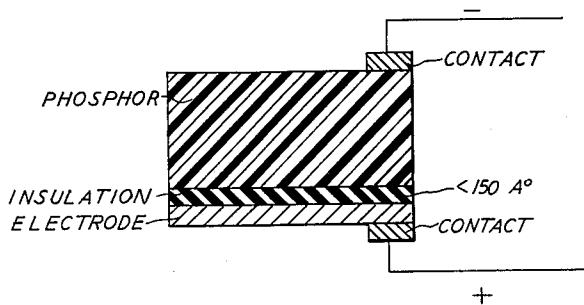


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LOW-VOLTAGE HOLE-INJECTION ELECTROLUMINESCENCE
IN CADMIUM SULPHIDE
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1

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LOW-VOLTAGE HOLE-INJECTION ELECTROLUMINESCENCE IN CADMIUM SULPHIDE

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5 Claims. (Cl. 313-108)

This invention relates to the field of electroluminescence and is more particularly concerned with a new system and apparatus for the production of electroluminescence upon the application of voltages far below those usually considered necessary by the art.

The structural characteristics of the apparatus necessary for the production of electroluminescence at very low voltages is readily comprehended by a study of the figure of drawing. In this drawing the active part of the apparatus is a phosphor chosen from the class consisting of cadmium sulphide, cadmium telluride, cadmium selenide and zinc telluride. The preferred material is cadmium sulphide. This material should be prepared to give a crystal of moderate conductivity. Material displaying a room temperature resistivity of about ten ohms per centimeter cube is suitable for this apparatus.

The portion of the phosphor to be connected to the negative potential is preferably coated or plated to provide a suitable means for the introduction of the electric current. The source of positive potential is connected to another portion of the phosphor through a suitable electrode structure. A plating of gold, silver, copper, or aluminum will serve. The thickness of this layer is not critical.

It is imperative that a layer of insulating material of tunnelling thickness be interposed between this metal electrode and the surface of the phosphor. The thickness of this insulating layer has been exaggerated in the drawing for the sake of clarity. Normally to permit tunnelling this insulating layer should not be substantially over one hundred angstroms in thickness. Suitable materials for this insulating layer are aluminum oxide, cellulose nitrate and polyvinyl formal. In the case of the aluminum oxide, a layer fifty angstroms thick produced directly on the surface of an aluminum electrode has been satisfactory. Layers one hundred angstroms thick have been employed using cellulose nitrate and polyvinyl formal.

Electroluminescent structures have been produced by the following procedure. They are constructed by depositing a very thin insulating film or a small area of a cadmium sulphide single crystal. The crystal is moderately conducting at room temperature. A metal film, usually gold, is deposited over this and electrodes are attached.

This two electrode device exhibits rectifying characteristics quite similar to those obtained if the insulator is omitted. The forward direction obtains when the metal is positive. When bias voltages in excess of one volt D.C. are applied in the forward direction, faint visible light is seen coming from the cadmium sulphide layer immediately adjacent the junction, its brightness increasing rapidly with voltage. At room temperature the light is red and at 77° K. green or green and red (yellow). The observed color spectrum and its variation with temperature are characteristic of the known luminescent behavior

2

of cadmium sulphide. With alternating voltages, the light follows the current alternations up to frequencies of 5 kilocycles per second or more. The efficiency is very low, being of the order of 10^{-7} to 10^{-4} photons emitted per electron through the external circuit. No electroluminescence was observed if the insulating layer was omitted.

These results point to hole injection as the mechanism of excitation. For this process, the insulating layer is necessary to allow for a potential difference to exist between the cadmium sulphide and metal, permitting electrons to tunnel from the valence band to the metal with a hole being formed in the barrier layer region of the cadmium sulphide. The hole can then be excited thermally into the bulk of the cadmium sulphide where it is available for radiative recombination.

A variety of metals will make rectifying contact with cadmium sulphide; among these are copper, platinum, silver, or aluminum. There is no basic reason why gold should be the most likely candidate.

The insulating material most frequently used was formvar (polyvinyl formal). It was deposited when a very dilute solution was applied to the cadmium sulphide and the solvent allowed to evaporate. Pre-cast collodian (cellulose-nitrate) films were also used but with less success. Aluminum oxide proved to be a very good material. It was deposited by evaporating a thin aluminum film (about 50° angstrom) and allowing it to oxidize in air before the heavy metal layer was applied.

Air drying gold and silver paste contacts applied directly to the cadmium sulphide also produced the electroluminescence, with the binder playing the role of the insulator.

Tunnelling as employed herein may be defined as a quantum mechanical phenomenon excited by moving particles that succeed in passing from one side of a potential barrier to the other although possessing insufficient energy to pass over the top. Ordinarily the thickness of the insulating layer necessary in this invention will not substantially exceed 150 angstroms.

We claim as our invention:

1. An electroluminescent structure comprising a conductive mass of a phosphor chosen from the class consisting of cadmium sulphide, cadmium telluride, cadmium selenide and zinc telluride, a metal electrode and a layer of insulating material having a thickness not substantially exceeding 150 angstroms interposed between the metal electrode and the phosphor.

2. An electroluminescent structure comprising a conductive mass of a phosphor, a metal electrode and a layer of insulating material having a thickness not substantially exceeding 150 angstroms interposed between the metal electrode and the phosphor.

3. An electroluminescent structure comprising a conductive mass of a phosphor, a metal electrode and a layer of insulating material having a thickness not substantially exceeding 150 angstroms interposed between the metal electrode and the phosphor, said insulating material being selected from the class consisting of aluminum oxide, cellulose nitrate and polyvinyl formal.

4. An electroluminescent structure comprising a conductive mass of a phosphor and an aluminum electrode, the aluminum electrode having a layer of oxide having a thickness not substantially exceeding 150 angstroms interposed between it and the conductive phosphor.

3

5. An electroluminescent structure comprising a conductive mass of a phosphor a and suspension of a finely divided metal suspended in an insulating material, said suspension being in contact with the conductive phosphor and supporting the finely divided metal within a distance not substantially exceeding 150 angstroms of the phosphor.

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4

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