Cathodoluminescent White Phosphors Optimization For Lighting Applications

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In recent years, a significant progress has been reported in the area of field emission cathodes and cathode materials for cathodoluminescent vacuum light sources. However, most of the prototypes utilize CRT phosphors optimized for color television. Cathodoluminescent phosphors for lighting applications require operation in different conditions than traditional television and display CRT phosphors. The operating voltages for the compact field emission light sources should be substantially lower than the ones of the CRTs (5-8 kV versus 15-25 kV), the light output should be considerably greater (above 10-30 thousands of candelas per square meter), the efficiency of the phosphors should be in the range of at least 30-40 Lm/Watt, and the thermal stability of the phosphors should ensure a stable operation at continuous excitation. The phosphors should also obey certain requirements for black body radiation temperature and should have color coordinates of traditional light sources.

So far, the attempts to find an efficient single-component luminescent material capable of generating visible light with the wide solar-like spectrum remain unsuccessful; therefore researchers rely on mixing individual color phosphors trying to replicate the wide warm- or cold-white spectrum of the day light, incandescent or fluorescent light bulbs. In this research, we investigated mixes of individual industrially available red green and blue phosphors in an attempt to create a thermally stable and energy efficient phosphor mixes capable of operating for prolonged time in the conditions of the vacuum field emission light sources.

We have studied two mixtures of NICHIA made phosphors, referred to as M1 and M2:

Phosphor mixture	**M1** (weight %)	**M2** (weight %)
blue NP-1011-17LZ (ZnS:Zn)	10	10
green NP-1108-85LZ (ZnS:Cu, Au, Al)	25	
green NP-1150-114LZ (Y_2SiO_5:Tb)		50
red NP-1056-128LZ (Y_2O_3:Eu)	65	40

The best previously tested phosphors were chosen as blue and red components [1] . The M1 mixture uses high efficient P-22 type green phosphor. M2 mixture uses the wide spectrum green phosphor Y_2SiO_5:Tb (Fig.1). We have tested efficiency of the mixtures at low power density, practically similar to TV application (Fig.2). Under those conditions M1 demonstrated significantly higher light yield than M2. However, as the power density excided 200 mW/cm^2, (Fig. 3 and Fig. 4), the difference is not so substantial. It is clear that ZnS-type phosphor is more temperature sensitive than Yttrium-silicate. Another advantage of the M2 mixture is good color rendering (Fig.5). The M2 provided lower color temperature: 3400 K versus 4200 K for M1 mixture, and had better color temperature stability under heating. The lifetime tests of the M1 and M2 phosphors are presented on the Fig.6.

The biggest efficiency drop was observed within first 10 Coulombs per sq cm of accumulated electron charge or 150 hours of the test. Further test showed reasonable low degradation about 2.5% in 100 hours. Some of the drop may be explained by darkening of the substrate glass under electron bombardment, which can be eliminated with correct glass type.

As a result of our investigation, we were able to identify phosphor powder mixes capable of emitting white light under continuous DC electron beam excitation at accelerating energies of up to 8 kW. The prepared mixes exhibit stable light emission and color characteristics while maintaining the efficiency of up to 40 Lm/Wt.

1. Chubun NN, Chakhovskoi AG, Hunt CE. Efficiency of cathodoluminescent phosphors for a field-emission light source application. JVST (B), vol.21, no.4, July 2003, pp.1618-21.

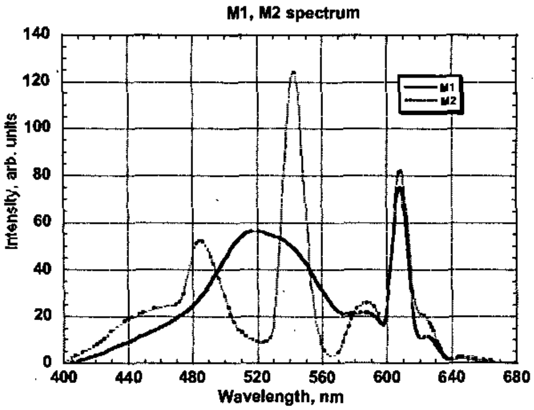

Figure 1 Mixtures 1 and 2 CL spectrum

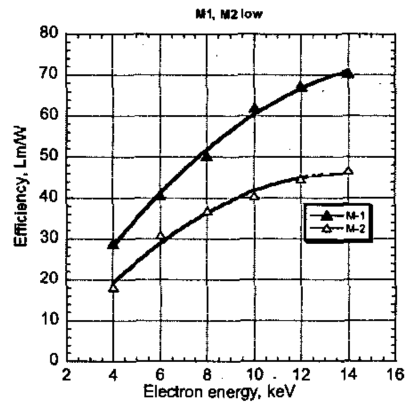

Figure 2 M1 and M2 efficiency at low power density

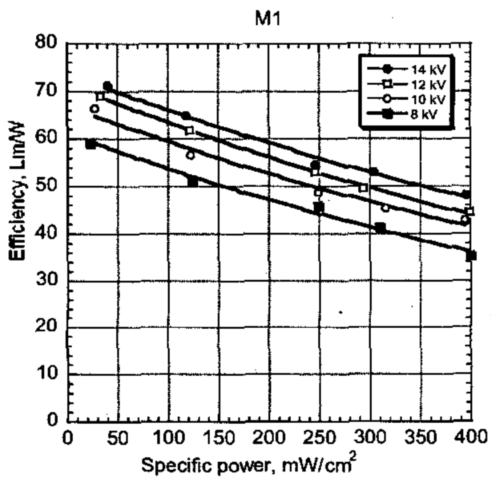

Figure 3 M1 efficiency at high power density

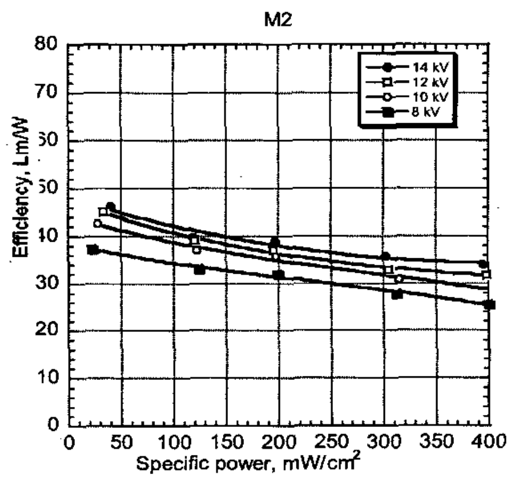

Figure 4 M2 efficiency at high power density

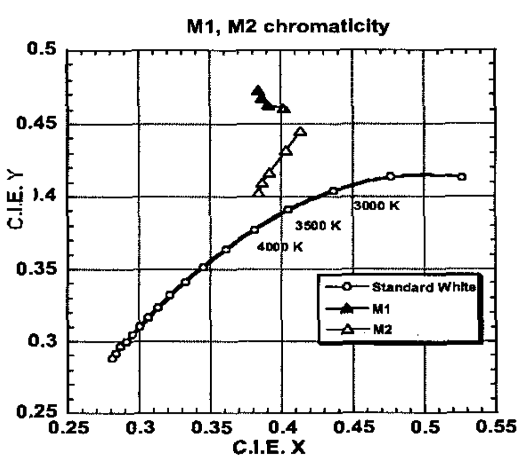

Figure 5 M1 and M2 C.I.E. 1931 Chromaticity data

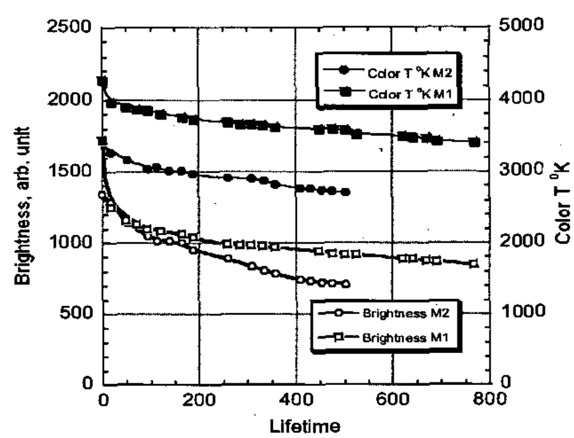

Figure 6. M1 and M2 brightness and color T° during lifetime tests