Rare-earth Information Center

Insight

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Binary Quasicrystals

Eighteen years ago, quasicrystals caused a considerable amount of excitement in scientific circles. These materials exhibit long range atomic ordering, and yet they do not have a periodic lattice. Most quasicrystals that have been studied to date exhibit icosahedral (five-fold) symmetry. Until recently, the lore of quasicrystals has been that three or more elements are required to produce the complex clusters that make up a thermodynamically stable quasicrystal. Now, A. P. Tsai et al. {*Nature*, **408**, 537-8 (2000)} have found a stable quasicrystal in the Cd-Yb system. Not only does the compound $Cd_{5.7}Yb$ possess a primitive icosahedral lattice, but it is also a congruently melting compound, in contrast to the previously known stable quasicrystals, which are all peritectic compounds. In principal, the binary compound should be much easier to understand than a ternary, and the congruent melting should make the preparation of high-quality samples much simpler. However, the fact that Cd has a vapor pressure of more than 0.1 bar at the melting temperature must complicate things. An interesting question that is not addressed in the current article is the valance of Yb in this compound. Yb can be 3+ with a small moment or 2+ with no moment. Of course, in a complex structure, all lattice sites do not necessarily have the same valance.

Bucky Balls

Carbon cages (fullerenes), commonly referred to as bucky balls, have been extensively studied with particular interest in placing metal ions within the carbon cage. A series of stable fullerenes exist starting with C_{60}. These cages satisfy the isolated-pentagon rule (IPR), which states that in the most stable fullerenes, carbon pentagons are surrounded by five hexagons. In two recent letters to *Nature,* C.-R. Wang et al. {*Nature,* **408**, 426-7 (2000)} and S. Stevenson et al. {*Nature*, **408**, 427-8 (2000)} report fullerene structures that violate the IPR. The two materials are $Sc_2@C_{66}$ (Wang) and $Sc_3N@C_{68}$ (Stevenson). In both cases, the Sc addition is credited with stabilizing a structure where there are fused-pentagons. The analysis of these structures is interesting in that when you allow fused-pentagons, there are 4,478 structural isomers for C_{66} and 6,332 structural isomers for C_{68}. From the symmetry of the x-ray diffraction patterns, the number of possible structures can be reduced to 8 for C_{66} and 11 for C_{68}. By a variety of methods, the authors determine that in both cases the stable structures have the fewest number of fused-pentagons possible. The samples of $Sc_2@C_{66}$ (Wang) were produced by the carbon arc generated soot process, with a direct current arc discharge between Sc/graphite composite rods. Using high-performance liquid phase chromatography, 2 mg of $Sc_2@C_{66}$ were isolated from 800 g of soot. Given this production efficiency and the yield of Sc from ore, it is amusing to speculate on the number of tons of ore that would be required to produce 1 g of this material.

Metal Hydride Optical Switches

For a number of years, we have followed the progress of metal hydride optical switches where changing the H content of a RE based film results in a change from a reflecting metal to a transparent insulator. The structure used consists of a transparent substrate, the rare earth film, which is ~200 – nm thick, and a 5-nm Pd over-layer. The Pd layer plays two important roles. First, it catalyzes the hydriding-dehydriding reactions, and second, it protects the RE film from oxidation. While the second of these roles is not always required, the first is.

Unfortunately, the optical transparency of the Pd layer is only about 50%, so even though the insulating RE film is 90% transparent, the maximum transparency of the device is only 50%. Since for catalysis, the Pd layer does not need to be continuous, R. Armitage et al. {*Appl. Phys. A*, **71**, 647-50 (2000)} have investigated using a Pd grid rather than a continuous film. While this may seem rather simple, keep in mind that standard processes for depositing thin film grids are not compatible with the highly reactive RE hydride layer. The process that was developed consisted of adding a WO_3 layer on top of the Pd layer. This layer was then patterned using fairly conventional processing that resulted in a WO_3 mask directly on the Pd layer. An Ar plasma etch was then used to remove the unmasked Pd, resulting in a grid with 40% coverage of the surface. Finally, the WO_3 was removed by light etching in KOH. The thickness of the Pd layer in these initial experiments was such that the masked area was not transparent, and as a result, the absolute transmittance was only 20%, however, the results are encouraging and the switching times were faster than anticipated.

Epitaxial Y_2O_3 Films on Nb(110)

Y_2O_3 has a high dielectric constant, high resistivity, and high breakdown voltages that make it an interesting candidate for very-large-scale-integration applications, such as high-density storage capacitors for dynamic random access memory (DRAM). Y_2O_3 films have traditionally been produced by evaporation, sputtering, or pulsed laser ablation of bulk Y_2O_3, or by depositing metallic Y films and subsequently oxidizing the films in air or oxygen. Recently, a novel, yet simple, approach has been tried by J. Hayoz et al. {*Appl. Phys. A*, **71**, 615-8 (2000)}. The authors noted that O can only be removed from a Nb(110) surface by prolonged heating to 2700 K. Thus, it is possible to produce such a surface that is clean of all impurities other than O. When Y metal is then deposited on this surface at a substrate temperature of 1300 K, a well ordered Y_2O_3 film is epitaxial to the substrate. The authors point out that O must be diffusing from the interior of the Nb creating a clean source of O for oxidation of the Y, and producing well ordered smooth $Y_2O_3(111)$ films.

High-energy-resolution Scintillation

Scintillation detectors are commonly used for the detection of x-rays and gamma rays. In these detectors, the incoming radiation creates an excited state, which decays with the release of an optical photon. This photon is detected using a photon multiplier tube. The most common scintillation material is NaI:Tl that was discovered in 1948. While many other scintillators have been discovered, none matches the overall performance of NaI:Tl in terms of efficiency, energy resolution, time resolution, and cost. Now, E. V. D. van Loef et al. {*Appl. Phys. Lett.*, **77**, [10], 1467-8 (2000)} have reported the scintillation properties of $LaCl_3$ doped with 10% Ce^{3+}. This material exhibits both better energy resolution and faster response times than NaI:Tl. The $LaCl_3$:Ce is said to be easy to grow though it is also hygroscopic. The high-energy resolution may make the material competitive with NaI:Tl for some applications.

Company Notes

Edge Technologies, Inc, Ames, IA, the sole supplier of the giant magnetostrictive material TERFENOL-D, has entered into a strategic supply agreement with Westport Innovations, Inc. of Vancouver, B.C., Canada, for the exclusive worldwide rights to use TERFENOL-D in gaseous fuel engines. Westport uses TERFENOL-D to govern the flow through natural gas injectors for light-duty diesel engines. Contact Bob Clifford, Tel. 515-296-8030 or 1-800-327-7291, Fax: 515-296-7168.

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