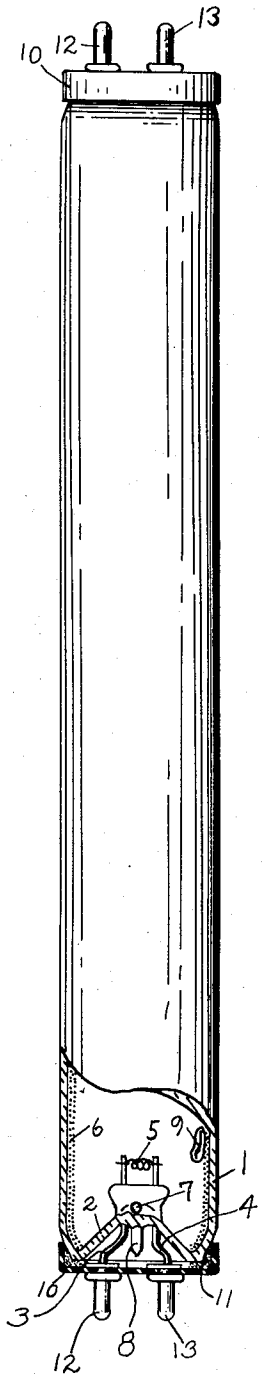
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ELECTRIC DISCHARGE LAMP

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ELECTRIC DISCHARGE LAMP

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This invention relates to the prevention of discoloration and increase of life in electric discharge lamps with oxide-coated cathodes, and particularly in fluorescent lamps.

I find that the addition of a small amount of hafnium oxide to the cathode coating greatly reduces such discoloration and increases the life of the lamp.

The figure shows a fluorescent lamp according to the invention, partly in section.

In that figure, an elongated tubular envelope 1 of light-transmitting material such as glass, has a stem 2 sealed to each end, with the lead-in wires 3, 4 sealed therethrough and carrying a cathode 5 at each end, which may be a doubly-coiled tungsten wire with an electron-emitting material held between the turns of its minor coil, as shown, for example, in U. S. Patent 2,258,158, issued October 7, 1941, to Erwin F. Lowry. A coating 6 of fluorescent material, for example of a calcium halo-phosphate activated with antimony and manganese, is applied to the inner surface of envelope 1 in the manner customary in the art. A small drop of mercury 9, and a filling of an inert gas, such as argon or krypton, at reduced pressure, is sealed into the envelope 1. For example, the filling may be argon at a pressure of a few millimeters of mercury, a pressure of the order of three millimeters being generally preferable.

During manufacture, the exhaust and filling of the lamp is effected through exhaust opening 7, in communication with exhaust tube 8, shown sealed off as it would be after the manufacture of the lamp.

A base 10 is affixed to the ends of the envelope 1, and may be held thereto by the cement 11. The base itself may be of plastic, if desired. The contact pins 12, 13 project through the base 10, and are connected to the lead-in wires 3, 4.

A coating of electron emitting material may be applied to the cathode, for example as in the Patent 2,258,158 previously mentioned. The electron emitting material is referred to as a "coating," for convenience, although it is preferably just a quantity of material held between the smaller turns of the coil 5, as in the patent mentioned.

The coating material may comprise one or more of the alkaline earth oxides, preferably barium, strontium and calcium oxides, together with a small quantity of hafnium oxide. The alkaline earth oxides may be applied to the electrode as carbonates and later reduced to the oxides during the exhausting of the tube. For example, an

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intimate, finely powdered mixture of 58% barium carbonate, 35% strontium carbinate, and 7% calcium carbonate will be satisfactory. A small amount of a nitrocellulose lacquer may be added as a vehicle for applying the coating to the cathode, the vehicle being removed by drying and decomposition during the exhaust process.

A small amount of finely-powdered hafnium oxide is added to the carbonates and intimately admixed therewith. The amount of hafnium oxide is preferably in a molal ratio to barium of about 1 to 5.5, although it may vary in amount between about 0.2 to 5.5 and 2 to 5.5.

After the stem 2 bearing the coated cathode 5 is sealed to the end of the envelope 1, the lamp is exhausted and filled with gas in the usual manner, through exhaust tube 8, prior to the sealing thereof. During this process the cathode is heated, for example by the passage of current therethrough, to convert the carbonates into oxides and carbon dioxide, the latter being removed by the exhaust, leaving the white oxides on the cathode.

I have tried many oxides of metals similar in some respects to hafnium, but the results were unsatisfactory. For example, the tests summarized in the following table show that the addition of oxides of beryllium, titanium, cerium and thorium were unsatisfactory, whereas the addition of hafnium oxide gave excellent results.

Table

Added oxide	Relative discoloration at various hours life				
	475	816	1,750	4,000	6,000
BeO	48	52	72	72	Failed.
TiO_2	36	42	70	Failed	Do.
HfO_2	0	0	4	10	30.
CeO_2	18	36	72	Failed	Failed.
ThO_2	26	40	60	73	Do.
None	38	40	42	94	Do.

The table clearly shows the superiority of hafnium oxide over the other similar oxides in keeping the discoloration low, and also shows that hafnium oxide gave longer life. For example at 4000 hours, the titanium and cerium oxide lamps had all failed, and at 6000 hours, the hafnium oxide lamps were the only ones still operating, the beryllium, titanium, cerium and thorium oxide lamps, together with those having no such additional oxide, having all failed. Moreover, the discoloration in these latter lamps was of an altogether different order of magnitude than that in the hafnium oxide lamps. In fact,

the discoloration in the hafnium oxide lamps at 6000 hours—a time at which all the other lamps had failed—was only about equal to the average discoloration in the other lamps at 475 hours' life.

The discoloration in the lamps with other than hafnium oxides added, while somewhat erratic, were roughly about the same, on the average, as if no oxide at all had been added.

The lamps marked "None" in the above table had their cathode coating of the barium, strontium and calcium mixture previously described herein, while the other lamps had admixed with the barium, calcium and strontium oxides, a small quantity of the particular oxide specified, the quantity in each case being that which gave a molal ratio to the barium oxide of 1 to 5.63. The ratio of the additional oxide to the barium oxide appears to be the important relationship, because the discoloration appears to be due chiefly to the barium.

The discoloration is greatest in lamps containing mercury vapor, and my invention is particularly effective in such lamps.

The lamps of the tests summarized in the table were 40 watt fluorescent lamps in a glass envelope 48 inches long and 1½ inches in diameter with a filling of argon at a pressure of about 3 millimeters of mercury, and mercury vapor. Such lamps operate at a temperature of about 40° C., corresponding to a mercury vapor pressure of about 6 microns. The filament wire was of tungsten.

What I claim is:

1. A discharge lamp cathode comprising a coiled tungsten wire and an electron-emitting material held by said wire and consisting mainly of hafnium oxide and barium oxide in molal ratio between 0.2 to 5.5 and 2 to 5.5.

2. An electric discharge lamp comprising a sealed tubular light-transmitting envelope, lead-in wires sealed therethrough, a gas filling at low pressure therein, a tungsten wire coil connected between said lead-in wires, and an electron-emitting mixture of powdered hafnium and barium oxides held in said coil, the molal ratio of hafnium to barium being between 0.2 to 5.5 and 2 to 5.5.

3. An electric discharge lamp comprising a sealed tubular light-transmitting envelope, lead-in wires sealed therethrough, a gas filling at low pressure therein, a tungsten wire coil connected between said lead-in wires, and an electron-emitting mixture of powdered hafnium and barium oxides held in said coil, the molal ratio of hafnium to barium being about 1 to 5.5.

4. An electric discharge lamp comprising a sealed tubular light-transmitting envelope, lead-in wires sealed therethrough, a gas-filling at low pressure therein, a tungsten wire coil connected between said lead-in wires, and an electron-emitting mixture consisting essentially of hafnium oxide, barium oxide and at least one other alkaline earth oxide held in said coil, the molal ratio of hafnium to barium being between 0.2 to 5.5 and 2 to 5.5, said hafnium and barium oxides constituting the main portion of the mixture.

5. An electric discharge lamp comprising a sealed tubular light-transmitting envelope, lead-in wires sealed therethrough, a gas-filling at low pressure therein, a tungsten wire coil connected between said lead-in wires, and an electron-emitting mixture consisting essentially of hafnium oxide, barium oxide and at least one other alkaline earth oxide held in said coil, the molal ratio of hafnium to barium being about 1 to 5.5, said hafnium and barium oxides constituting the main portion of the mixture.

6. An electric discharge lamp comprising a sealed tubular light-transmitting envelope, lead-in wires sealed therethrough, a gas filling at low pressure therein, mercury vapor therein, a tungsten wire coil connected between said lead-in wires, and an electron-emitting mixture of powdered hafnium and barium oxides held in said coil, the molal ratio of hafnium to barium being between 0.2 to 5.5 and 2 to 5.5.

7. An electric discharge lamp comprising a sealed tubular light-transmitting envelope, lead-in wires sealed therethrough, a gas filling at low pressure therein, mercury vapor therein, a tungsten wire coil connected between said lead-in wires, and an electron-emitting mixture of powdered hafnium and barium oxides held in said coil, the molal ratio of hafnium to barium being about 1 to 5.5.

8. An electric discharge lamp comprising a sealed tubular light-transmitting envelope, lead-in wires sealed therethrough, a gas-filling at low pressure therein, mercury vapor therein, a tungsten wire coil connected between said lead-in wires, and an electron-emitting mixture consisting essentially of hafnium oxide, barium oxide and at least one other alkaline earth oxide, held in said coil, the molal ratio of hafnium to barium being between 0.2 to 5.5 and 2 to 5.5, said barium and hafnium oxide constituting the main portion of the mixture.

9. An electric discharge lamp comprising a sealed tubular light-transmitting envelope, lead-in wires sealed therethrough, a gas-filling at low pressure therein, mercury vapor therein, a tungsten wire coil connected between said lead-in wires, and an electron-emitting mixture consisting essentially of hafnium oxide, barium oxide and at least one other alkaline earth oxide held in said coil, the molal ratio of hafnium to barium being about 1 to 5.5, said barium and hafnium oxide constituting the main portion of the mixture.

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