Magnetic Interfaces and Nanostructures
Room 204 - Session MI+MS+NS-ThM

Advanced Magnetic Storage and Manufacturing Processes

Moderator: E.A. Dobisz, Hitachi Global Storage Technologies/San Jose Research Ctr.

8:20am **MI+MS+NS-ThM1 Interface Stability between Amorphous Ferromagnetic Layer and Oxide Barriers in Tunneling Magnetoresistive Films at Elevated Temperatures***, **X. Peng**, D. Kvitek, A. Morone, E. Granstrom, S. Xue,* Seagate Technology

Interface stability and microstructure between amorphous ferromagnetic (FM) layers Fe@sub 56@Co@sub 24@B@sub 20@ (atomic percent), and oxide barrier layers (AlO) as deposited by physical vapor deposition, in both as-deposited and annealed states, have been studied using magnetic measurement by looper, elemental depth profiling by X-ray Photoelectron Spectroscopy (XPS), and atomic level microstructure by Transmission Electron Microscopy (TEM) respectively. AlO is amorphous on both amorphous Fe@sub 56@Co@sub 24@B@sub 20@ and crystalline FM layers. Substantial Fe diffusion towards the AlO layer and Al towards FM layer are clearly observed for Fe@sub 56@Co@sub 24@B@sub 20@/AlO system for annealing beyond 360°C, and will likely cause the MTJ devices made from this system to not functioning.

9:00am **MI+MS+NS-ThM3 Nanoimprint Technologies for Magnetic Recording Media***, T. Ando, **C. Haginoya**, K. Kuwabara, M. Ogino, K. Ohashi, A. Miyauchi,* Hitachi Ltd., Japan **INVITED**

The discrete-track and patterned media have been developed as future magnetic recording media.@footnote 1,2,3@ Nano-scale patterns are formed on the disk surface of these media. The fine patterning technologies are required for producing the patterned disks. The nanoimprint technology is attractive for the fabrication of nano-scale structures in view of cost and mass production. There are two main types of the nanoimprint technologies. One is the thermal nanoimprint technology that fine structures are formed on thermoplastic polymer layer. Another is the photo nanoimprint technology that ultra-fine structures are formed on photo-curable polymer layer. There are several key points for media application such as pattern formation area, resolution, precise control of pattern transfer, lifetime of nano-mold, alignment and so on. The pattern formation area is important for producing patterned disks. We developed a thermal nanoimprint machine that has the auto-parallel system, two step pressure system and so on. The machine enabled us to imprint fine dots on a 300 mm diameter Si wafer using a 300 mm diameter mold. The pattern formation area is large enough to produce the 65 mm diameter patterned disks. The fine resolution is required for high recording density. Austin et al. formed 6 nm half-pitch structure using supperlattice stamper,@footnote 4@ and this resolution seems enough for Tbpsi storage era. D. Wachenschwanz et al.@footnote 1@ and Y. Soeno et al.@footnote 3@ evaluated write/read performance of the discrete-track media that the grooves and servo patterns were formed by using thermal nanoimprint and etching processes. Nanoimprint is promising way for discrete-track and patterned media. @FootnoteText@@footnote 1@ D. Wachenschwanz et al., INTERMAG 2005, no. BB02 @footnote 2@ B.D. Terris et al., INTERMAG 2005, no. BB03 @footnote 3@ Y. Soeno et al., INTERMAG 2005, no. FR04 @footnote 4@ M. D. Austin et al., 3rd Conf. on Nanoimprint Nanoprint Technology 2004, no. III.2

9:40am **MI+MS+NS-ThM5 Ultra Narrow Magnetic Recording Heads: Processing Challenges***, **M.-C. Cyrille**,* HITACHI Global Storage Technologies - San Jose Research Center **INVITED**

As the areal density of magnetic recording increases well beyond 100Gb/in2, the critical dimensions of recording heads continue to shrink at a rate of 30% per year.@footnote 1@ Today, thin film heads with 100nm or less critical dimensions are being routinely fabricated in manufacturing. By the end of 2006, the physical trackwidht of read head sensors is expected to be less than 60nm. The industry is turning to Direct write E-beam and DUV 193nm as the lithography tools of choice to meet those small dimensions. As the material set used to fabricate thin film magnetic heads is unique to this technology, specific challenges arise when trying to pattern such small devices without loss of performances. Damage due to standard patterning techniques can be now be observed on both the reader and the writer as their dimensions become smaller than 100nm and advances in tooling and processes tailored to each kind of magnetic sensor are required to overcome this issue. @FootnoteText@@footnote 1@ Fontana R.E., MacDonald S.A., Santini H, Tsang C., IEEE Trans. Mag 35, 806 (1999)

10:20am **MI+MS+NS-ThM7 Correlated AFM/MFM and Magneto-Optical Studies on Epitaxial L1o FePd Thin Films***, R.A. Lukaszew, M. Mitra, **J. Skuza**,* University of Toledo*; A. Cebollada-Navarro, J.M. Garcia-Martin, C. Clavero Perez,* Institute of Microelectronics in Madrid (IMM) - Spain

The latest trend in data storage exploits perpendicular recording. Magnetic binary alloys (e.g. Fe-Pd, Fe-Pt) are of significant interest in magneto-recording because highly ordered L1o structures of these alloys exhibit very large magnetic anisotropy that can withstand the super-paramagnetic limit when reduced in size to accommodate the projected demands for higher areal densities. They can be deposited as films with the anisotropy axis perpendicular to the film plane, making them suitable for perpendicular media. There are practical problems associated with this scheme because usually the experimentally achieved perpendicular anisotropy tends to be too large for writing on this media. Therefore it has been suggested that canted magnetization would be more appropriate. Here we show our correlated XRD, AFM/MFM and magneto-optical studies on two series of epitaxial L1o FePd thin films of varying thickness grown on MgO. We have observed that the choice of capping material has significant effect on the resulting magnetic and magneto-optical properties of the films. We will show correlated structural and magneto-optical data for films grown under identical conditions but capped with either MgO or Pd. Our studies demonstrate that in the first case the films exhibit strong perpendicular anisotropy while in the latter the films have a magnetization component along the plane of the films in addition to the perpendicular component, thus yielding a net canted magnetization. In addition the films capped with Pd exhibit smaller coercivities than the ones capped with MgO thus enhancing their prospect use in heat-assisted magneto-recording.

10:40am **MI+MS+NS-ThM8 Magnetic Properties of Epitaxial FeN Thin Films***, R.A. Lukaszew,* University of Toledo*; R. Gonzalez-Arrabal,* University Autonoma of Madrid, Spain*; **C. Sanchez-Hanke**,* Brookhaven National Laboratory*; R. Loloee,* Michigan State University*; D. Boerma,* University Autonoma of Madrid, Spain

Low anisotropy and low magnetostriction iron based FCC films are attractive candidate materials for inductive thin film write heads in magnetic recording. Currently these are made of permalloy and other Fe alloys with polarization ranging from 1.0-1.6 T. Higher polarization is needed to create sufficient stray field to write on the higher-coercivity media that is needed as head and bit dimensions decrease to allow higher areal densities. Fe-N has been proposed as a possible material for the sensing element in read-head. Fe-N exhibits a variety of phases, some of which have enhance magnetic moment. In particular the meta-stable @alpha@"- Fe16N2 is particularly interesting because has the largest saturation magnetization reported of all known materials. We will present a comparative experimental study on epitaxial Fe-N thin films with varying degrees of @alpha@", @alpha@' and @gamma@' phases. The films were obtained using either sputtering or MBE. In the latter case, the films were grown in the presence of a N flow and the growth conditions were optimised in order to obtain a high content of @alpha@"- Fe16N2. A variety of characterization techniques was used to establish the epitaxial character of the films as well as the amount and kind of phase present. The magnetic properties of the samples was characterized by element specific X-ray Magnetic Circular Dichroism (XMCD).

11:00am **MI+MS+NS-ThM9 Processing Technology for Magnetic Random Access Memory***, **M.C. Gaidis**, J.P. Hummel, S.L. Brown, S. Kanakasabapathy, E. O'Sullivan, S. Assefa, K. Milkove, D. Abraham, Y. Lu, J.N. Nowak, P. Trouilloud, D. Worledge, W.J. Gallagher,* IBM **INVITED**

Magnetic Random Access Memory (MRAM) offers the potential of a universal memory - it can be simultaneously fast, nonvolatile, dense, and high-endurance. Depending on application, these qualities can make MRAM more attractive than SRAM, DRAM, flash, and hard drive memories, with a market measured in the billions of dollars. Small-scale demonstrations have realized much of the potential of MRAM, but scaling the memory to production on economically-profitable 200 or 300 mm wafer sizes creates unique processing challenges heretofore unseen in a large-scale semiconductor fabrication facility. MRAM read operations rely on electron tunneling through a thin (1 nm) insulating barrier between magnetic films. The exponential dependence of tunnel current on barrier thickness imposes requirements for across-wafer film uniformity on the order of 0.01 nm, made possible only by recent developments in deposition technology. To maximize performance, typical magnetic film stack designs can incorporate more than 10 distinct film layers. Very few of these layers can be etched by semiconductor-industry-standard RIE processes, and thus have required development of novel patterning techniques specifically tuned to minimize corrosion and to handle the nonvolatile nature of etch byproducts. The elements in these complex film layers tend to interdiffuse at temperatures below that of back-end-of-line (BEOL) semiconductor processing, thus necessitating the development of low-temperature processes for creating the BEOL wiring and packaging. Although daunting, each of the aforementioned challenges has largely been overcome. This presentation provides an overview of the basic MRAM structure and operation, followed by a discussion of the MRAM-specific processing techniques that have been developed to realize this technology in megabit arrays on 200 mm wafers.

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