Rare-earth Information Center

Insight

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In-plane textured MgO

A recent paper by C.P. Wang et al. {*Appl. Phys. Lett.*, **71**, 2955-7 (1997)} reports the growth of in-plane textured (100) MgO films on amorphous Si_3N_4 substrates, using ion beam assisted deposition (IBAD). While no rare earths are used in the process and the films are not rare earth doped, this paper may have significant impact on one type of rare earth material. Last August, I reported on the progress being made in what is now being referred to as second generation high temperature superconducting wires. When $YBa_2Cu_3O_7$ if deposited by laser ablation on a biaxially textured substrate, the Y123 is biaxially textured, which results in low angle grain boundaries in the film and, hence, high superconducting critical currents. Two competing processes are being developed to produce long lengths of biaxially textured substrates on which to base conductors. Oak Ridge National Laboratory has developed a process called RABITS, which uses a texture Ni substrate produced by conventional rolling process. The textured Ni then has a ceramic buffer layer deposited, and finally the Y123. Los Alamos National Laboratory (LANL) has produced a textured yttria-stabilized-zirconia (YSZ) layer on a metal substrate using IBAD. The rate limiting step for the LANL process is the IBAD deposition of the YSZ. For IBAD films, the texture develops as the film thickness increases. The significance of the work of Wang et al. at Stanford is that they have produced texture in MgO layers 100 Å thick, which is better than that which has been obtained in YSZ films 5000 Å thick. Since the IBAD process essentially requires a fixed number of ions per atom deposited, the reduction of the required thickness corresponds directly to a 50-fold increase in the throughput rate for the process. While not reported in the published paper, the Stanford group reported encouraging preliminary results onY123 films on these substrates at the fall MRS meeting in Boston.

New Rare Earth Phosphors

Two interesting papers on new rare earth phosphors appeared four days apart in early February. The papers by Xiao-Dong Sun et al. {*Appl. Phys. Lett.,* **72** 525-7 (1998)} and E. Danielson et al. {*Science,* **279**, 837-9 (1998)} deal with different materials and phosphor colors, but they share more than a close proximity in publication date. Both groups used a combinatorial deposition technique to produce "libraries" of materials from which to select the phosphor with optimum composition or to identify new materials. Conceptually, this is rather simple. An automated deposition system, using combinatorial physical masks, sequentially deposits elements in a grid of samples. In the case of Sun et al., 128 different compositions or stoichiometries were deposited on a 1 x 1 inch single crystal substrate for each experiment. The array is then heat treated to react the

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elements and the properties determined. A similar process was used by Danielson et al. Sun et. al. reported that $(Gd_{2-x}Zn_x)O_{3-\delta}:Eu_y^{3+}$ has a photoluminescent quantum efficiency of 86%. For x = 0.46 and y = 0.06, the main emission peak is at 621 nm, which is better suited to the requirement for saturated colors in full color displays. Danielson et al. reported a new phosphor material containing one-dimensional chains. The phosphor, Sr_2CeO_4, has its emission maximum at 485 nm, which appears blue-white. The quantum yield is 48%. Danielson et al. prepared a combinatorial library of more than 25,000 members in isolating the new phosphor.

Exchange Coupled Superlattices

Two phase exchanged coupled magnets have been of considerable interest for several years. These magnets are a mixture of a magnetically hard phase, such as $Nd_2Fe_{14}B$ or Sm-Co, and a phase with a higher saturation magnetization than can be obtained in the hard phase. For a suitable microstructure, the hard phase can induce coercivity in the soft phase through exchange coupling. Work on these materials has been generally limited to rapidly solidified or mechanically alloyed materials, in order to obtain the fine distribution of grains required. These materials are by nature macroscopically isotropic, which severely limits the energy product that may be obtained. In addition, the distribution of phases is far from ideal. Recently, E. E. Fullerton et al. {*Appl. Phys. Lett.*, **72**, 380-2 (1998)} have reported on the production of an exchange coupled Sm-Co / Co superlattice. The layers in the superlattice are epitaxial and, of course, the thickness of each layer may be individually controlled. This is an ideal situation for studying the exchange interaction. The superlatices have a four-fold in-plane magnetic anisotropy. For a fixed Sm-Co layer thickness of 450 Å, the coercivity of the films in the (110) direction is a strong function of Co layer thickness with the coercivity for 100 Å Co layers, roughly twice than of that for 200 Å Co layers. Co-Sm layer thickness also has a strong effect on coercivity.

Magneto-optical Readout

Data storage is a tremendously competitive field and recent advances in magnetic recording have pressed magneto-optical storage to increase its capacity to stay competitive. While very small domains on the order of 0.2 μm can be recorded, using laser-pumped field modulation (LP-MFM), these domains are very difficult to readout. Xiao Ying et al. {*Appl. Phys. Lett.,* **72**, 614-6 (1998)} report on the use of domain expansion to enhance the readout signal. In this process, there are two magnetostatically coupled magnetic layers, the readout layer, GdFeCo, and the recording layer, which is TbFeCo. Clearly, the Tb layer has considerably more coercivity than the Gd layer and induces a magnetic domain in the Gd layer. When a modulated external field, with a period half of that of the recording pattern, is applied during readout, the domain in the readout layer is expanded so that the signal to noise is greatly enhanced. The authors suggest that a density of greater than 10 $Gbits/in^2$ may be realized using this technique.

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