

Section 5: *Preparation of Phosphor Screens*

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Section 5

PREPARATION OF PHOSPHOR SCREENS*

The following are examples of how to deposit inorganic phosphor powders in thin and uniform layers onto flat surfaces (usually glass). These methods have been tested and used in this laboratory. They are useful but certainly not the only ways of preparing phosphor screens.

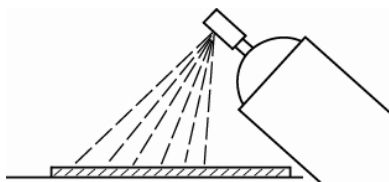
5.1 Phosphor Screens by Brushing

This method gives excellent, thin but dense, phosphor layers. It is especially good for small screens. The method is quick and easy and has been extensively used in the laboratory.

Procedure

Place the clean substrate (glass, etc.) on a horizontal surface.

Spray a layer of Krylon-Clear (out of a spray can) onto the substrate. Keep nozzle of the spray can about 5–10 cm over the substrate and spray enough to have the liquid lacquer uniformly flowing over the area. Try to keep the lacquer as uniform in thickness as possible.

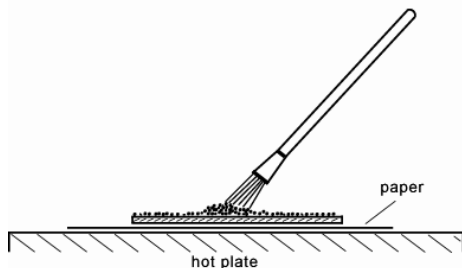


Let dry in air.

Place the substrate, the lacquer up, onto a piece of white paper and some of the phosphor to be coated onto the dry lacquer layer.

Now place all onto an electric hot plate with a flat metal top.

Heat up the hot plate to a temperature where the paper under the substrate just about turns brown. Simultaneously, move the phosphor over the lacquer with a soft hair brush. The lacquer becomes tacky when hot and coats quickly with a very dense yet thin phosphor layer.



* This section is from W. Lehmann's *Phosphor Cookbook*.

Take the screen off the hot plate; let cool down. Lacquer becomes solid.

Wipe excess loose phosphor particles off with a soft paper tissue.

The screen is now ready for most applications. The phosphor adheres very tightly to the substrate and is not easily damaged.

In some cases, however, the organic layer underneath of the phosphor layer cannot be tolerated. It can easily be burned out by heating in the open air, 400°C, for a few minutes. Afterwards, the phosphor will still stick to the substrate but the layer is much softer and easier damaged by accidental touching.

Reference

1. Lehmann, W., U.S. Pat., 2 798 821 (1954).

5.2 Phosphor Screens by Settling in a Kasil Solution

This method gives somewhat less dense (macroscopically) layer than brushing but permits tight thickness control and is easily used for large screens. It is widely in use to prepare phosphor screens for cathode-ray tubes.

Procedure

Clean the glass to be coated. Place it in a sufficiently large beaker, face up.

Prepare two stock solutions.

Solution A: K-silicate solution in water, 3% solids

Solution B: 1 g Sr acetate, $\text{Sr}(\text{C}_2\text{H}_3\text{O}_2)_2$, in 1 liter water

Pour solution A into the beaker to 20–40% of the volume.

Screen the phosphor through a fine sieve immediately before use (this is an important point).

Weigh the amount of phosphor to give the desired layer of thickness, grams per square centimeter, over the area of the beaker opening. About 5–10 mg/cm² usually is sufficient for most phosphors and purposes.

Pour solution B, a volume equal to that of A, into a glass cylinder; add the weighed amount of phosphor; close the upper end of the cylinder with one hand and shake vigorously. Then pour the suspension quickly to the solution A in the beaker.

Cover the beaker and let stand for about 1–24 hours.* The phosphor settles down during this time and the phosphor layer reacts with the silicate of the solution. Small amounts of this reaction product, or of Sr silicate from the reaction between parts A and B, will bind the phosphor to the substrate.

Decant the excess liquid.

Cautiously (as not to damage the still soft phosphor layer) rinse the screen several times in water.

Dry in air.

* Best reaction times depend on the material. Zn_2SiO_4 phosphors give well-adhering screens after 1–2 hours. ZnS-type phosphors react slower and have to stand overnight or longer.

Reference

1. Vosburgh, K.G., Swank, R.K., and Houston, J.M., *Adv. Electr. Electron. Phys.*, 43, 205 (1977).

5.3 Phosphor Screens by Cathaphoretic Deposition

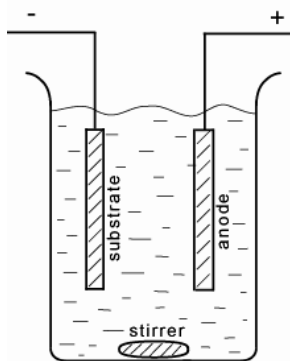
This method is used to prepare dense layers of fine-particled phosphors for high-resolution cathode ray screens.

Procedure

Coat the glass surface to be coated with a very thin, optically transparent gold layer by evaporation in a vacuum.

Provide a solution of 200 mg $\text{Mg}(\text{NO}_3)_2 \cdot \text{H}_2\text{O}$ in 1 liter methanol. Pour this solution into a beaker and add a few grams of the phosphor. Keep the solution in suspension by stirring (magnetic stirrer).

Insert the Au-coated substrate and an inert anode (Pt, carbon, etc.) into the upper part of the beaker. Distance anode–cathode a few centimeters.



Apply about 100–150 V DC (substrate = negative). Current should be about 5–10 mg/cm^2 . A very uniform and compact phosphor layer will stick to the substrate within about 10–30 sec. Longer times give thicker but less uniform layers.

Turn off voltage and stirrer; let the excess phosphor settle. Then take the screen cautiously out of the solution (the phosphor adheres to the substrate even in the absence of any additional binder).

Rinse briefly in water.

Wash briefly in a solution of about 10 g NaOH (or KOH) + 10 g NaCN (or KCN) in 1 liter water to dissolve the Au film which is no longer needed.

Rinse again in water and then in methanol.

Dry.

Reference

1. Grosso, P.F., Rutherford, R.E., and Sargent, D.E., Electrophoretic deposition of luminescent materials, *J. Electrochem. Soc.*, 117, 1456 (1970).

5.4 Filming of Phosphor Screens

Phosphor layers in commercial CR tubes are backed by a thin metallic Al film which the exciting electrons penetrate to reach the phosphor particles. The Al film provides an optically reflecting rear layer (thus enhancing the output brightness of the tube) and protects the phosphor against damage by ion bombardment from unavoidable gas residues in the tube.

Procedure

Place the phosphor screen, face up, into a beaker on a metal carrier to permit easy lifting out again. Add water to cover the screen.

Provide a solution of:

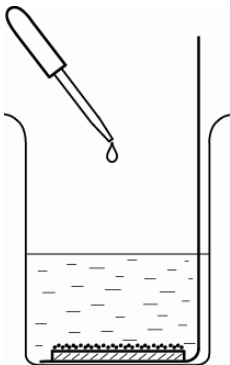
50 ccm ethyl cellulose in amyl acetate (commercial cellulose binder),

65 ccm propyl acetate,

30 ccm isopropyl alcohol,

2 ccm octyl acetate.

With an eye dropper, drop 1–5 drops (depending on the surface area) of the above filming solution onto the water in the beaker.



The solution will quickly spread over the whole water surface. The solvent evaporates within about 20–30 sec, leaving behind a solid, very thin film of ethyl cellulose floating on the water.

Carefully lift screen out.

Let dry in air. The cellulose now forms a very thin solid film touching only the tops of the phosphor particles. It prevents the Al during the subsequent vacuum deposition to penetrate in between the particles.

Deposit the Al film by evaporation in vacuum.

Heat the screen in open air to about 300–400°C for a few minutes.

The cellulose film will burn out leaving behind a shiny Al film.