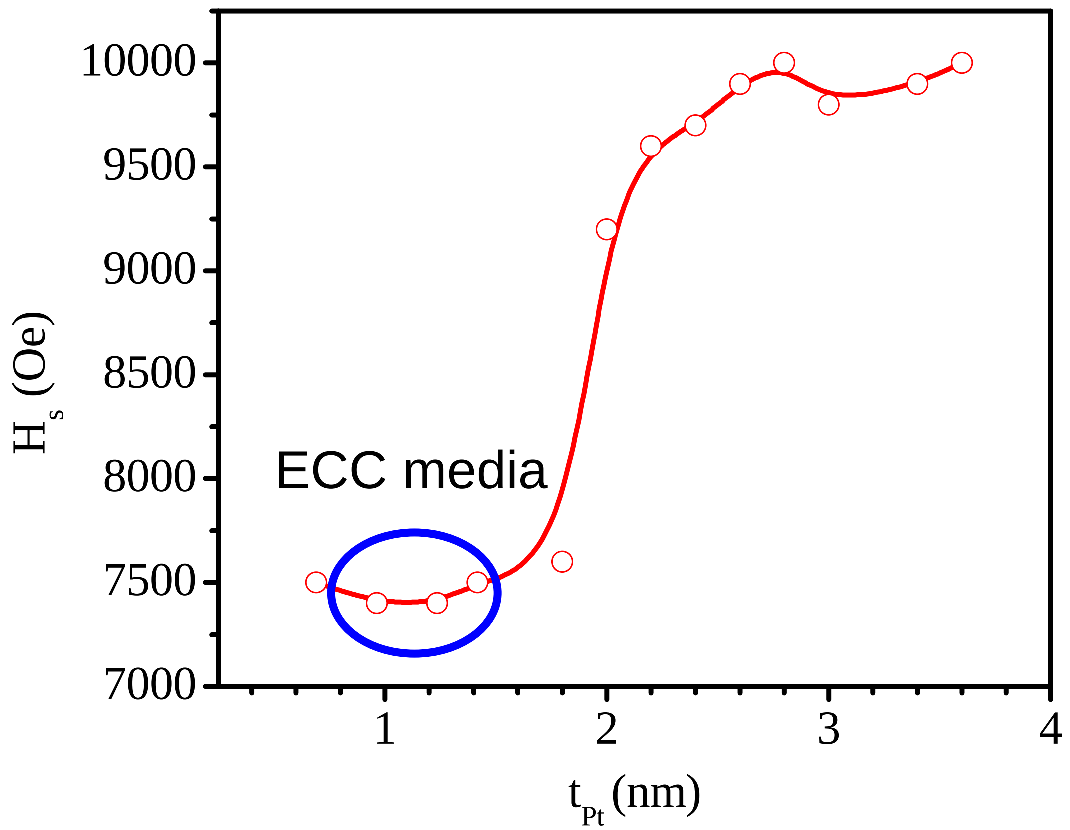
Perpendicular Hysteresis Loops of ECC Media

Si(2 nm)/CoCrPt-SiO_2 (8 nm)/Pt(t nm)/CoCrPt-SiO_2(20 nm)/Ru(40 nm)/Ta(5 nm)/Glass





H_s~ Interlayer Thickness



Si(2 nm)/CoCrPt-SiO_2 (8 nm)/Pt(t nm)/CoCrPt-SiO_2(20 nm)/Ru(40 nm)/Ta(5 nm)/Glass

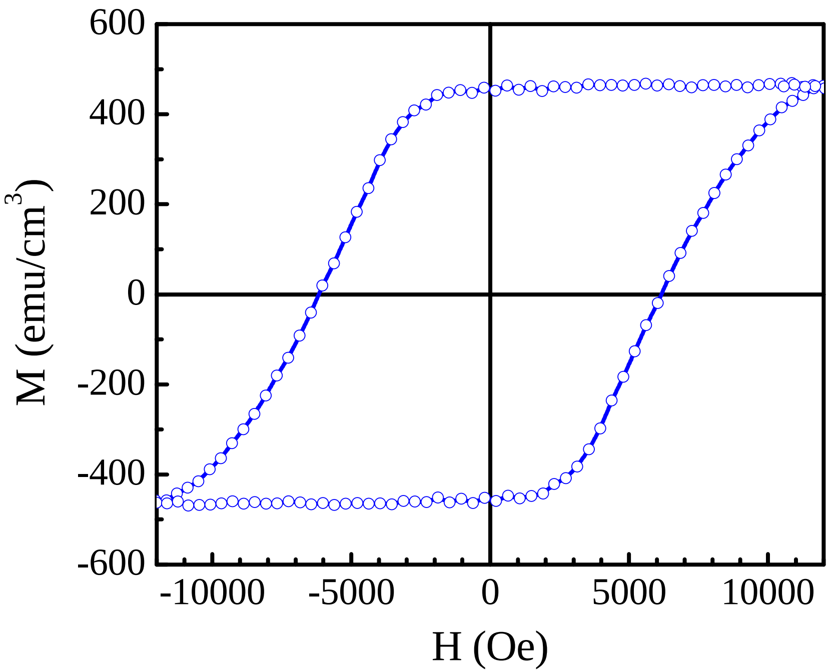
Disk Structures

Media Type	Structures
ECC	**Si(1.5nm)/CoCrPt-SiO_2(8nm)/Pt(1.0nm)/CoCrPt-SiO_2(20nm)/Ru(20nm)/Ta(2.5nm)/SUL**
Con. PMR	**Si(1.5nm)/CoCrPt-SiO_2(20nm)/Ru(20nm)/Ta(2.5nm)/SUL**
Ref. PMR	**N.A.**

- After fabrication, all disks were packaged in the clean room and shipped to the company for post procession and spin-stand testing.
- Carbon overcoat was 3.5 nm thick. Lubricant is ~1.0 nm thick.
- **Reference PMR media is provided by a company, which is targeting for 200 Gbit/in^2 areal density magnetic recording.**

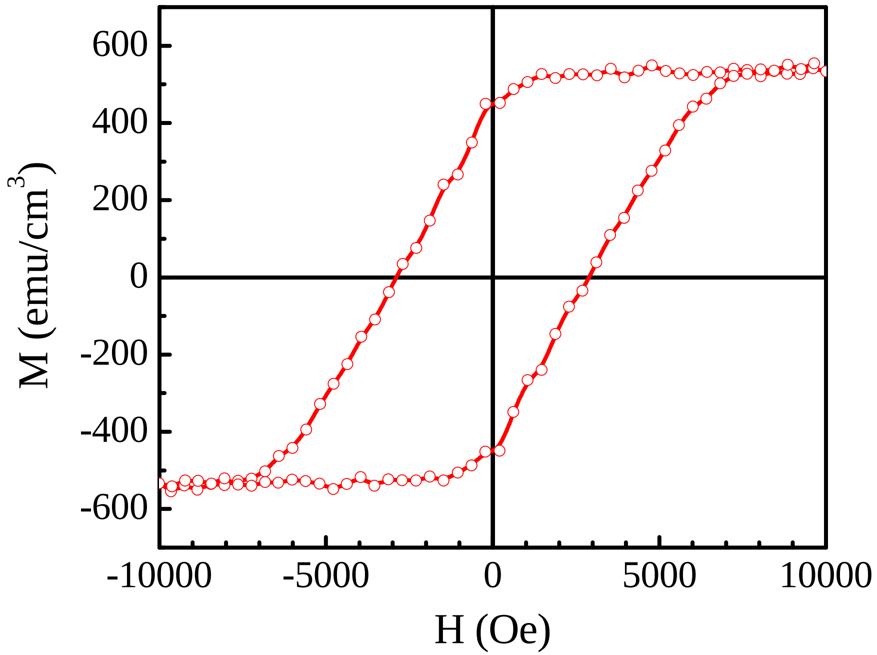
Perpendicular Hysteresis Loops

Con. PMR (single hard layer)



H_c = 6.3 kOe
H_s = 12.5 kOe

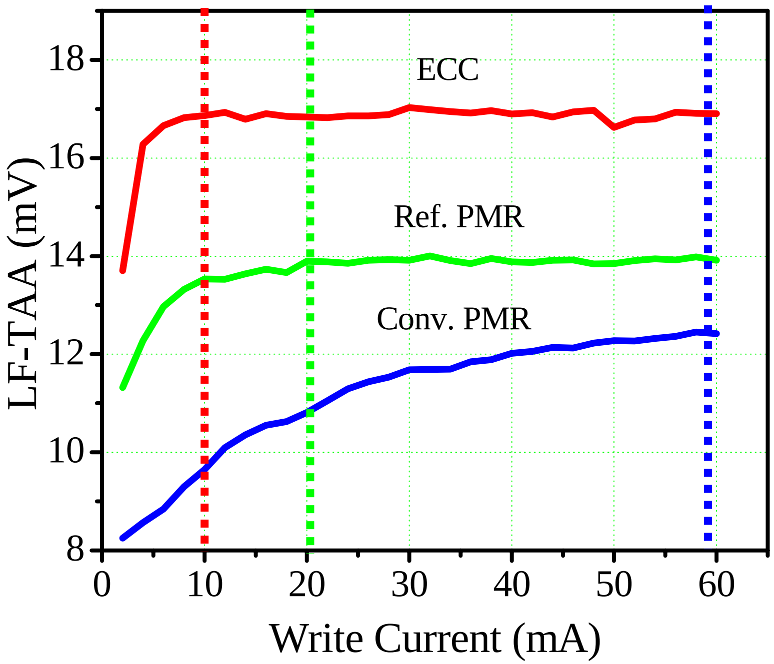
ECC media



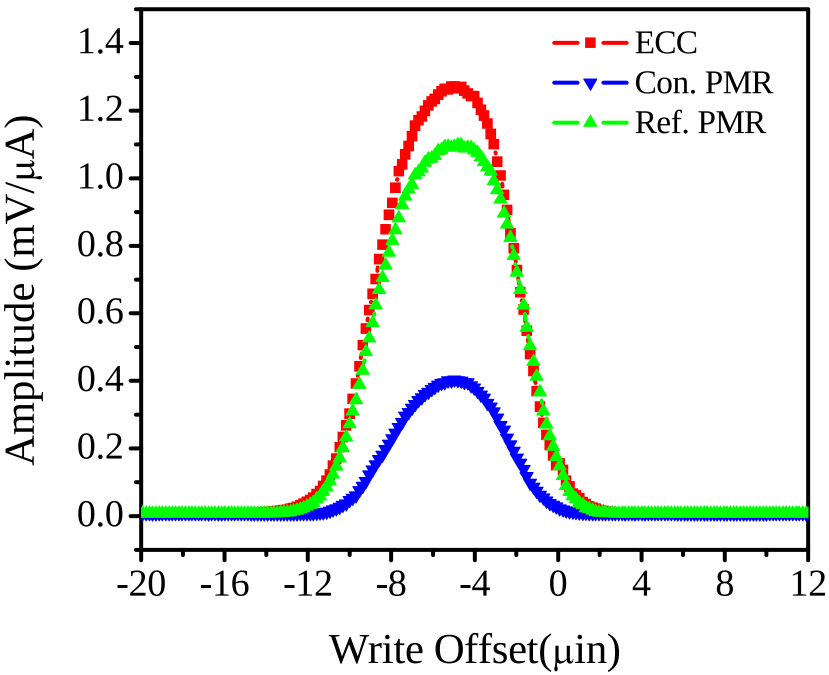
H_c = 3.0 kOe
H_s = 7.0 kOe

Spin-stand Test Results (1)

Saturation Curve

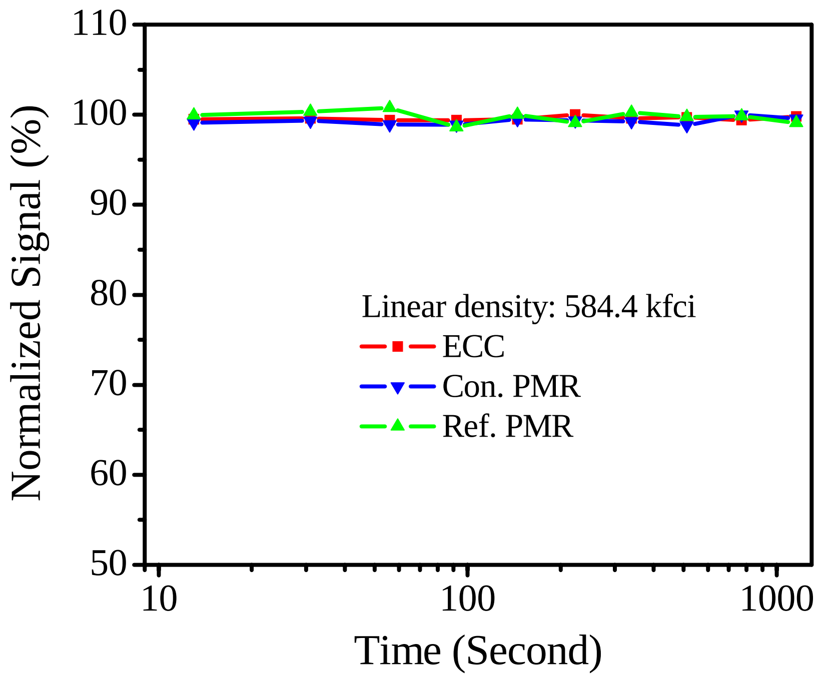


Track Profile

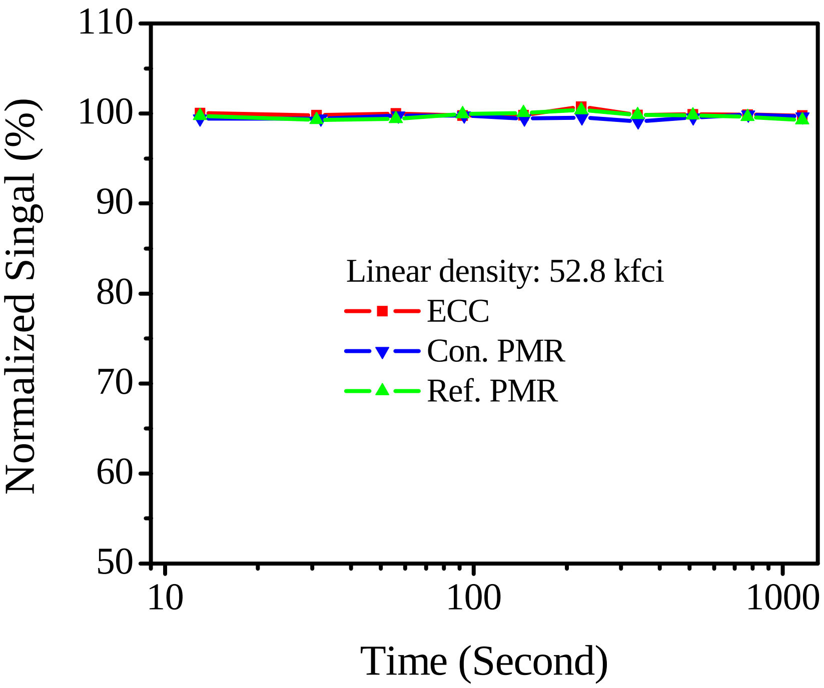


Spin-stand Test Results (2)

HF-Time Decay

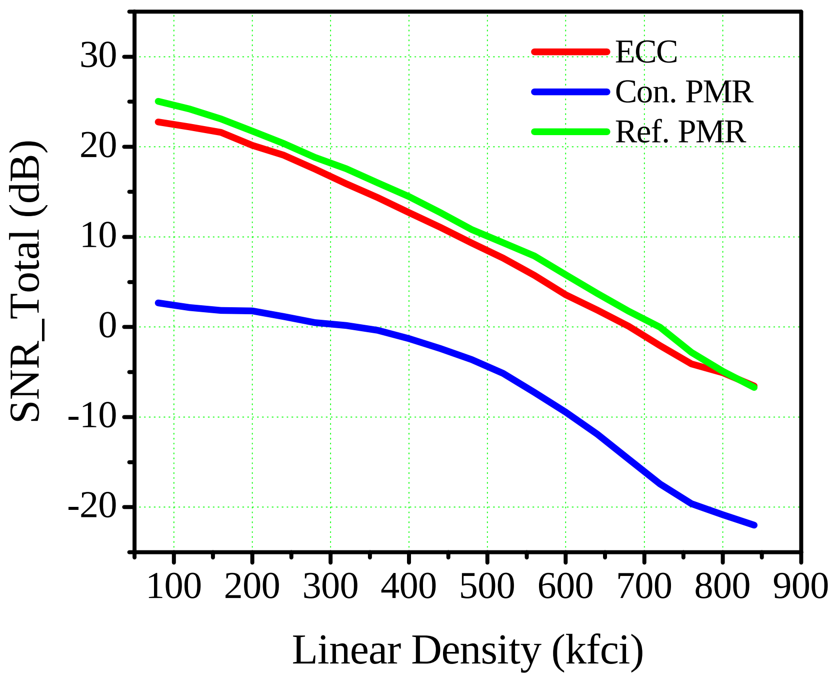


LF-Time Decay

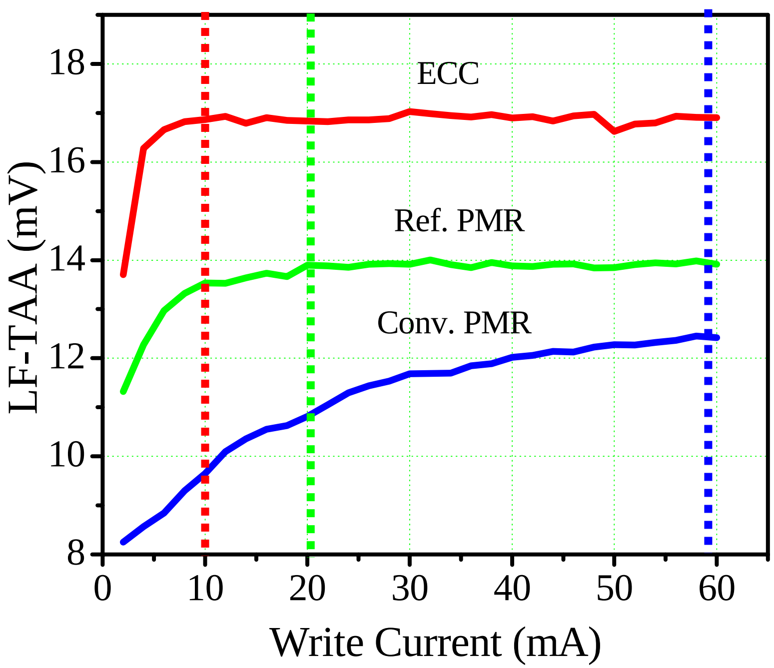


Spin-stand Test Results (3)

Roll-Curve

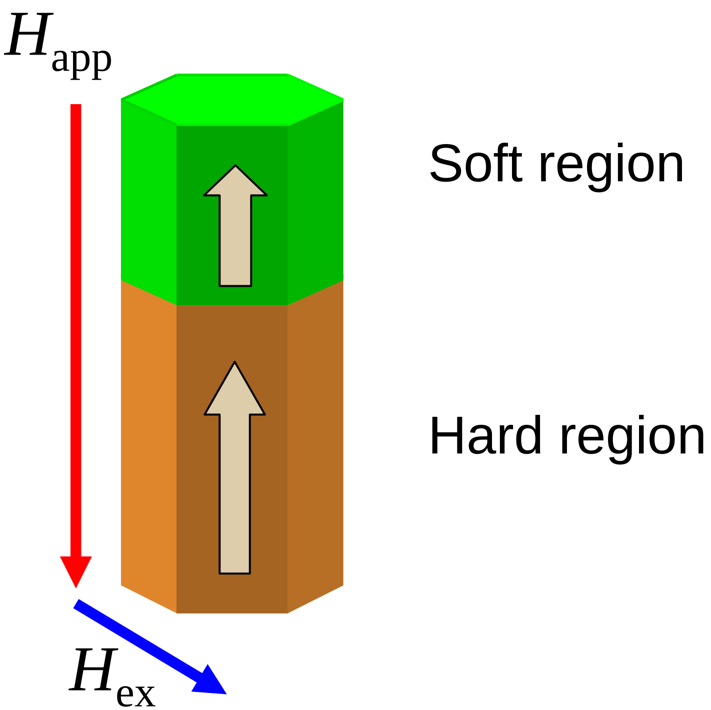


Saturation Curve

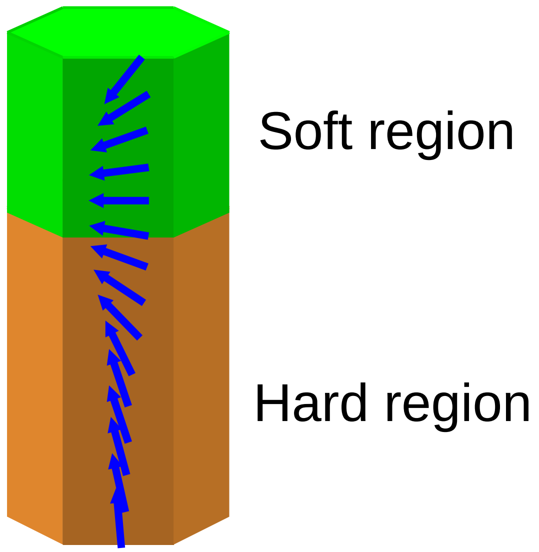


Switching Mechanisms

Coherent Switching



Incoherent Switching



Criteria
- Exchange Length in the Soft Layer

- A Domain wall must fit in the soft layer near the switching point for exchange-spring model.

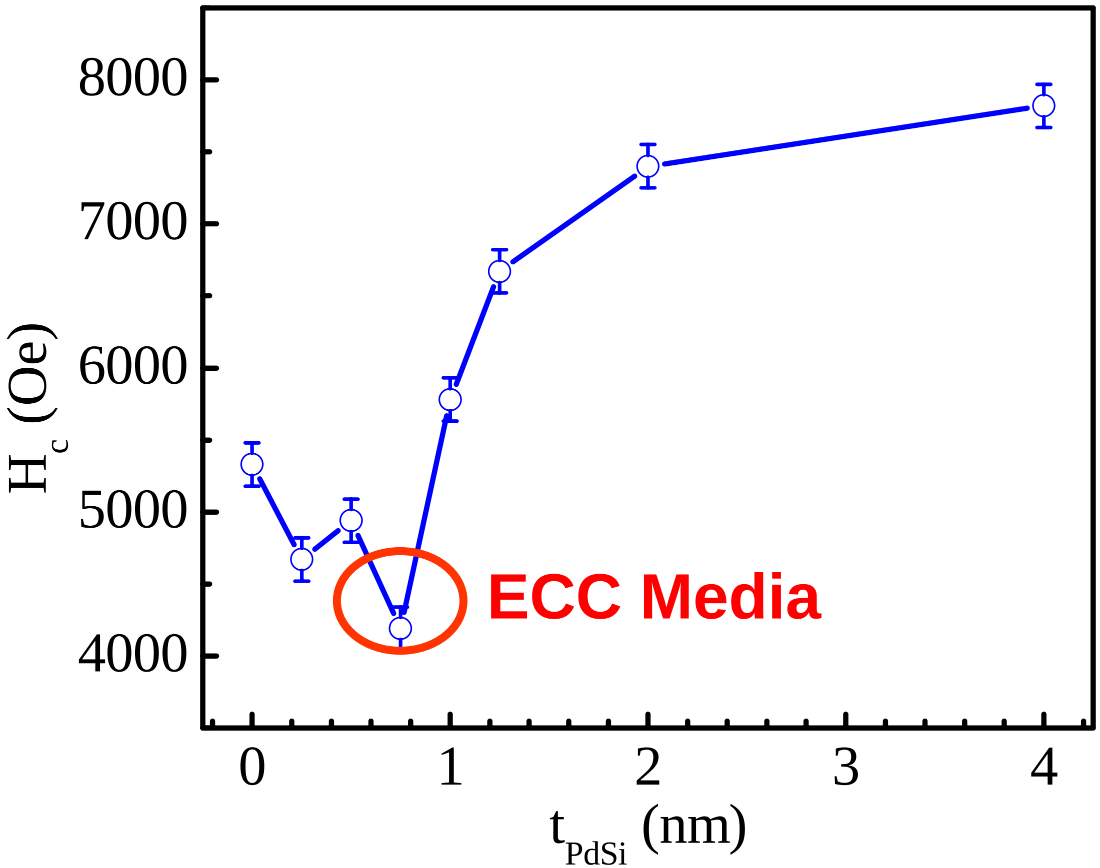
- Domain Wall Width:

$$\ell_{DW}^{soft} \approx \sqrt{\frac{2\boldsymbol{A}_{soft}}{\boldsymbol{H}_{appl}\boldsymbol{M}_{soft}}}$$

A. Dobin and H. Richter, DB-10, Intermag 2006

ECC Media Using $[Co/PdSiO]_n$

Si(1.0 nm)/FeSiO(6.5 nm)/PdSi(t nm)/$[Co/PdSiO]_{16}$(18.2 nm)/UL & SL/GL



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Domain Wall Width in FeSiO (M_s= 450 emu/c.c.)

Domain Wall Width:

$$\ell_{DW}^{soft} \approx \sqrt{\frac{2A_{soft}}{H_{appl} M_{soft}}}$$

A. Dobin and H. Richter, DB-10, Intermag 2006

$$M_{FeSiO} = 450\,\text{emu/cm}^3$$

$$M_{FeSiO}^{Core} = 620\,\text{eum/cm}^3$$

$$A_{FeSiO} = 1\times 10^{-6}\ \text{erg/cm}$$

$$H_{appl} = H_c \approx 4.19\,k\text{Oe}$$

$$\ell_{DW}^{FeSiO} \approx 8.8\,\text{nm} \quad > t_{FeSiO}\ (6.5\,\text{nm})$$

A domain wall can not fit in 6.5 nm FeSiO (Ms= 450 emu/c.c.) at the coercivity point. Dynamic tilted switching (two spin-model) is the main mechanism for coercivity reduction.

Domain Wall Width in CoCrPt-SiO_2 (M_s= 800 emu/c.c.)

Domain Wall Width:

$$\ell_{DW}^{soft} \approx \sqrt{\frac{2A_{soft}}{H_{appl} M_{soft}}}$$

A. Dobin and H. Richter, DB-10, Intermag 2006

$$M_{CoCrPt} = 800\ \mathrm{emu/cm^3}$$

$$M_{CoCrPt}^{Core} = 950\ \mathrm{emu/cm^3}$$

$$A_{CoCrPt} = 1\times10^{-6}\ \mathrm{erg/cm}$$

$$H_{appl} = H_c \approx 3.0\ k\mathrm{Oe}$$

$$\Rightarrow \quad \ell_{DW}^{CoCrPt} \approx 8.4\ \mathrm{nm} \quad \sim t_{CoCrPt}\ (8.0\ \mathrm{nm})$$

A domain wall can fit in 8.0 nm CoCrPt-SiO_2 soft layer at the coercivity point. Domain wall propagation (exchange-spring model) may be the main mechanism for coercivity reduction.

Conclusions

- Compared to conventional PMR media, ECC media showed an excellent saturation writing performance.

- Disk level thermal stability was tested. No thermal degrading was found for ECC media, which confirmed the thermal stability of ECC media.

- The switching mechanism of ECC media can be coherent switching or incoherent switching.