Temperature Effects on the Cathodoluminescent Degradation of Sulfide-Based Powder Phosphors

B.A. Abrams, L. Williams, J.S. Bang, P.H. Holloway
University of Florida
Department of Materials Science and Engineering
Gainesville, FL 32611-6400

Temperature effects on cathodoluminescent (CL) intensity, spectrum and degradation of ZnS:Ag,Cl powder phosphor have been investigated.[1] Thermal quenching was studied by incrementally increasing the temperature of the phosphor without exposure to a continuous electron beam and measuring the decreased CL intensity. A characteristic thermal quenching temperature of 150^{o}C was observed for ZnS:Ag,Cl. In addition to the reduced CL intensity, the spectra shifted to longer wavelengths and changed shape at elevated temperature. The shift was dominated by band gap narrowing at high temperatures, while the shape change was attributed to copper contamination from the heater stage. The CL spectral distribution and intensity were 100% recoverable upon cooling back to room temperature when the electron beam exposure was minimal. With a continuous electron beam exposure, CL degradation at elevated temperatures was studied. The CL intensity upon cooling to RT (after 24 C/cm^2 at 2keV primary beam energy) was less than 40% of the original intensity before heating. The loss of CL intensity at high temperatures was less than that at RT for the same primary beam energy and coulombic dose. This is consistent with the Electron Stimulated Surface Chemical Reaction (ESSCR)[2-4] Model of degradation that predicts that elevated temperatures will reduce the mean stay time of physisorbed gases, and thus will decrease the rate of the surface reactions leading to CL degradation.

The amount of heating from the electron beam was calculated using a simply heat transfer model and shown to be significant for powder samples.[1] This is consistent with morphological erosion observed on the surface of the ZnS particles degraded at elevated temperatures or high power densities. It is speculated that at a temperatures of about 300^{o}C, surface chemical reactions in combination with heating leads to removal of S and evaporation of Zn. The consequences of beam heating on current saturation measurements will be discussed.

1. Billie L Abrams, Ph.D. Dissertation, University of Florida, December 2001.
2. P.H. Holloway, T.A. Trottier, J. Sebastian, S. Jones, X.-M. Zhang, J.-S. Bang, B. Abrams, W.J. Thomes and T.-J. Kim, J. Appl. Phys. **88**, 483-488 (2000)
3. P.H. Holloway, T.A. Trottier, B. Abrams, C. Kondoleon, S.L. Jones, J.S. Sebastian and W.J. Thomes, J.Vac.Sci.Technol. **B17**, 758-764 (1999).
4. B. L. Abrams, W. Roos, P.H. Holloway and H.C. Swart, Surf. Sci. **451**, 174 (2000).

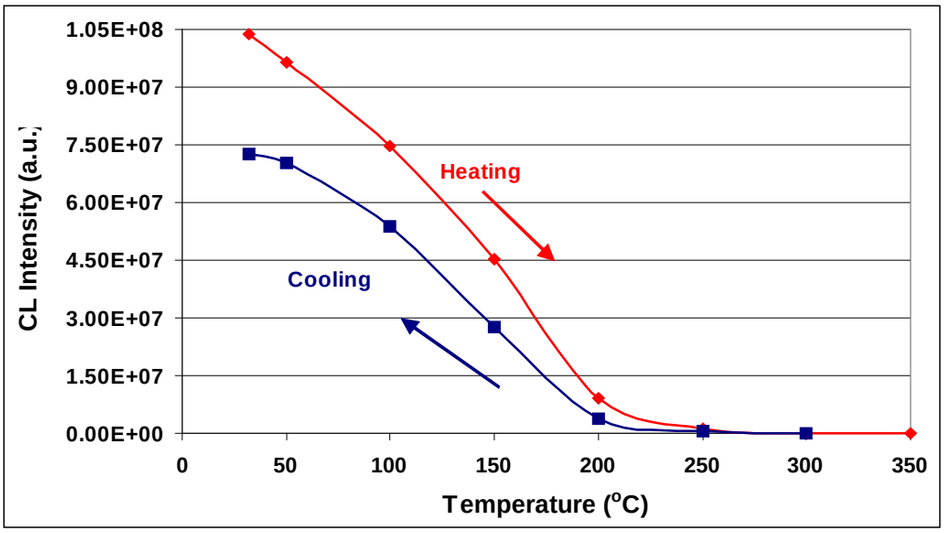

Figure 1 Cathodoluminescent intensity versus temperature of ZnS:Ag,Cl powder sample for heating and cooling with beam exposure of a few coulombs/cm^2 at 2 keV.