Rare-earth Information Center

Insight

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Variable Color Temperature Fluorescent Lamp

I found a recent paper by J. Ravi and J. Maya {*J. Appl. Phys.*, **87**, [9], 4107-12 (2000)} extremely interesting. Not only did it present an interesting development in fluorescent lamps, but also it provided a excellent discussion of the operation of fluorescent lamps, which is certainly well known to people in the industry, but which for those of us in other areas is perhaps a little shaky. For a large company, the disposal of a fluorescent lamp bulb is more expensive than its purchase, since each bulb contains mercury, and at least in the U.S., if you throw away enough of them, they must be treated as toxic waste. The mercury in the bulb, together with an inert gas, forms a low-pressure plasma discharge. The discharge produces radiation at 185, 254 and 365 nm in the UV band and 405, 436 and 546 nm in the visible band. Unfortunately, or fortunately for those in the rare earth phosphor business, the majority of the energy is in the UV with 254 nm as the predominate line. Current phosphors are optimized for maximum excitation at this wavelength. Fluorescent lamps are manufactured with different color temperatures where the lower the color temperature, the redder the tone of the white light. According to the authors, a relatively warm, read red, light with a color temperature of 4000 K is favored in offices while 6500 K, which we perceive as a cool light and simulates sunlight, is employed in factories. For the lights in your home, 3000 K and under is common. For each lamp color temperature, there is a blend of phosphors to yield that color, and hence to change the color of the light in a room, you must change the bulbs. Under some conditions, it may be desirable to change the lighting within a room without changing the bulb. You could, of course, have several lamps of different colors in a single fixture, but this is not particularly practical. Thus, lighting manufacturers are seeking ways to vary the color temperature in a single bulb. Fluorescent lamps are typically driven by a sinusoidal voltage waveform, but the relative intensities of the Hg lines turn out to be dependent on the waveform. Ravi and Maya reference their work to a continuous 50 kHz drive. By varying the waveform characteristics, they determined that they could alter the intensity ratio of the 365-254 nm radiation. They then identified a commercial phosphor whose excitation spectrum peaks near 365 nm and is negligible at 254 nm. This phosphor emits at 420 nm, which is blue. The phosphor was blended with the standard green/red lamp phosphor combination. With this combination, the color of the lamp may be varied by changing the driving waveform. While the concept was demonstrated with existing commercial phosphors, new phosphors must be developed to produce a commercially viable bulb.

All-optical Nonlinear Feedback Device

As I understand current fiber optic communication devices, the fiber optics serve only as highly efficient pathways. There are amplifiers within these pathways, but switching is performed by converting the optical signal into an electronic signal, performing the desired operations and then converting the signal back to an optical signal. All-optical switching would clearly be preferable, but this requires the optical equivalent of a transition that has not yet been demonstrated. Y. Maeda and Y Matsuoka {*Appl. Phys. Lett.*, **76**, [24], 3504-6 (2000)} have recently demonstrated a device that can invert and amplify optical signals at 1.5 μm. Such a device may lead to the realization of all-optical NOR and NAND logic gates. The device relies on the negative non-linear absorption of erbium-yttrium aluminum garnet (Er:YAG) crystals. The crystals are part of a feedback ring resonator and an Er doped fiber amplifier. The degree of output modulation was dependent on the Er dosage and amplifier gain, and was 83% for 50 at% Er.

Nonvolatile Memory Device

There is considerable interest in producing nonvolatile memory devices, and recent attention has focused on metal-ferroelectric-semiconductor field-effect transistors (MFSFETs). In these devices, the metal-ferroelectric-semiconductor (MFS) form a capacitor, which biases the transistor and shows hysteresis in the capacitance-voltage (C-V) curve, because of the remnant polarization of the ferroelectric. This hysteresis allows the transistor to function as a nonvolatile memory device. Fabrication of these devices is difficult, because of the fact that the ferroelectric is typically a quaternary compound, and contains elements that tend to diffuse into the Si semiconductor. An alternative to the MFS layers is a metal-insulator-semiconductor (MIS) structure, if one can be fabricated with C-V hysteresis. A variety of such structures have been fabricated, using such structures as Al/AlN/Si and Al/SiO_2/SiC, but the C-V hysteresis in these structures results from uncontrolled defects, and hence is not reproducible in width. L. Kim et al. {*Appl. Phys. Lett.*, **76**, 1881-3 (2000)} have recently demonstrated that using CeO_2 for an insulating layer in a Al/CeO_2/Si structure results in reproducible hysteresis where the hysteresis width can be controlled by varying the thickness of the CeO_2 layer. A maximum hysteresis width of ~1.8 V has been obtained for 3000 Å thick CeO_2. TEM measurements show that there is a 45 Å-thick amorphous SiO_2 layer at the CeO_2-Si interface. The hysteresis in the C-V curve is attributed to stresses in the CeO_2 film, which are thickness dependent.

Inorganic Yellow-red Pigments

Cobalt blue and cadmium red bring pictures of rich strong colors, but unfortunately in the modern world, they also bring concerns about the environment. While the cadmium pigments themselves are not a hazard, there is concern that the compound may be broken down at waste disposal sites and incineration plants, resulting in a bioavailable form of cadmium. These concerns have resulted in strong restrictions on the use of cadmium pigments. M. Jansen and H. P. Letschert {*Nature*, **404**, 980-2 (2000)} have recently identified a solid solution $CaTaO_2N$ and $LaTaON_2$. These perovskites have favorable properties with respect to brilliance, tinting strength, opacity, dispersability, light-fastness and heat stability. In addition, the color can be tuned from yellow through orange to deep red by adjusting the composition. Bright color in a solid is, in general, because of the selective absorption of light by an electronic interband transition. If the bandgap is too wide, as is typical in metal oxides, the optical absorption does not occur in the visible portion of the spectrum. However, in the materials under study, the bandgap can be reduce by as much as ~1eV by the introduction of N. In the perovskite materials, the thermal stability of the oxonitirdes in an inert atmosphere is much better than that of cadmium yellow, while its behavior in an oxidizing atmosphere is essentially identical.

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