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One of the many suggested causes of lumen depreciation in fluorescent lamps is the presence of sodium in the glass envelope. Our investigations have concentrated so far on the darkening of soda-lime glass and the role of sodium in uncoated discharge tubes. The darkening has nothing to do with the formation of sodium amalgam but is caused by droplets of elemental mercury inside the glass network. The glass surface was studied with x-fluorescence, ESCA, RBS, and TEM.

503 The Mechanism of Focused Phosphor Depreciation on Direct-View Storage Cathode-Ray Tubes: L. B. Church, Tektronix, Inc. Beaverton, OR 97077

A previously unreported mechanism of modified Zn₂SiO₄ phosphor depreciation was recently observed in direct-view storage CRT's. The depreciated phosphor is found in tightly focused small areas that are randomly placed on the faceplate. The affected phosphor has diminished luminosity and requires a higher electron voltage to produce a stored image. Physical and chemical comparison of the depreciated and normal phosphor showed that the only difference was of a crystallographic nature. A mechanism has been proposed to show how this particular mode of phosphor depreciation occurs and how it is different from other similar modes of aging.

General Session

504 Mechanism of Particle Growth of (Zn_{0.85}, Cd_{0.15})S:Cu, Al Phosphor: B.-I. Li, X.-p. Lu, and C.-x. Guo,* Dept. of Physics, University of Science and Technology of China, Hefei, Anhui, China

Mechanism and laws of particle growth of (Zn_{0.85}, Cd_{0.15})S and (Zn_{0.85}, Cd_{0.15})S:5 × 10⁻⁵ Cu, 2 × 10⁻⁴ Al, 4% KI, 2% CS(NH₂)₂, 3% AlNH₄(SO₄)₂ in 650°-1100°C firing processes have been investigated. In these systems the rate of increase in particle size followed D^m = kt, where D is the average particle diameter at firing time t, m and k are constants. The constant m and Arrhenius activation energy of particle growth of these systems were obtained. Mechanisms of particle growth and flux action were discussed.

505 Preparation and Luminescence of the ZnS:Eu²⁺ Phosphor: W.-I. Li, J.-d. Zhang, and S.-h. Xu, Changchun Institute of Physics, Academia Sinica, Changchun, Jilin, China

A new method for preparing ZnS:Eu²⁺ phosphor without H₂S and flux is proposed. The emissions of the ZnS:Eu²⁺ phosphor consist of two bands at 550 and ~650 nm. The intensities of the emissions depend on the substitution of small amount of Cd²⁺ for Zn²⁺ in the ZnS host. The 550 nm band decreases but the 650 nm band increases with the increase of Cd²⁺. The red photoluminescence is drastically enhanced at the liquid nitrogen temperature. This phosphor has a long decay time about 50 msec under CR excitation, and about 1 sec under 365 nm excitation. It is due to traps situated in the bandgap.

506 Syntheses and Spectral Properties of Eu-Mn Coactivated Apatite Phosphors: R. G. Pappalardo, T. Peters, and A. Vetrov, GTE Laboratories, Precision Materials Technology Laboratory, Waltham, MA 02254

Blue-emitting Sr chloroapatite:Eu and yellow-emitting Ca fluoroapatite:Sb; Mn are the two components in current phosphor blends for high-efficacy lamps. In order to replace the two-component blend with a single material exhibiting the required emission both in the blue and in the yellow spectral region, the coactivation of apatites with both Eu²⁺ and Mn²⁺ was investigated. Several phosphor compositions were prepared and characterized with respect to their spectral properties. Although the resulting materials exhibited the required blue and yellow emission bands for excitation at 254 nm, two serious limitations could not be overcome: first, even the brightest phosphors prepared had a definite body-color; second, the inadequate Eu-Mn energy transfer provided an emission intensity in the yellow spectral region that was only ~50% of that shown by the current "Lite White" blends.

507 Luminescent Properties of Cerium Aluminate: M. N. Alexander,* A. G. Sigai, and C. W. Struck, GTE Laboratories, Inc., Waltham, MA 02254

The single phase region for cerium aluminate (magnetoplumbite/beta alumina structure) has been determined to be 11 ≤ Al/Ce ≤ 13.4. This material exhibits both blue and u.v. emissions. At least three almost noninteracting centers contribute to the broad "blue" band emission, and another produces the u.v. emission. The relative intensities vary with sample composition, both among the "blue" subbands, and also between "blue" and u.v. emissions.

508 On the Structural and Luminescent Properties of the M'LnTaO₄ Rare Earth Tantalates: L. H. Brixner* and H.-y. Chen, E. I. du Pont de Nemours & Co., Central Research & Development Dept., Experimental Station, Wilmington, DE 19898

The structure of M'YTaO₄, first described by Wolten (1) has been redetermined and refined to an R value of 6.1%. The M' modification occurs with Ln = Sm to Lu. The rare earth in this structure is in 8 coordination, and the tantalum is 6 coordinated. We do not find it to be closely related to the Fergusonite-type monoclinic M'YTaO₄; it would take a drastic rearrangement of atoms to convert to that structure. Blasse and Brill (2) have used M'YTaO₄ as a host for both Nb⁵⁺ and Tb³⁺. We can show that the M' structure provides an environment for more efficient luminescence, and makes the composi-

tion YTa_{0.98}Nb_{0.02}O₄ the first oxide-based x-ray phosphor to be substantially better than CaWO₄. In addition to Nb and Tb, we have incorporated the activators Sm, Eu, Dy, and Tm into the M'YTaO₄ host. Luminescence, absorption, and Raman spectra are discussed.

1. G. M. Wolten, *Acta Crystallogr.*, **23**, 939 (1967).
2. G. Blasse and A. Brill, *J. Lumin.*, **3**, 109 (1970).

509 Rare Earth Green Phosphor for Three Band Fluorescent Lamps: K. Terashima and Y. Kimura, Toshiba Corp., Electron Tube and Device Div., 72, Horikawacho, Saiwai-ku, Kawasaki-city, Kanagawa, 210, Japan and K. Kohmoto, Toshiba Corp., Lamp Div., 72, Horikawacho, Saiwai-ku, Kawasaki-city, Kanagawa, 210, Japan

The compounds (La, Ce, Tb)₂O₃ · mSiO₂ · nP₂O₅ are investigated to obtain green phosphor for high efficient three band fluorescent lamps. The compounds, m of 0.1 to 0.3, n of 0.8 to 0.9, have intense green emission under u.v. excitation and less brightness depreciation through baking process in lamp manufacture. Characteristics of three band fluorescent lamps using the compounds are also discussed.

510 Green-Emitting Phosphors Based on Cerium Terbium Magnesium Borate Compositions: P. Maestro,* J. P. Browaeys, and P. Douglier, Rhone-Poulenc Recherches, 93308 Aubervilliers Cedex, France and C. Fouassier, Laboratoire de Chimie du Solide du CNRS, 33405 Talence Cedex, France

The efficiency of the green emission of the new borate Ce_{1-x}Tb_xMgB₃O₁₀ compositions in the 150-290 nm excitation range has been investigated. An external quantum efficiency of the order of 73% is obtained for terbium concentrations as low as x = 0.20. The good behavior of the emission intensity with respect to external effects (e.g., aqueous treatment or crushing) is shown. Owing to its low terbium content (~8% wt terbium), this phosphor could be of an economical interest for use in applications such as low pressure mercury vapor lamps, gas discharge display panels.

511 Effect of Ce on Tb³⁺ Luminescence in Y₃Al₅O₁₂ Host: Z. H. Wang, S. Y. Zhao, J. J. Wei, Y. Wu, and S.-h. Xu, Changchun Institute of Physics, Changchun, Jilin, China.

Tb³⁺ luminescence in Y₃Al₅O₁₂:Tb (P53) is remarkably enhanced by Ce particularly the emission corresponding to the transition ⁵D₄ → ⁷F_{5,3}. The effect of Ce on other luminescence properties, such as current density and voltage dependence of Tb³⁺ luminescence, was investigated. Energy transfer from Ce to Tb³⁺ was discussed.

512 Observation of Satellite Structure in the ³D₁ and ³D₀ Levels of Y₂O₃:Eu Lamp Phosphors: R. B. Hunt and R. G. Pappalardo, GTE Laboratories, Precision Materials Technology Laboratory, Waltham, MA 02254

High-resolution dye-laser spectroscopy of powders of commercial phosphors, e.g., Y₂O₃:Eu, has been found to provide the kind of fine spectral detail one normally associates with the high-resolution spectra of single crystal materials. In a study of the thermal dependence of the pathways of excited state relaxation in Y₂O₃:Eu lamp phosphors, we have followed in detail the decay and intersite transfer of the excitation energy within, and from, the ³D₀ and ³D₁ levels of Eu²⁺. As a result we have found evidence of satellite, or pair, structure within the linewidth of various excitation lines associated with the ³D₀ and ³D₁ levels. For a given electronic transition, the kinetics of intersite energy-transfer were found to be dramatically different, depending on whether the center or the wing of an excitation line is used to pump energy into the Eu²⁺ system.

513 The Effects of Pairing and As-Codoping on the Lifetime of Mn²⁺ in Zn₂SiO₄: D. J. Robbins,* B. Cockayne, I. F. Chang, D. B. Dove, E. A. Giess, and E. E. Mendez, IBM T. J. Watson Research Center, Yorktown Heights, NY 10598

High resolution absorption and luminescence measurements have been made on Zn₂SiO₄ single crystals doped with both Mn and As. Selective laser excitation reveals new zero phonon lines resulting from Mn-pairing at concentrations <1%. The Mn²⁺ lifetime at room temperature is shortened when pairing is evident. Absorption and photoluminescence excitation spectra show a strong Mn²⁺ → conduction band ionization transition with threshold ~3.9 eV. Codoping with As produces extended persistence of the Mn²⁺ emission only for excitation above this threshold.

514 Single Crystal YAG: Tb(P53) Phosphor Produced by Ion Implantation: D. J. Robbins,* B. Cockayne, A. G. Cullis, and J. L. Gasper, Royal Signals and Radar Establishment, Malvern, Worcestershire WR14 3PS, England

Single crystal yttrium aluminum garnet (YAG) has been successfully doped with Tb³⁺ by ion implantation and subsequent annealing. High temperature thermal annealing has given luminous efficiencies comparable with single crystal material doped directly during Czochralski growth. Laser annealing proved less successful. A penetron effect, yielding blue or green luminescence according to E beam voltage, has been observed for the thermally annealed material.

515 Photoluminescence of Cerium-Doped YAG Single Crystals: C. M. Wong,* C. Warde, and S. Rotman, Massachusetts Institute of Technology, Cambridge, MA 02139

Luminescence decay lifetimes and spectra (200-700 nm) of undoped YAG and Ce:YAG crystals at 300 and 77 K were measured with pulsed u.v. excitation. Significant broadband u.v. emission,