教育部補助博士班研究生出席國際會議報告

序號：89

姓　名	江若帆	會議期間	2003/7/27---2003/8/1
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出國報告：			

參加 ICM 2003 會議報告

公元 2003 年 International Conference on Magnetism 於 7 月 27 日至 8 月 1 日，在義大利羅馬市舉行。此次會議有來自於歐、美、日、韓等數十餘國的磁性學者與會，乃是在磁學物理及應用上的一大盛會。本人於 7 月 28 日凌晨抵達羅馬市，隨即進入會議會場進行註冊報到的手續，正式揭開了為期五天的會議行程。在報到現場，本人遇到了多位昔日的同學、同事以及磁性領域的前輩們，與他們談了最近一年的研究方向與成果，彼此交換一些研究上的心得，並藉由他們的介紹，認識了一些其他領域的研究學者。閒談當中發現到，彼此研究領域雖不盡相同，但是能有相當大的合作空間，例如本人這幾年來累積了不少的有關高品質磁性薄膜成長方面的經驗，配合上他們的一些精密分析技術，將能夠以實驗方式釐清許多磁學上的物理觀念。除了與一些與會學者的討論，經由主辦單位所印製的論文摘要，我發現在這一年來世界各研究機構對於磁性物理學或應用上又有了許多精采的研究成果！使得我深信這次的會議一定能有許多的收穫。

綜觀此次的國際磁學會議，主要的熱門研究主題為：(一)高密度紀錄媒體。(二)巨磁阻或穿遂式自旋閥讀頭。其中巨磁阻自旋閥部分包含了交換場的研究，而我的 group 在這方面已有相當傑出的表現。在未來的研究上，我將更深入地繼續這部分的研究，同時投注心力於高密度紀錄媒體上。

此次會議在磁性理論與最新動態及應用上，收穫匪淺，並與各個不同的研究團體交換許多的心得及論文，且攜回多項設備的目錄，可說是一大豐收。

ICM 2003/7/29

- **Oral Session 2D** Disordered and frustrated systems—spin glasses
- **Poster Session**

2S-am-16 Thickness effects on magnetic properties of nanocrystalline CoFeBN soft magnetic thin films (Hanyang Univ. & Tohoku Univ.)

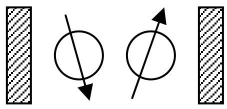
soft magnetic films for high frequency operation ＝＞ controllable anisotropy field & high magnetization

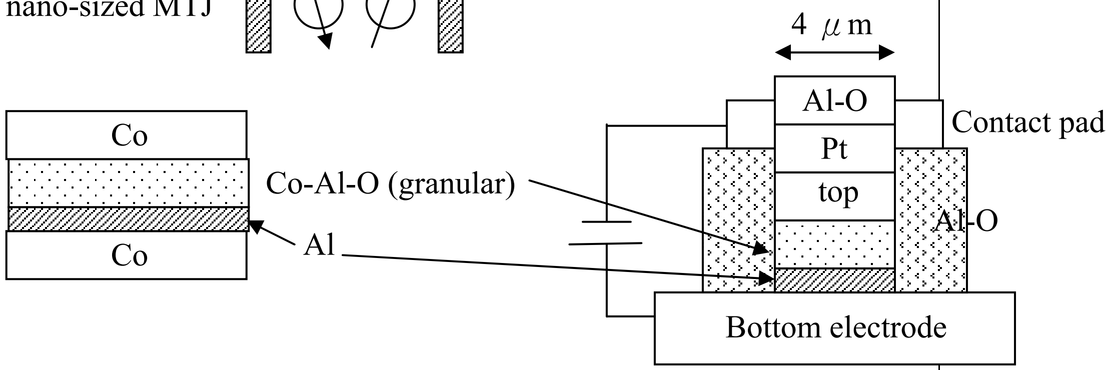
- Si (100) substrate, $Fe_{70}Co_{30}$ target, base pressure<$1*10^{-8}$ Torr, working distance~5 cm, reactive of N_2 with working pressure of 1 mTorr
- 4πMs~15-20 kG, Hc~45-0.3 Oe, μ＝500 up to 2.3 (2.7) GHz
- addition of B & N ＝＞ increase ferromagnetic resonance frequency (f_{res})

CoFeBN/TiN/CoFeBN μ~200, however, Q< 100

2U-am-10 Spin-dependent single-electron tunneling phenomena in nanofabricated granular systems

they used FIB etching to reduce the size of sample structures and restrict the possible current paths. However, there were some disadvantages for FIB process such as the ion beam irradiation damage or the resolution of microfabrication

nano-sized MTJ 



TMR ＞ 40 %

2W-am-05 Microwave permeability of Y-type hexaferrites in zero and low fields

except for ferromagnetic thin films, there are numbers of ferrite research groups that utilized Y and Z-type hexaferrites for application requiring high μ materials at low frequencies

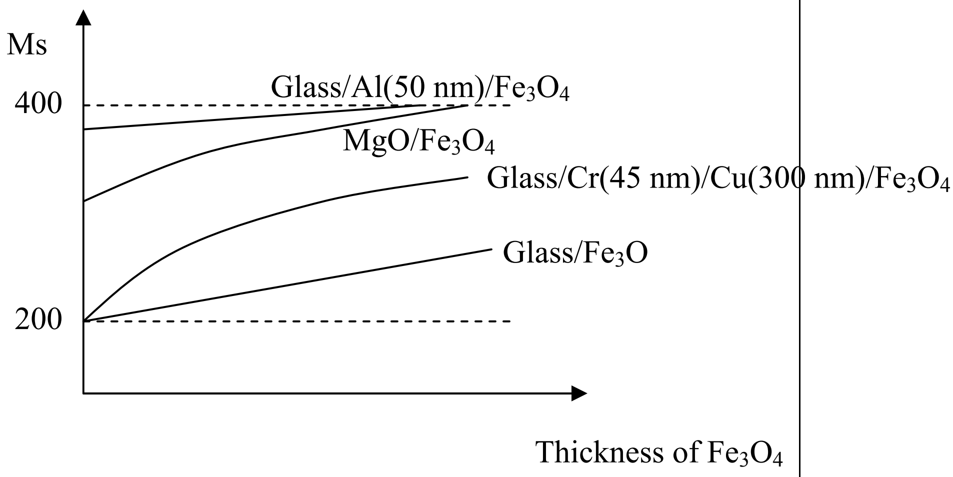
measured permeability from 0.045 to 10 GHz ranged from 3 to 4 for H ＝600 Oe, and μ＝7 to 6 in zero field

2W-am-15 Soft magnetic properties of as-deposited Fe-Al-O nano-crystalline thin films

the nanocrystalline Fe-Al-O thin films of 16 mm diameter and 1 μm thickness were deposited on Si wafer

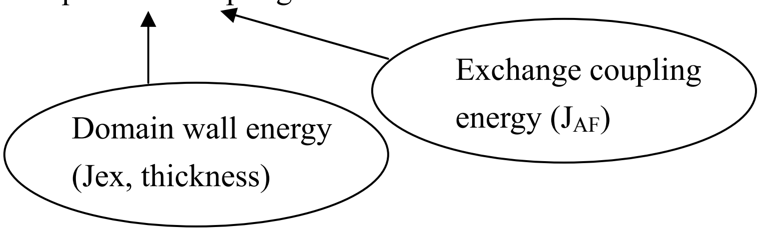
4πMs of 19.4 kG, Hc of 0.6 Oe, Hk of 6 Oe, μ_{eff} of 2500 up to 100 MHz, and resistivity of 40~70 μΩ—cm

2W-am-21 Effect of metallic underlayer on structural and magnetic properties of sputtered Fe_3O_4 films



2F-pm-01 Domain size tuning of biquadratic coupling in antiferromagnetically coupled thin films

biquadratic coupling ＝＞ fluctuation mechanism



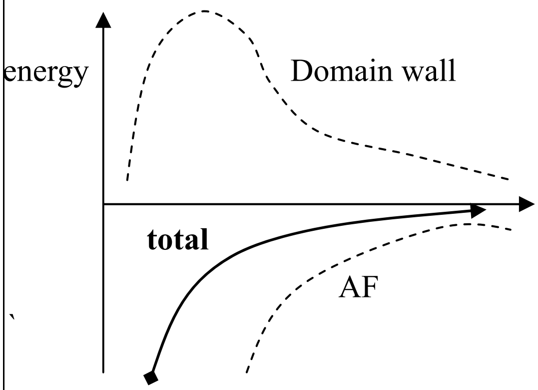
Fe/Cr/Fe
$J_2 \alpha -4(\triangle J_1)^2 L^2/\pi^2 AD$
PRL. 67. 3172 (1991)

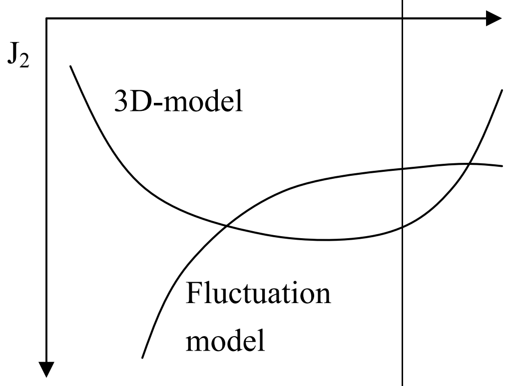
・Co/Ru/CoCrPtB AFC media

1. two exchange coupled layer

2. Co layer has large domain wall energy
(fluctuation of the sign of the exchange field)

=> biquadratic coupling should be observed in AFC media by varying the thickness of LL





FM valid if
$J_2 < (-0.15) * |J_1|$

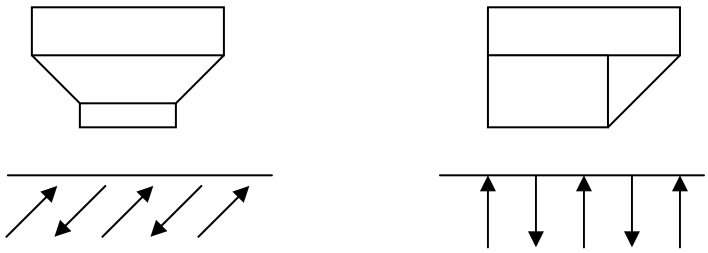
Magnetic Storage Technologies by M. Kryder

- SNR ~ $\log_{10}(N)$ N : numbers of grain (that's one of the purpose of grain refining)
  $\tau = (1/f_0)\exp(K_uV/K_BT)$

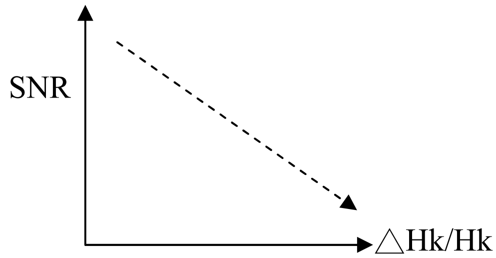
- PRM demo of Seagate
  KBPI : 850
  KTPI : 131 (850*131 ~ 111 Gbpsi)
  Data rate : 409.6 Mb/sec
  RPM : 5400

- issues of PRM => application of canted field => incomplete reversal of M => uneven transition region => origin of noise

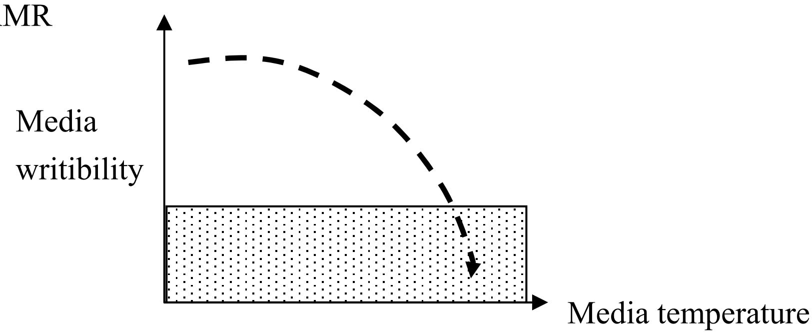
- importance of tilted PRM (TP) when compared to conventional PRM (CP)



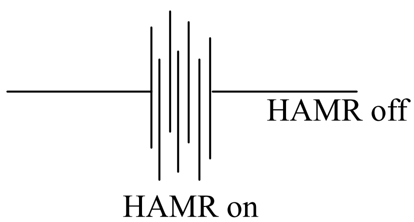
• △Hk/Hk

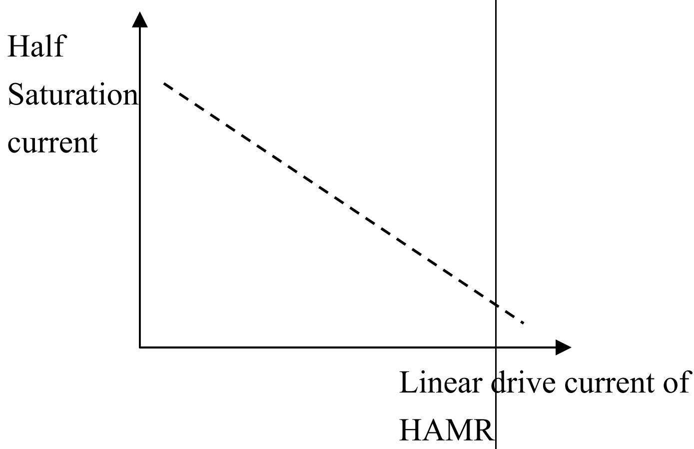


• HAMR



• HAMR spin tester





• PW50 mapping of HAMR

＝＞ high writing resolution potential
(heat dominates over write field gradient)

＝＞ use of “optical waveguide” (Ridge waveguide transducer)
maximum power density : $1.67*10^{-4}$ mW/nm^3

	spot size : 31 nm ・SOMA (10 nm FePt ＝＞ 5 Tb/in^2) However, how to find low cost means of making media…because that 1 Tb/in^2 ＝＞ 12.5 nm lithography would be required ・SOMA FePt had been done by Seagate (PRM, HAMR media, and Probe media—xy stogare) as-deposited fcc FePt ＝＞ (530℃) fcc/fct ＝＞ (650℃) fct but poor uniformity ・Major remaining gap obtaining sufficiently small HMS to enable the resolutions required

ICM 2003/7/30

- **Oral Session 3D** Nanostructured and nanopatterned magnetorecording media

3D-am-01 Patterned media for high density recording

- design parameters : single domain particle & uniaxial anisotropy & thermal stability $\tau = \tau_0 \exp(KuV/k_BT)$…..if KuV/k_BT is equal to 50, a media will be for about 10 year stable

moreover, to achieve proper SNR, the grains in media need to be as small as possible with less exchange coupling

- main issue of PRM ＝＞ sharp transition (Hd has to be lowered), volume less critical
- HAMR & Pattern media

Ion irradiation, FIB etching

Laser interference (Ar laser 351 nm)

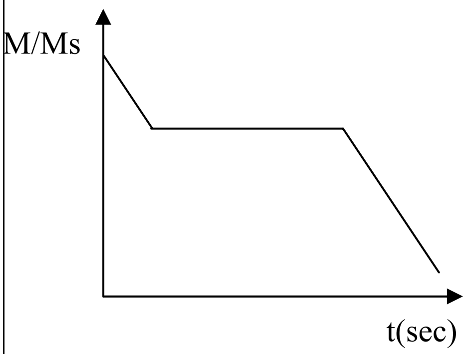
e-beam (pattern size 75 nm) IEEE, 38(4), 1731(2002)

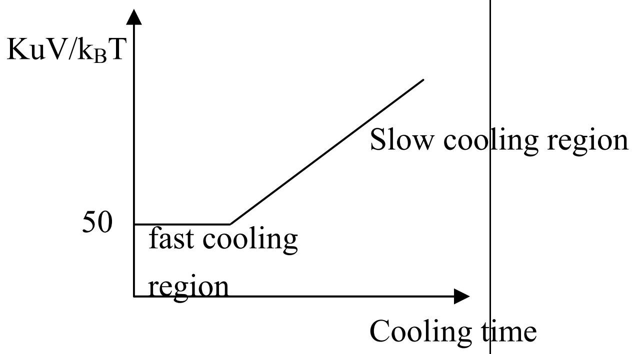
- Deposition & Imprint
- Ion irradiation in a multilayer
  ＝＞ destroying the interface
  ＝＞ non-protected (paramagnetic) & protected (ferromagnetic)
  Science 280, 1919-1922 (1998)
- Patterning with Block Copolymer (PMMS, PS)
  ＝＞ circumferential pattern media
  IEEE, 38(5), 1949 (2002)
- FIB (50-700 nm)
  ＝＞ 206 Gb/in^2
  APL, 81(15), 2875 (2002)

3D-am-03 Temperature dependence of the magnetic properties of electrodeposited Co-Pt films with high perpendicular anisotropy

	Co-rich Co-Pt magnetic alloys with high perpendicular anisotropy are of interest in a variety of applications, including pattern media and magnetic actuators for MEMS. The importance resides in the fact that they can maintain their hard magnetic properties in films up to several microns thick when deposited near room temperature. ・ HCP $Co_{80}Pt_{20}$ on Cu (111)/ Si(110) Ms ~ 879—942 emu/cm^3 & Hc ~ 6 kOe ・ for MEMS ＝＞ high force, large gap, zero-voltage operation, bi-directional activation ＝＞ electroplating is better than sputtering ・ Si (100)/ Cu (100) ＝＞ fcc CoPt (200) Si (110)/ Cu (111) ＝＞ hcp CoPt (00.2)…..by rocking curve High current density ＝＞ low SF density ・ simple estimation of K_{eff}＝ (Hk_{eff}*Ms)/2 & Ku ＝ K_{eff} ＋$2\pi Ms^2$ ＝＞ Ku ＝ 1.02 * 10^7 erg/cm^3 of this system, which is twice of the value of conventional Co **3D-am-05 Magnetization thermal stability at thermomagnetic writing in perpendicular recording media** the thermal decay of the magnetization during thermal-magnetic writing, however, may be significant and may limit the potential application of HAMR they studied the effects of cooling rate, dispersion in grain volumes and anisotropy fields, damping and intergranular interactions ・ models of granular thin film (1) critical volume model (2) self-consistent mean field model ・ cooling after the head field is removed ＝＞ what should we consider? ・ temperature dependent ＝＞ Ms, Ku, Hk (1) reduce Tc–Tw (2) reduce damping constant α (3) increase exchange coupling ＝＞ to improve area density advantages of HAMR ・ Critical Volume Model (1) lognormal volume distributions (2) Hd ＝ $-4\pi Ms$ (3) Neel–Arrhenius law Vc(t)＝(###)/Ku(t)*(###)

thermal decay during cooling (isothermal)…..freezing condition

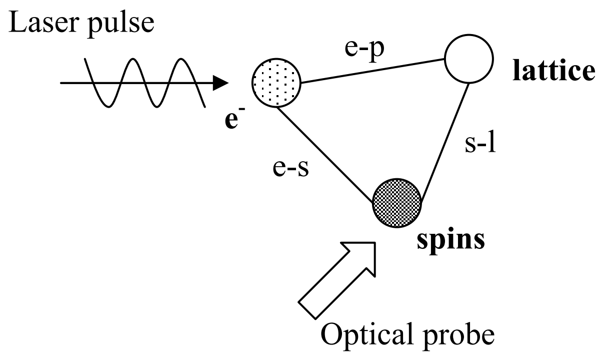




- Self-Consistent Mean Field Model ＝＞ Ruigrok formula
  J. M. S. J., 25, 313 (2001)

3D-am-06 Fabrication of Sm-Co films with perpendicular magnetic anisotropy

- $SmCo_5$: 11~20 × 10^7 erg/cm^3
  (a) without heat treatment ＝＞ soft magnetic properties
  (b) 250℃ heat treatment ＝＞ $SmCo_5$ (110)/ Cr (200)
  ＝＞ Hc ~ 3 kOe at the thickness of 2.5 nm (in-plane)
- SmCo for PRM
  ＝＞ Cu (111) 200 nm without heat/ SmCo (00.2) 40 nm with heat
  lattice mismatch ~ 2.29%
  ＝＞ heat treatment from 0—400℃
  ＝＞ Hk ＞ 15 kOe & Hc ~ 6 kOe even though the thickness of SmCo is 10 nm

	• **Oral Session 3SY** Fast magnetization dynamics **3SY-am-02 The secrets of femtosecond magnetization dynamics** interest in this challenging field is fuelled both by the desire to develop novel concepts for ultrafast switching of magnetic devices, and pure scientific curiosity – establishing fundamental understanding of spin systems in the extreme non-equilibrium case • pump-probe optical techniques with femtosecond laser pulses • laser induced magnetization dynamics (PRL, 76, 4250 (1996))  • time-resolved photo emission & two-photo photoemission & time resolved MOKE **3SY-am-03 Imaging spin dynamics in closure domain and vortex structures** one of the important questions in the spin dynamics of nanostructures is the nature of excitation spectra in systems that are not uniformly magnetized. This situation occurs in many cases, including non-ellipsoidal samples and samples with domain structure • use of TR-Kerr microscopy as a localized spectroscopic probe • how do spin dynamics (μ , time scale & mode structure) influenced by confinement (1) closure domain in square elements (2) vortex structure (3) edge domain in wires • time resolved MOKE JAP, 79, 5898 (1996) • low frequency dynamics

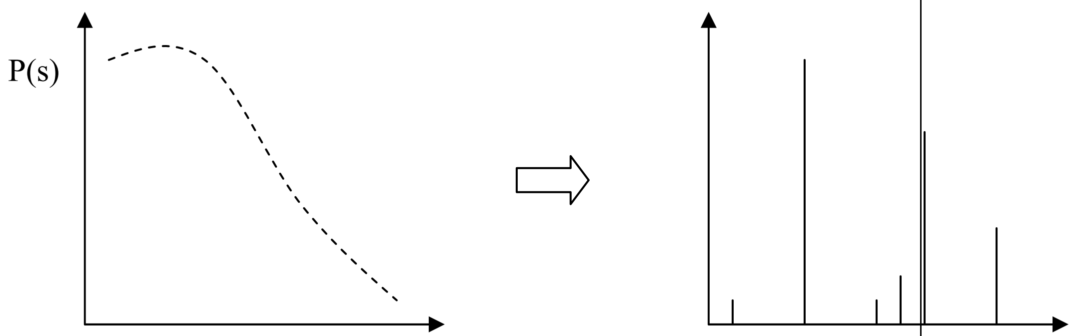
	PRL, 53, 190 (1984) • Vortices in NiFe disks PRL, 83, 1042 (1999) & JAP, 91, 8037 (2002) Science, 298, 577 (2002) ＝＞ SPSTM Science, 289, 930 (2000) ＝＞ MFM

ICM 2003/7/31

- **Oral Session 4SY** Biomagnetics/ Medical applications
- **Poster Session**

4T-am-12 Dynamic hysteresis and Barkhausen noise in CoFeSiB thin films

- MOKE (local) versus FLUX (fluxometric method, global, used for ribbon often)
  By using FLUX, they are able to perform measurements of dynamic hysteresis and of Barkhausen effect, thus investigating the hysteresis properties from the high frequency range down to the quasi-static case
- FLUX-----Barkhausen noise (by describing the domain wall motion)



In Fe films, no BH noise is observed, while in these Co films they detect a significant noise

4V-pm-09 Investigation of the Fe_3O_4 (001) surface by low-energy He^+ ions scattering

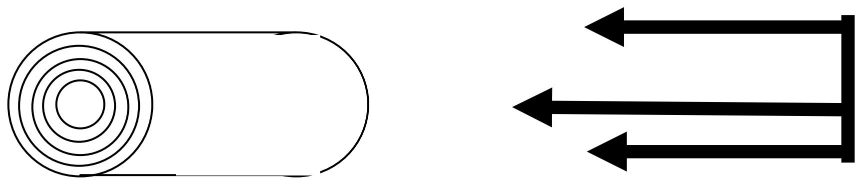
- LEIS of He^+ of 4–8 keV ＝＞ single crystalline (001) surface
  Two distinct peaks in the energy spectra ＝＞ (He^+–O) & (He^+–Fe)
  Indicating that the outermost surface layer is composed of both O & Fe atoms
  A large enhancement of the He^+–O scattering peak was observed in the Verway phase transition region (freezing of the e^- hopping between Fe^{2+} & Fe^{3+})
- LEIS ＝＞ octahedral Fe-oxygen layer terminated on the magnetite (001) surface
- a large contribution from re-ionization of neutralized particles in a collision with atoms in the deeper layer

4W-pm-05 Complex permeability of permalloy–ferrite hybrid composite materials

- NiZn (MnZn) spinel ferrite core & $Fe_{55}Ni_{45}$ particles were used (mixing ferrite and permalloy powder with PPS resin, melting at 300℃ and pressing, cooling under 1000 kg/cm^2 pressure)
- Permeability measurement ＝＞ coaxial line technique (10 kHz to 6 GHz)
- Low μ' of 14 ~ 8 & μ'' of 0 ~ 6, f_{res} of 10^8 ~ 10^9 Hz
- Frequency disperse of permeability
  ＝＞ domain wall resonance & spin resonance

4W-pm-23 Magnetic spectra of laminates with thin iron-based films

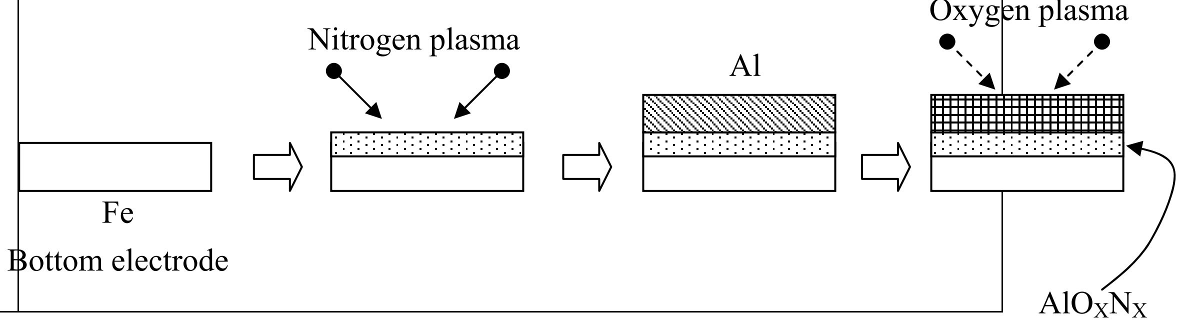
- modern technology of thin film inductor and tunable devices
  ＝＞ sputtering, which allows to reach high permeability values at high frequency
- sample preparation (iron based 0.1-1 μm-thick continuous film)



- magnetic properties of thin films ＝＞ peak width, intensity & frequency

4X-pm-07 Nitrogen effects at the interface of insulating barrier in a nitrogen-treated magnetic tunneling junction

- Ta/ NiFe/ FeMn/ NiFe/ Fe/ Al_2O_3/ NiFe/ Au



- after annealing, MR ratio of nitrogen-treated TMR junction is improved while keep low RA ＝＞ suppress the diffusion of metal element

4X-pm-10 Spin dependent tunneling in magnetic tunnel junctions with $(Hf_xAl)O_y$ barrier

- high quality oxide tunnel barrier
  ＝＞ strong chemical & thermal stability, high breakdown voltage, should not affect much TMR values by the bias voltage (disadvantage of AlO_x)
- MTJ structure of Ta 5/ CoFe 17/ IrMn 7.5/ CoFe 5/ $(Hf_xAl)O_y$ 1.4/ CoFe 5/ Ta 5
  (1) formation of Al_2O_3
  (2) TMR ratio enhancement of 18%
  (3) Soft magnetic properties enhancement of 54%
  (4) Effective height decrease of 22%
  (5) V@50% TMR ratio enhancement of 15%

barrier	TMR (%)	H_{ex} (Oe)	Hc (Oe)
AlO_x	18.7	305	34
$(Hf_xAl)O_y$	22.1	421	16

ICM 2003/8/1

- **Oral Session 5B**   Amorphous and nanocrystalline materials

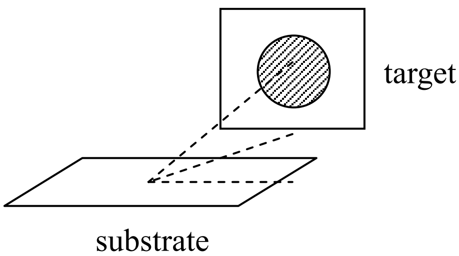
- **Poster Session**

5U-am-23 Magnetoresistance of trilayer films with Fe_3O_4
difficult to obtain the Fe_3O_4 thin film with the stoichiometric composition because of the existence of many iron oxides, α–Fe_2O_3, γ–Fe_2O_3, Fe_3O_4 and FeO

- high quality Fe_3O_4
  ＝＞ Ar ＋ H_2 mixture sputtering gas on MgO (100)
  (oxygen partial pressure was controlled by H_2 concentration)
- Co/ M (M=Pt, Cu, TiN)/ Fe_3O_4
  ＝＞ GMR 0.1% at R.T. & 0.7% at 4.2K
  ＝＞ considering the different current ratio of the three layers
  ＝＞ small GMR maybe resulted from the unbalanced resistivity

5X-am-03 Microstructure and magnetic properties in FeCoB/ NiFe double layer
soft magnetic underlayer for perpendicular recording media
＝＞ high $4\pi Ms$, low Hc & high in-plane uniaxial anisotropy field Hk (increase SNR)

- FeCoB (250 nm) ＝＞ Hc ~ 43 Oe, Hk ~ 330 Oe, $4\pi Ms$ ~ 22 kG, $\lambda s \sim 3.5 \times 10^{-5}$
- FeCoB (200 nm)/ NiFe (3 nm)
  ＝＞ Hc ~ 1 Oe, $4\pi Ms$ ~ 22 kG, $\lambda s \sim 1.7 \times 10^{-5}$
  ＝＞ reduction of grain size by NiFe with low surface energy
- maintain high Hk (up to 300 Oe) at 300℃ annealing
  & 500℃ ＝＞ change the direction of Hk
- induced Hk (tunable) by oblique sputtering



5X-am-23 Optimisation of the exchange coupling characteristics of PtMn-CoFe films prepared by BIBD

PtMn AF in spin-valve sensors and MR head

=＞ improved reliability, better thermal stability and corrosion resistance, and high exchange bias field

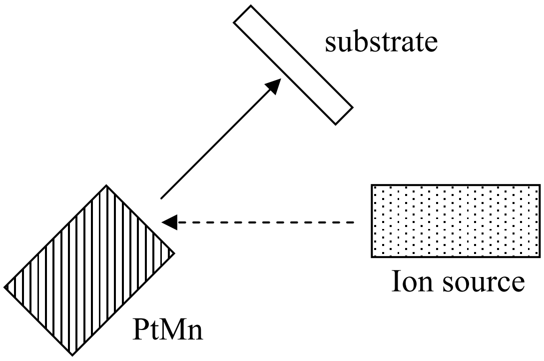
=＞ concentration ratio of Pt & Mn in films within a narrow window around 1:1

and after a phase transformation to the ordered fct phase, $L1_0$, is promoted by means of thermal annealing

- Ion beam (Xe sputtering gas)

=＞ homogeneity, good structure & magnetic properties, excellent thermal stability & high Tb

- control the PtMn composition by varying the angle



5V-pm-10 Soft magnetic properties and high frequency characteristics of Fe-based nanocrystalline films

electro-magnetic devices

=＞ decrease the size & increase the efficiency

=＞ high Ms, Hk, ρ, μ, low Hc, good corrosion & high f_{res} and low eddy current loss

- $f_{res} = \gamma(Hk*4\pi Ms)^{1/2}/ 2\pi$
- $Fe_{77}Hf_9N_{14}$ =＞ 4πMs ~ 17 kG, Hc ~ 0.8 Oe, Hk ~ 4 Oe, μ ~ 4500 (100 MHz), ρ ~ 80 μΩ–cm
- $Fe_{78}Co_8Ta_9N_5$ =＞4πMs ~20 kG, μ_{eff} ~ 1000 (600 MHz), f_{res} ~ 1.8 GHz

- Fe-based ＝＞ FeBN ＝＞ $(Fe_{0.7}Co_{0.3})BN$
-

	4πMs	Hk	ρ	μ_{eff}	f_{res}
$Fe_{78.1}B_{7.6}N_{16.4}$	12	12	210	400	2.1 G
$(Fe_{0.7}Co_{0.3})_{84.2}B_{4.6}N_{11.2}$	15	80	180	150	3.3 G

5V-pm-20 Nanogranular Co-Fe-Al-O sputtered thin films for magnetoelastic device applications in the GHz frequency range

(Fe, Co) nanograins (4 ~ 13 nm) in an amorphous Al-O matrix
＝＞ small Hc due to a very small (Fe, Co) grain size

- instrument of 9 GHz & $\mu'_r \sim 4\pi Ms/Hk$
- 4πMs ~ 14.04 kG, f_{res} ~ 2.38 GHz, ρ ~ 150 μΩ-cm, Hk ~ 50 Oe, Hc ~ 1.25 Oe
- sharp resonance ＝＞ low damping constant
- loss of ferromagnetic resonance on permeability
- loss of electromagnetic induction on permeability

發表論文全　文：	（如附件）

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