Rare-earth Information Center Insight

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A Field-emission Flat Panel Display Based on Carbon Nanotubes

Field emission electron sources produce a stream of electrons when an electric field to the material in a vacuum causes electrons. A variety of work has been reported on field-emission sources for flat panel displays. Since there is no heated filament, field-emission sources can be made quite small, so there is essentially a separate electron gun for each pixel of a display. In principle, this makes it possible to fabricate a display a fraction of an inch in thickness. Carbon nanotubes have been reported by many workers to exhibit field-emission of electrons, and recently, Q. H. Wang et al. {*Appl. Phys. Lett.*, **72**, 2912-3, (1998)} have reported the fabrication of a 32 x 32 pixel flat panel display based on a carbon nanotube – epoxy composite cathode. The electrons emitted from the cathode excited an Al_2O_3(Eu) red phosphor. The display is reported to be easily scalable and easy to fabricate.

Imprinting Magnetic Structures

The coupling of thin magnetic layers, through nonmagnetic metallic layers, has been the subject of a considerable amount of research. Multilayers of La(32 Å)/Fe(30 Å) have been particularly interesting in that each Fe layer is ferromagnetic with the magnetization in the plane of the layer. The plane to plane coupling is such that the magnetizations of the layers form a spiral, which is incommensurate with the periodicity of the layers. Over a macroscopic sample, spirals of both chiralities exist in roughly equal proportions. When the multilayer is exposed to an external field of a low as 90 Oe, this structure was destroyed and the moments aligned with the applied field. In preparing samples to investigate this effect, G. P. Felcher et al. {*Appl. Phys. Lett.*, **72**, 2894-6 (1998)} came across a rather interesting effect. The multilayers were prepared by Ar sputtering in a UHV chamber. When these samples were investigated by neutron diffraction, it was found that the entire sample had one chirality. The paper does not mention how long it took to figure out the explanation, but it is quite interesting. The geometry of the sputtering setup resulted in an accidental field of 3 Oe at the sample position. As each layer is deposited, the 3 Oe field aligns the direction of the magnetization of that layer with the field (presumably with the in plane projection of the field). During sputtering the sample is rotated slowly in order to enhance uniformity. Thus, the projection of the field is in a different direction for each magnetic layer. The 3 Oe field is not sufficient to rotate the magnetization of the layers, which are already formed. While not discussed in the paper, one can propose at least two possible explanations for the low coercivity of the layer, which is forming. One is that the effective temperature of the surface is higher than that of the already formed layers, and hence, the coercivity is low. The second has to do with the dimensions of the film as it grows. For partial coverage, during the initial stages of the layer deposition, it is quite possible that superparamagnetic clusters form on the surface. As they grow, they are easily oriented by the small magnetic field and freeze in the magnetization direction. As is predicted by this explanation, the

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periodicity of the magnetic structure is easily changed by varying the rotation speed of the sample during deposition.

$Sm_{2+\delta}Fe_{15}Ga_2C_2$ Permanent Magnets

While Nd-Fe-B magnets are excellent near room temperature, their low Curie temperature places several restrictions on their applications. Sm-Co is useful over a wider temperature range, but the cost of these magnets is prohibitive for many applications. One of the materials being investigated, for high temperature operation, is $Sm_2Fe^{17}C_y$, which can be stabilized by partial substitution of Ga for Fe. Hot pressed magnets made from mechanically alloyed powder have successfully produced magnets with 1.7 T coercivity and 45 kJ/m^3 energy product. Using melt spun ribbon, J. van Lier et al. {*J. Appl. Phys.*, **83**, 5549-51 (1998)} have reported the successful production of hot pressed magnets with coercivities of 2 T and BH_{max} of 60.3 kJ/m^3 (7.58 MGOe). The powders were hot pressed at temperatures between 725°C and 850°C. In order to achieve maximum density, temperatures of 800°C or higher were required, while temperatures above 750°C produced a decrease in coercivity. The hot pressing was optimized for 775°C. The melt-spinning route is claimed to be considerably easier than mechanical alloying. The Curie temperature of the alloy investigated was 362°C, and it is expected that partial substitution of Fe by Co can significantly raise this temperature.

Ferromagnetism in $LaFeO_3$-$LaCrO_3$ Superlatices

For forty years, theory has predicted that a linear metal dimer of a d^3 and a d^5 metal element bridged via oxygen should have a ferromagnetic interaction. Such a dimer is Fe^{3+}-O-Cr^{3+}. This could be realized if Fe^{3+} and Cr^3 could be introduced alternately on the B site of perovskite-type transition metal oxides (ABO_3). Unfortunately, attempts at bulk synthesis have failed as the material phase separates into the Fe oxide and Cr oxide phases. Recently, K. Ueda et al. {*Science,* **280** 1064-6 (1998)} have managed to demonstrate the ferromagnetic coupling by constructing an artificial superlattice composed of alternating unit layers of $LaCrO_3$ and $LaFeO_3$. The superlattice was prepared by laser molecular beam epitaxy on a $SrTiO_3$ substrate. Using this technique, it was possible to prepare both the ordered material and the solid solution, where Cr and Fe occupy the B site randomly. The ordered material was ferromagnetic, while the disordered material was antiferromagnetic.

YBM Magnex International

YBM Magnex International, Inc. has recently been the subject of a federal investigation and considerable amount of adverse press. On the advice of the company's auditors, Deloitte & Touche LLP, an independent committee composed solely of outside directors of the company engaged outside legal council and a U.S. based investigative firm to investigate the concerns identified by the auditors. The Executive Summary of the committee report is now available. No evidence of criminal acts by the company, its officers, or its employees was found during the investigation. It was noted that while some Russian or Ukrainian suppliers were not registered with their respective business registries, this was not unusual for these regions. The report notes that there were significant breaches of corporate policy in a number of areas. The committee recommendations include numerous changes in corporate policy and enhanced enforcement of those policies. For further information, contact Mr. Guy Scala, (215) 579-0400.

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