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(54) Title: **ENCAPSULATED LONG LIFE ELECTROLUMINESCENT PHOSPHOR**

(57) Abstract: A process for making an electroluminescent phosphor having a given emission spectra A, comprises the steps of manufacturing a beginning electroluminescent phosphor having an emission spectra B, different than A. A coating is applied to the phosphor having the emission spectra B to increase the resistance of the phosphor to the deleterious effects of moisture and change the emission spectra of the phosphor to emission spectra A. The application of the coating includes the steps of reacting a coating precursor with a mixture of oxygen and ozone.

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## ENCAPSULATED LONG LIFE ELECTROLUMINESCENT PHOSPHOR

5CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority from provisional application S.N. 60/166,619 filed November 19, 1999.

TECHNICAL FIELD

This application relates to a process for producing an electroluminescent phosphor, and more particularly, to a process that produces an electroluminescent phosphor with a desired emission spectra.

BACKGROUND ART

Electroluminescent (hereinafter EL) phosphors are used for backlighting in LCD's, in copying machines, for backlighting membrane switches, for automotive dashboard and control switch illumination, for automotive exterior body lighting, for aircraft style information panels, for aircraft information lighting, and for emergency egress lighting. U.S. Pat. Nos. 3,014,873; 3,076,767; 4,859,361; 5,009,808 and 5,110,499 relate to methods for producing EL phosphors. Since EL phosphors are sensitive to moisture it is not uncommon for the phosphors to be coated with a moisture-resistant coating of a metal oxide such as alumina. Such coating processes have involved reacting the phosphor, via a chemical vapor deposition process, with a coating agent such as, for example, trimethylaluminum and water vapor. An example of such a coated phosphor is shown as Sample Number CJ564 in TABLE I and as CJ30 in TABLE II. The phosphor coating, in the first instance, contains 4.4 weight percent (hereinafter wgt. %) aluminum, has a Y color coordinate of 0.199 on the C.I.E. Chromaticity Diagram (X value, 0.158) and a half-life of 195 hours and, in the second instance, 4.0 wgt.% aluminum, a Y value of 0.203 and a half-life of 256 hours. As used herein the half-life refers to that period of time when the brightness of the phosphor decreases to ½ of its brightness at 24 hours.

A different coating process having many advantages over the TMA/water process comprises reacting a coating agent such as TMA with an oxygen-ozone mixture. This latter process is water-free; however, in some instances this process produces undesired emission changes in the phosphor. Even though such phosphors have achieved some commercial success in areas where, for example, brightness might be more desirable than a particular emission spectra,

1 it would be an advance in the art to provide a process for achieving a desired emission spectra  
2 in a phosphor having a moisture-sensitizing coating applied by an oxygen-ozone process.

3  
4 DISCLOSURE OF THE INVENTION

5  
6 It is, therefore, an object of the present invention to obviate the disadvantages of the prior art.

7  
8 It is another object of the present invention to produce electroluminescent phosphors having  
9 a commercially desirable emission spectra with very long life and high brightness.

10  
11 This invention achieves these and other objectives, in one aspect of the invention, by  
12 providing a process for making an electroluminescent phosphor having a given emission  
13 spectra A, which comprises the steps of manufacturing a beginning electroluminescent  
14 phosphor having an emission spectra B, different than A. This beginning phosphor has  
15 applied thereto a coating to increase the resistance of the beginning phosphor to the  
16 deleterious effects of moisture while simultaneously changing the emission spectra of the  
17 beginning phosphor from B to emission spectra A. The process is water-free and comprises  
18 reacting a coating agent with a coating precursor and a mixture of oxygen and ozone.

19  
20 Utilization of this method not only provides a phosphor with a desired emission and moisture  
21 protection, but, surprisingly, greatly increases the life.

22  
23 BEST MODE FOR CARRYING OUT THE INVENTION

24  
25 For a better understanding of the present invention, together with other and further  
26 objectives, advantages and capabilities thereof, reference is made to the following disclosure  
27 and appended claims.

28  
29 This invention provides a process for producing an electroluminescent phosphor that has a  
30 commercially desirable emission spectra, moisture protection, long life and high brightness.  
31 The invention is especially suited for zinc sulfide, copper activated phosphors or other zinc  
32 sulfide phosphors where copper is a co-activator, for example, with chlorine.

Referring now to TABLE I, in addition to the previously mentioned prior art phosphor coated by a TMA/water process (Sample Number CJ 564), there are shown control phosphors having Sample Numbers of ELB849, ELB875, and ELB826. These are standard, uncoated, commercially available phosphors (all having essentially the same composition but coming from different lots) having desired color emission with an X coordinate of about 0.160 and a Y coordinate of about 0.200, which provides a blue-green emission. The small variances shown by the color coordinates are well within commercial tolerance specifications.

However, when these materials are coated by the aforementioned oxygen/ozone process a decided color-shift takes place which is represented by a noticeable change in the Y coordinate. These materials are designated, in TABLE I, by Sample Numbers TH54, which is a coated version of ELB849; TH111, a coated version of ELB875; and TH53 and TH36, which are coated versions of ELB826 differing only in the amount of the coating. Even though the coated materials have increased life and improved brightness, the color-shift makes them unacceptable to many customers.

TABLE I

Sample Number	Type	AL Wt. %	Emission Color		Light Output (Foot Lamberts)			Life Hrs to 1/2 24 Hrs	Efficacy lm/watt
			X	Y	2 Hr.	24 Hr.	100 Hr.		
ELB849	813	NA	0.160	0.203	13.6	10.0	6.2	142	----
TH54	NE600	3.9	0.156	0.169	9.2	7.9	6.7	288	3.2
ELB875	83	NA	0.161	0.213	16.1	12.1	7.9	-----	----
TH111	TNE600	2.6	0.158	0.178	12.0	10.2	7.4	157	2.6
ELB826	813	NA	0.159	0.202	16.2	12.2	7.8	141	1.9
TH53	TNE600	2.7	0.157	0.177	11.0	9.2	6.9	213	3.3
TH36	NE600	3.9	0.157	0.175	8.5	8.0	6.3	288	3.6
CJ564	60	4.4	0.158	0.199	10.8	9.1	6.6	195	3.4

Accordingly, this problem has been solved by a process for making an electroluminescent

phosphor having a given emission spectra A, which comprises first, manufacturing a beginning electroluminescent phosphor having an emission spectra B, different than A. This beginning phosphor has applied thereto a coating to increase the resistance of the beginning phosphor to the deleterious effects of moisture while simultaneously changing the emission spectra of the beginning phosphor from B to emission spectra A. The process is water-free and comprises reacting a coating agent with a coating precursor and a mixture of oxygen and ozone.

In particular, a beginning ZnS:Cu phosphor was prepared by increasing the normal amount of copper contained therein, from 0.032 wgt.% to 0.039 wgt.% (as determined by atomic absorption analysis). This is a significant increase and raised the Y coordinate to about 0.250 while leaving the X coordinate substantially unaffected.

Generally, the phosphor composition of this invention was prepared from materials as follows:

Material	Test Batch
ZnS (unactivated S-10)	25 lbs
CuSO <sub>4</sub> (anhydrous)	11.3 g
BaCl <sub>2</sub>	341 g
MgCl <sub>2</sub> (dried)	341 g
NaCl	227 g
Sulfur (sublimed)	2 lbs
ZnO (K-25)	56.5 g

The beginning phosphor was produced from the above-cited materials by the standard method of heating the zinc sulfide in a furnace to an elevated temperature in the presence of the copper activator and halide fluxes to achieve an electroluminescent phosphor, cooling the phosphor to ambient temperature and washing the phosphor to remove the flux. The resulting ZnS:Cu phosphor was then dried. Phosphors created by this method are generally known. One such phosphor, having 0.032 wgt.% copper, is a Type 813 electroluminescent

phosphor (ZnS:Cu) available from Osram Sylvania, Inc., Towanda, PA.

The phosphor was coated by the method disclosed in co-pending patent application Serial No. 09/585,221, the teachings of which are hereby incorporated by reference. In particular, two 3.5 kg samples of modified Type 813 (i.e., a phosphor having an increased amount of copper), Lot ELB478-50, (see TABLE II) were treated with trimethylaluminum and oxygen/ozone in a 2" diameter fluid bed at 180°C with variation in the amount of aluminum deposited. During the coating treatment of run TH92, 50 g of a thin-coated sample were collected from the fluid bed reactor and labeled as TH92A. Also, a standard Type 60 production lot (CJ30) which is a Type 813 phosphor treated with TMA/H<sub>2</sub>O coating process is included in TABLE II for comparison. While the flow rates of nitrogen through the TMA container were maintained at 0.75 l/minute, rates of nitrogen flow at the bottom of the reactor were kept at a total of 3.75 l/minute. Also, the oxygen/ozone gas mixture was transported into the reaction vessel at a flow rate of 4.6 l/minute. The resulting data on the coated phosphors are shown in TABLE II.

**TABLE II**

Sample Number	Type	Al Wt. %	Emission Color		Light Output (Foot Lamberts)			Life Hrs to ½ 24 Hrs	Efficacy lm/watt
			X	Y	2 Hr.	24 Hr.	100 Hr.		
ELB478-50	813 Modified	NA	0.168	0.254	19.8	19.0	15.3	497	1.17
TH92A	WNE600	2.0	0.165	0.229	14.8	15.0	14.0	663	2.49
TH92	TNE600	2.8	0.166	0.225	12.4	12.7	11.8	804	2.61
TH93	NE600	4.1	0.164	0.211	10.3	10.8	10.2	~1295	2.79
CJ30 Standard	60	4.0	0.161	0.203	12.3	10.7	7.9	256	3.20

As can be seen from Table II, the lamp results indicated that the new WNE/TNE/NE600 products made from the modified Type 813 phosphor have significantly better brightness and tremendously longer life than those of current products. For example, the initial brightness at 24 hours of TH92A (WNE600) lamp was measured at 15 foot lamberts, which is 40% greater than that obtained with the standard CJ30 lot that was prepared by the TMA/H<sub>2</sub>O process. Also, the half-lives of the lamps were enhanced more than 150%, for example, 256

1 hours with the standard lot CJ30 versus 663 hours with Lot TH92A. As usual, the greater  
2 the amount of aluminum deposit, i.e. the greater the coating thickness, the longer the half-life.  
3 Most impressively, and surprisingly, the half-life of TH93 (NE600) with a coating weight  
4 of 4.1 % aluminum, was estimated at 1295 hours which is about five times the 256 hours of  
5 the standard DJ30 lot.

6

7 Thus there is provided a process for producing an electroluminescent phosphor with an  
8 increased efficiency, great life expectancy and desirable emission spectrum.

9

10 While there have been shown and described what are at present considered the preferred  
11 embodiments of the invention, it will be apparent to those skilled in the art that various  
12 changes and modifications can be made herein without departing from the scope of the  
13 invention as defined by the appended claims.

14

1    CLAIMS:

2

3

4    What is claimed is:

5

6    1.     A process for making an electroluminescent phosphor having a given emission  
7    spectra A, comprising the steps of: manufacturing a beginning electroluminescent phosphor  
8    having an emission spectra B, different than A; applying a coating to said phosphor having  
9    said emission spectra B to increase the resistance of said phosphor to the deleterious effects  
10   of moisture and change the emission spectra of said phosphor to emission spectra A, said  
11   application of said coating including the steps of reacting a coating precursor with a mixture  
12   of oxygen and ozone.

13

14   2.     The process of Claim 1 wherein said emission spectra B has a CIE y value of about  
15   0.250 and said emission spectra A has a CIE y value between 0.230 and about 0.200.

16

17   3.     The process of Claim 2 wherein said phosphor is a ZnS:Cu and contains about 0.39  
18   Wgt.% copper.

19

20   4.     The process of Claim 1 wherein said coating precursor is trimethylaluminum.

21

22   5.     An electroluminescent phosphor created by the process disclosed in claim 1.

23

24   6.     The electroluminescent phosphor of Claim 5 wherein said phosphor has a half-life of  
25   greater than 663 hours.

26

27   7.     The electroluminescent phosphor of Claim 5 wherein said phosphor has a half-life of  
28   about 1295 hours.