Significant reduction of cathodoluminescent degradation in sulfide-based phosphors

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(Received 24 November 1997; accepted for publication 12 February 1998)

The degradation of cathodoluminescent (CL) brightness under prolonged electron-beam excitation of phosphors has been identified as one of the outstanding critical issues for flat-panel field-emission displays. In this letter, we have demonstrated that a TaSi2 coating on Y2O2S:Eu3+ phosphors substantially inhibits the cathodoluminescent degradation characteristics without reducing its efficiency. The coating was deposited by pulsed laser deposition of TaSi2 targets onto a fluidized bed containing phosphor particles. Cathodoluminescent degradation experiments conducted at 2 keV and at 150 μA/cm2, showed that the CL brightness decreased by more than 50% after a Coulomb load of 15 C/cm2 on the uncoated material. In contrast, the TaSi2-coated phosphor powders showed much less degradation, with CL brightness only decreasing by approximately 12% after electron irradiation with the same dose. © 1998 American Institute of Physics.

Sulfide-based phosphors such as Y2O2S:Eu3+, ZnS:Ag, and ZnS:Cu are potential phosphor materials for field-emission display applications.1-5 It is well known that the sulfur-containing phosphors exhibit the highest luminous efficiencies of all the currently available industrial phosphors. However, one of the outstanding problems in the use of the sulfide-based phosphors is the cathodoluminescent (CL) degradation.4-8 Under standard operating conditions (low accelerating voltage <7 keV, high current density >5 mA/cm2, vacuum 1×10^-5 Torr, Coulomb load =15 C/cm2), the sulfur-based phosphors can degrade more than 50% from their original brightness. The CL degradation is related to the total charge impressed upon the phosphor screen. Although many different mechanisms have been reported for the degradation of phosphors, many relate to similar surface phenomena. Recent studies in CL degradation have centered around sulfur-containing phosphors.7,8 Studies on ZnS:Ag have shown that during electron-beam aging, both carbon and sulfur are depleted from the near-surface regions of the phosphor with concomitant increase in the O and Zn surface concentration.7 The surface region of the ZnS phosphor is converted to a sulfur-depleted, oxygen-rich compound, such as ZnO or ZnSO4.7 Due to this nonluminescent “dead layer,” which can range up to 0.4 μm thick, the cathodoluminescent efficiency is dominated by the power loss of the electron beam in the nonluminescent layer.

One possibility for slowing the degradation rate is to coat the surface of the phosphors with a material that inhibits CL loss. In order to be commercially viable, the coating must not be detrimental to the handling qualities, brightness, and chromaticity of the phosphor and should be thin enough to be transparent at low energies. Several coatings have been investigated by using wet-based deposition techniques.8 The thickness, composition, and coverage depend on the chemistry of the wet process.

Some recent studies on oxide and phosphate coatings depos-

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In conclusion, we have demonstrated that TaSi$_2$ coatings on sulfide-based phosphor powders can significantly increase CL lifetimes of the phosphor. The TaSi$_2$ coating prevented chemical transformation of the oxysulfide surface into an oxide layer.


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**FIG. 1.** Schematic of a coated phosphor particle to retard the cathodoluminescent degradation.

**FIG. 2.** Schematic of modified laser deposition system for coating phosphor powders.

**FIG. 3.** Comparison of CL degradation rates of the coated and the uncoated phosphors.

**FIG. 4.** Initial and final Auger electron spectroscopy spectra obtained from the uncoated Y$_2$O$_2$S:Eu$^{3+}$ powders, taken at 0.07 and 15 C/cm$^2$.

**FIG. 5.** Initial and final Auger electron spectroscopy spectra obtained from the TaSi$_2$-coated Y$_2$O$_2$S:Eu$^{3+}$ powders, taken at 0.07 and 15 C/cm$^2$.