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Transparent *p*-type Semiconductor

As we are all aware, optoelectronics is an area of growing importance. There is considerable effort in such areas as the development of optical computers. Apparently, there are significant gains to be made by using wide band gap materials over conventional Si based materials, and oxides are particularly interesting of wide-gap materials. However, for the fabrication of optoelectronic semiconductor elements based on *p-n* junctions, a transparent material having *p*-type conductivity, which is optically active and has a wide- and direct-band gap, is required. These materials appear to be in short supply. Recently, K. Ueda et al. {*Appl. Phys. Lett.*, 77, [17], 2701-3 (2000)} have reported on a layered oxysulfide, LaCuOS, which can be doped with Sr^{2+} to produce a *p*-type material. (Interestingly, LaCuOS was first prepared as a result of the interest in Cu-O layered materials for high temperature superconductivity.) It seems that the trick in doping these materials is to produce holes in the upper edge of the valence band without introducing optical transitions that absorb in the region of interest. The films, in the current study, achieved both a high level of doping and maintained greater than 70% transmission in the visible to near infrared portion of the spectrum. At shorter wave lengths, inter-band transitions destroy the transparency. The materials are expected to be useful for the fabrication of transparent transistors, presumably for display applications, light-emitting diodes, and solar cells. From a material standpoint, the authors make the observation that in order to obtain bright-colored oxysulfides, it is necessary to pretreat the starting powders to eliminate intrinsic defects. The authors treated the starting La_2S_3, Cu_2S and SrS in H_2S and "oxidized" the La_2O_3 in air. I view the possibility that the La_2O_3 is not fully oxidized as being highly unlikely. However, RE_2O_3 powders tend to absorb atmospheric water on their surface. For some oxides, i.e. Nd_2O_3, it is necessary to go to 900°C to remove this absorbed water.

Magnetic Fluctuations in $YBa_2Cu_3O_{6.6}$

Last month, I discussed some of a recent review of the properties of high temperature superconductors. One of the more intriguing characteristics is that in underdoped material, there is growing evidence of inhomogeneous distributions of charge and spin referred to as striped phases. These fluctuations have been observed in Y123 materials by neutron diffraction, but the results have implied two-dimensional stripes while one-dimensional stripes were expected. A recent paper by H.A. Mook et al. {*Nature*, **404**, 729-31 (2000)} demonstrates that the stripes are indeed one-dimensional, and the apparent two dimensionality stems from the twinned nature of the crystals. As you may recall, when single crystals of Y123 are grown at high temperature, they are tetragonal and only become orthorhombic and superconducting when the crystals are oxygen annealed at low temperature. The oxygen that is added during this anneal orders in chains resulting in the tetragonal to orthorhombic transition, which is accompanied by considerable strain in the crystals. Small crystals have been effectively detwinned by oxygen annealing under stress, but this is difficult for the large crystals that are required for the neutron diffraction measurements used to detect the stripe formation. While the authors were not entirely successful in detwinning their 4.4 gram crystal, they did manage to produce a twin domain population of 2:1 that breaks the symmetry of rotations about the *c*-axis. By comparing the diffraction patterns for the crystal, which gives the domain ratio to the reflections for the stripes, the authors clearly demonstrate that the apparent 2D nature of the stripes in previous measurements reflects the average of 1D stripes in the two twin directions.

Red Phosphor for Field Emission Display

A recurring theme in phosphor development is the need for high luminance for full-color flat panel field emission displays. These displays operate at lower voltages and higher currents than CRT displays, and hence the well-established CRT phosphors are not applicable. While a number of sulfide phosphors have been developed, these may degrade under high currents and disperse into the vacuum. Precipitation of the phosphor on the field emitter then degrades the performance of the display. Jung-Chul Park et al. {*Appl. Phys. Lett.*, 77, [14], 2162-4 (2000)} have recently investigated a red phosphor, Li-doped $Gd_2O_3:Eu^{3+}$. The Li doping appears to play two distinct roles. First, it has a profound effect of the particle morphology of powders prepared by sol-gel methods. In the absence of Li, the powder consists of irregularly shaped agglomerations of particles smaller the 0.5 μm. With Li, uniform pseudospherical particles with a diameter of 2-3 μm are produced. The more uniform particles are believed to contribute to the enhanced performance of the phosphor. Second, the Li is also believed to be incorporated in the crystal structure. The authors believe that the incorporated Li acts as a coactivator; that is, there is an effective energy transfer from the electron beam to the Li, which then is coupled to the Eu, resulting in higher efficiency than direct interaction of the exciting beam with the Eu. The new phosphor is claimed to have higher cathodoluminesence efficiency than commercial $Y_2O_3:Eu$ and $Y_2O_2S:Eu$ phosphors in the 500 V – 1kV range.

Er-doped $Cd_3Al_2Si_3O_{12}$ Glass

There is considerable interest in Er^{3+}-doped optical fibers since the 1.53 μm emission of Er^{3+} lies in the region of minimum optical attenuation for silica optical fibers. Solid state lasers based on Er^{3+} emission would be very useful in fiber telecommunications. Studies have been made of both polycrystalline and glass materials. Glasses offer easy fiber fabrication and adjustable compositions, but chalcogenide glasses, where much of the work has been done, are less robust than oxide glasses. H. Lihui et al. {*Appl. Phys. Lett.*, 77, [18], 2849-51 (2000)} have reported that Er-doped cadmium aluminum silicate glass exhibits very intense emission at the Er^{3+} 1.53 μm wavelength. The emission was observed with both 0.488 μm Ar^+ laser excitation and .633 μm He-Ne excitation, clearly eliminating measurement error as the source of the intense emission. The glass is stated to have high chemical and thermal stability.

High Efficiency Power Plants

In the September 2000 *Insight*, I discussed advances in fuel cells and mentioned an interesting article by R. F. Service in *Science*, which discussed possible major industrial sized developments. The Department of Energy and the EPA have just announced {*C&EN*, November, 25, (2000)} the construction of a 1-MW fuel cell and microturbine power plant. The plant will use high-temperature solid oxide fuel cells that use rare-earth oxides as part of the cell to convert natural gas to electricity. As this takes place at 1800°F, there is a considerable amount of hot, pressurized exhaust gas. By using this gas in a microturbine generator, the total power output is enhanced by 10%.

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