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PROCESS FOR PRODUCING SILVER-OXYGEN-CESIUM PHOTON CONVERTER

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FIG. 1.

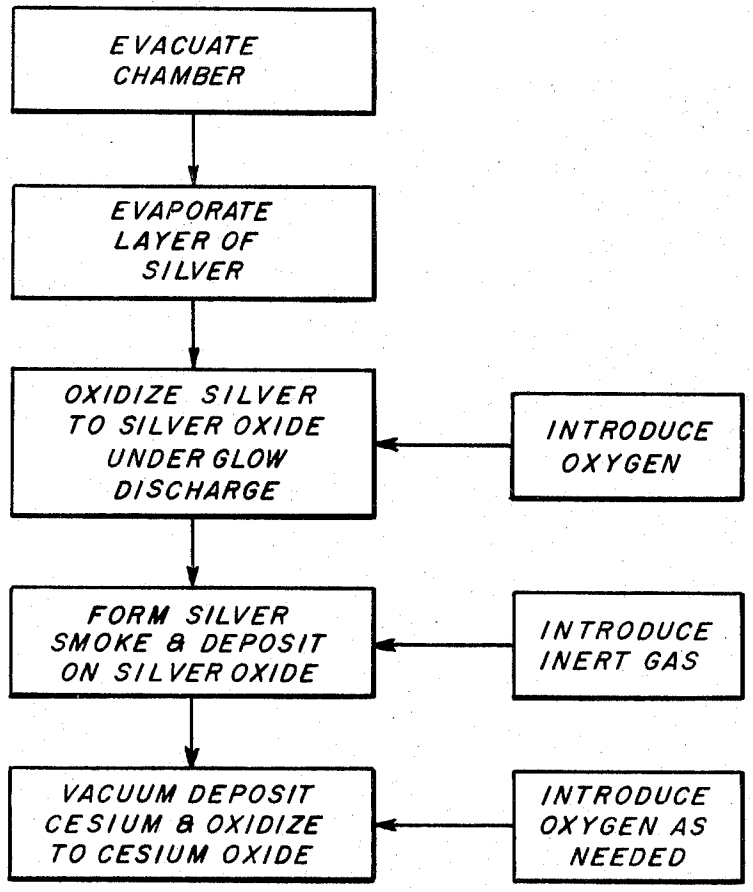
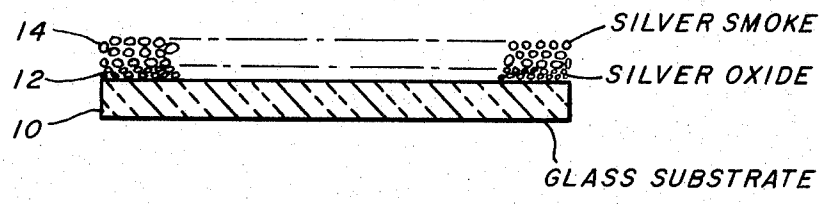


FIG. 2.



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PROCESS FOR PRODUCING SILVER-OXYGEN-CESIUM PHOTON CONVERTER

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U.S. Cl. 117—217 5 Claims

ABSTRACT OF THE DISCLOSURE

Process for preparing a silver-oxygen-cesium photoemitter wherein a layer of silver is initially deposited on a substrate and then oxidized, followed by deposition of a low density silver deposit (i.e., density of 2 to 20% of bulk density) and evaporation of cesium. The silver oxide layer acts to release oxygen upon heating thereby forming cesium oxide in the voids of the low density silver deposit without collapsing the deposit.

BACKGROUND OF THE INVENTION

In copending application Ser. No. 270,774, filed July 11, 1972, now U.S. Pat. No. 3,809,941, a process is described for producing a photoemitter responsive to infrared wavelengths. Essentially, the process comprises the steps of depositing a layer of the low density deposit on a substrate of silver oxide in the presence of an inert gas atmosphere, evaporating cesium and depositing it on the previously-deposited low density layer, and introducing sufficient oxygen into the atmosphere during evaporation of the cesium to form a layer of cesium oxide over the low density silver particles.

While the process described in the aforesaid copending application is basically sound, it is not entirely satisfactory for reproducible production techniques for the reason that the structural stability of the low density smoke deposit is very poor. That is, in order to successfully oxidize the cesium, it is first necessary to oxidize the silver smoke; however the silver smoke is unable to withstand the bombardment of the oxygen ions during the glow discharge necessary for formation of silver oxide. As a result, the oxidation of cesium through decomposition or reduction of silver oxide formed on the smoke layer becomes very difficult. Previously, the problem was alleviated by selectively glow discharging the excess silver smoke on the walls of the test envelope to form silver oxide, thus leaving the smoke on the faceplate of the test envelope in tact.

Of primary interest in producing a silver-oxygen-cesium photoemitter of high quantum efficiency is the production of cesium oxide in a way such that it makes intimate contact with the silver particles. Furthermore, this must be attained in reproducible mass production processes.

SUMMARY OF THE INVENTION

In accordance with the present invention, a new and improved process for producing a silver-oxygen-cesium photoemitter is provided whereby the cesium oxide of the photoemitter makes intimate contact with the previously-deposited low density silver particles without disturbing the structural stability of the low density deposit itself.

Specifically, in carrying out the invention, a hard vacuum evaporated silver film of approximately 50% transmission is initially evaporated on a substrate and then oxidized via a glow discharge in oxygen, thereby forming a silver oxide film on the substrate. By depositing the low density silver on the silver oxide film and then applying a film of cesium in the manner employed in prior art methods for producing silver-oxygen-cesium photosurfaces, the release of oxygen by the silver oxide and the

resulting formation of the cesium oxide fills the voids of the low density silver deposit and facilitates intimate contact of the particles comprising the low density deposit with the cesium oxide. At the same time, since the initially-deposited silver oxide layer is used to oxidize cesium, the structural stability of the smoke particles is not impaired.

The above and other objects and features of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings which form a part of this specification, and in which:

FIG. 1 is a flow diagram of the process for producing the photoemitter of the invention; and

FIG. 2 is an illustration of the photoemitter structure after application of a silver oxide film and low density silver particles, but before application of a film of cesium.

In carrying forth the invention, a substrate, such as the forward face of a multiplier tube, is initially provided with a hard vacuum evaporated silver film of approximately 50% transmission. In this respect, and as shown in FIG. 1, the photomultiplier envelope, for example, is initially evacuated to produce a hard vacuum, followed by vacuum deposition of a layer of silver of approximately 50% transmission as explained above. Conventional deposition techniques are used in this step. Following the deposition of the silver layer, oxygen is introduced into the enclosure; electrodes are connected across the silver film previously deposited and some other suitable element in the envelope; and a potential is applied across the electrodes to effect a glow discharge in the presence of oxygen. Under these circumstances, the silver will oxidize to silver oxide.

Thereafter, a low density silver film is formed and deposited over the silver oxide film within an inert gaseous atmosphere. Low density deposits, of course, are well known to those skilled in the art. In general, the metallic constituent, in this case silver, is heated to achieve an evaporation rate sufficient for achieving a black deposit. This function is controlled by varying the temperature. However, since the evaporation rate varies widely for different materials, the amount of heating required also varies, and this must be adjusted for silver. In addition, the evaporation rate is pressure-dependent and thus will vary with the inert gas pressure in the chamber. The vapor pressure of the metal, however, is primarily a function of temperature. Silver is very stable, with a low vapor pressure, and thus must be heated to its melting temperature to develop an adequate black silver deposit.

In the processing, it will be observed that a low density deposit which is white initially develops, which becomes black upon establishing the proper operating parameters. As one specific example, the inert gas pressure and the rate of evaporation of the silver are controlled so as to achieve a black deposit of the silver particles within the chamber for deposition on the previously-deposited silver oxide film. The inert gas pressure is typically in the range of about 3–4 millimeters of mercury. Smoke deposition is performed at room temperature, although perhaps slightly elevated in temperature due to the heating of metal, and takes from 15–60 seconds for developing a black deposit in the range of 5–20 micrometers in thickness over a substrate having a circular surface of 2 inches in diameter. The individual particles thus deposited ranged from 2–5 micrometers in width and 5–50 micrometers in length.

Upon conclusion of the smoke deposit, the enclosure is evacuated to establish a hard vacuum. The substrate, in this case the face of a photomultiplier tube with the low density deposited layer over a layer of silver oxide, is then heated to a temperature typically of 150° C. Under these conditions, cesium is vacuum deposited over the low

density silver particles; while oxygen is introduced into the enclosure to assist in the oxidation of cesium as required. However, the major part of the oxygen for formation of cesium oxide is derived from the previously-deposited silver oxide film. That is, the release of the oxygen by the silver oxide results in the formation of cesium oxide which fills the voids of the silver smoke and thus results in a reproducible production technique.

Prior to the application of the cesium film, the structure would resemble that shown in FIG. 2 wherein the substrate (i.e., the face of a photomultiplier tube) is identified by the reference numeral **12**; while the low density silver deposit is identified by the reference numeral **14**. The low density layer **14** comprises semi-continuous links or chains of particles having substantial voids therebetween. These voids are then filled with the vacuum deposited cesium which, when oxidized, provides a photomissive surface responsive to infrared wavelengths. The resulting photoemitter has both metallic and semiconducting characteristics. In the photoemission process, energy is absorbed from incident radiation, creating so-called "hot" electrons having energies exceeding the energy levels of electrons which exist in solid at thermal equilibrium. These hot electrons move to the interface between the photoemissive surface and the vacuum environment in which it is used and then escape from the material into the vacuum. The photoemissive material of the invention, in contrast to many photoemissive materials, will absorb infrared radiation with higher efficiency to product electron emission which can be detected, for example, by means of a collecting electrode with the envelope.

Although the invention has been shown in connection with a certain specific embodiment, it will be readily apparent to those skilled in the art that various changes in the process steps can be made to suit requirements without departing from the spirit and scope of the invention.

I claim as my invention:

1. In a method for forming a photoemissive surface,

the steps of applying to a substrate a film of elemental silver, thereafter oxidizing said silver film to produce silver oxide, forming silver smoke and depositing it over the oxide film as a black film of low density silver particles, and under the influence of heat applying over the low density particles a film of cesium which forms cesium oxide via decomposition of the silver oxide.

2. The method of claim **1** wherein said substrate is surrounded by a chamber and including the step of evacuating said chamber and vacuum depositing said layer of elemental silver.

3. The method of claim **1** including the step of applying an electrical potential across said film of elemental silver to produce a glow discharge while subjecting said film of silver to oxygen to effect oxidation of the same.

4. The method of claim **1** wherein said substrate is surrounded by an enclosure, and including the step of introducing an inert gas into said enclosure when said film of low density silver particles is applied to the silver oxide film.

5. The method of claim **1** wherein said substrate is surrounded by an enclosure, and including the step of introducing oxygen into said enclosure when cesium is applied over said low density particles.

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U.S. Cl. X.R.

117—93.1 GD, 107, 219, 223, 225