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Tomita et al.

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[45] **Jan. 29, 1974**

[54] **METHOD OF MANUFACTURING SHADOW MASKS**

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[73] Assignee: **Hitachi, Ltd.,** Tokyo, Japan

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[30] **Foreign Application Priority Data**

May 6, 1970 Japan 45/38484

[52] **U.S. Cl.** ..... **29/25.11,** 313/85 S

[51] **Int. Cl.** **H01j 9/14**

[58] **Field of Search** . 156/3; 29/25.13, 25.18, 25.17, 29/25.11, 25.1; 313/85 S

[56] **References Cited**

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[57] **ABSTRACT**

A shadow mask to be utilized in a color cathode ray tube is manufactured by the steps of preparing a shadow mask blank including laminated layers of a first metal and a second metal having different melting points, forming a plurality of small perforations through the shadow mask blank such that each perforation has a first predetermined diameter at the junction between the layers and a second predetermined diameter in the layer of the second metal, the second diameter being smaller than the first diameter and corresponding to the diameter of phosphor dots which are formed on a phosphor surface when the perforated shadow mask blank is used as a mask pattern for forming the phosphor dots by conventional photo-etching techniques and subjecting the perforated shadow mask to heat treatment for melting the layer of the second metal to enlarge the second diameter.

6 Claims, 6 Drawing Figures

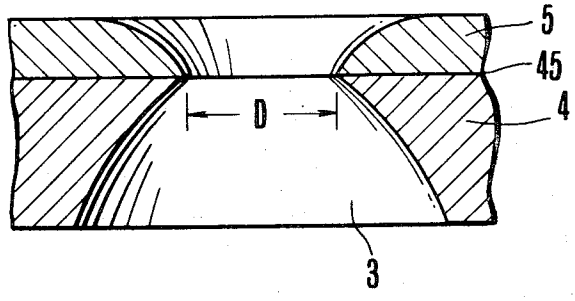


FIG. 1

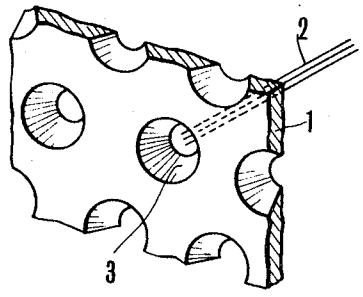


FIG. 2

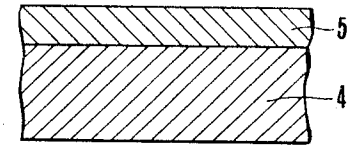


FIG. 3

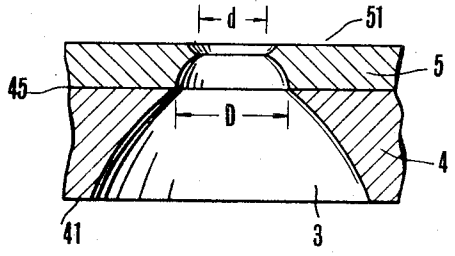


FIG. 4

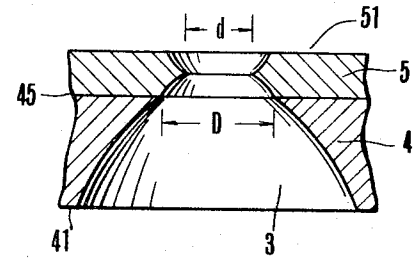


FIG. 5

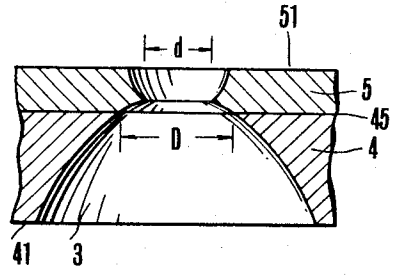
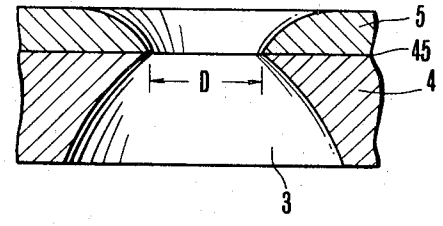


FIG. 6



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METHOD OF MANUFACTURING SHADOW MASKS

BACKGROUND OF THE INVENTION

This invention relates to a method of manufacturing shadow masks for use in shadow mask type color cathode ray tubes.

A shadow mask type color cathode ray tube generally comprises three electron guns mounted in one end of a glass envelope, a shadow mask provided with a plurality of small perforations positioned adjacent the face plate of the envelope, and a phosphor surface having a mosaic of a plurality of phosphor dots corresponding to the small perforations on the face plate. A triad of phosphor dots adapted to emit three different light colors is formed on the phosphor surface at a position to correspond to one of the small perforations of the shadow mask and these triads are excited by electron beams passing through the perforations in the mask for emitting different colors, whereby a picture image of desired color is reproduced. Thus, the shadow mask acts as a means for shaping the electron beams so that they will impinge upon the triads of phosphor dots corresponding to the respective electron beams for different colors. More particularly, as shown in FIG. **1** of the accompanying drawings, a metal plate **1** is formed with a plurality of small perforations **3** having a definite spacing for passing electron beams **2.** The configuration of each perforation takes the form of a frustum of a cone having a larger diameter on the side of the phosphor surface than on the side of the electron guns (not shown) in order to prevent irregular reflection of the electron beams on the inner wall of the perforation obliquely impinging upon it.

It is also known that, in addition to the ability to shape the color electron beam, as described above, the shadow mask is also used as a mask pattern for forming the phosphor dots on the phosphor surface of the color cathode ray tube using the conventional photo-etching technique.

In recent years, the so-called matrix type color cathode ray tube has been developed wherein the regions between the phosphor dots are coated with a black substance, graphite for example, in order to absorb ambient light. It has also been proposed to make the diameter of the phosphor dot smaller than that of the electron beam so as to improve the color purity, thus improving contrast. Where the shadow mask is used as the mask pattern in such a color cathode ray tube, it is necessary to first form small perforations through the shadow mask for forming the phosphor dots using the photo-etching technique and then enlarge the diameter of the perforations for shaping the electron beams.

For this reason, it has been the practice to first form small perforations through the shadow mask using the etching process, said perforations having a diameter smaller than the diameter of the electron beam. After using the perforated shadow mask as the mask pattern, the diameter of the small perforations is enlarged by the etching process to a diameter sufficient to obtain an electron beam having a desired diameter larger than the phosphor dot, thus forming a second perforation for passing the electron beam. In such a case, it is important to shape the inner wall of the second perforation as a frustum of a cone, with the result that it is difficult to etch the perforation by the second etching process so as to provide the inner wall of uniform configuration. Further, there is a problem that during the etching process, the etching solution also etches the mask frame, which is provided for supporting the shadow mask, or the leaf springs welded to the frame, thus causing an undesirable peeling off of the welds. Thus, the prior method of manufacturing the shadow mask is complicated because it requires two etching steps, one for forming small perforations to enable the shadow mask to be used as the mask pattern for forming the phosphor dots and the other for enlarging the first perforation to have a diameter of a size sufficient for passing the electron beam.

SUMMARY OF THE INVENTION

Accordingly, a first object of this invention is to provide a method of manufacturing a shadow mask according to which it is possible to prepare by a single etching step a shadow mask for shaping electron beams to have diameters larger than those of the phosphor dots.

A second object is to provide a method of forming a shadow mask comprising the steps of forming small perforations which serve as a mask pattern by etching from opposite surfaces a multi-layer metal plate consisting of a first metal layer and a second metal layer, forming phosphor dots by a well known light exposure technique, and then heating the mask pattern to enlarge the diameter of the small perforations penetrating through the second metal layer.

A third object of this invention is to provide a novel method of manufacturing a shadow mask from a blank consisting of metal layers of different melting points.

A fourth object of this invention is to provide a shadow mask having small openings for shaping electron beams having diameters larger than those of the phosphor dots at the junction between two laminated metal layers of different melting points.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** shows an enlarged perspective view of a portion of a conventional shadow mask for use in a color cathode ray tube;

FIG. **2** shows an enlarged section of a portion of one example of a shadow mask blank utilized to manufacture the novel shadow mask for use in a color cathode ray tube;

FIGS. **3** to **5** show enlarged sections of perforations formed by using various types of etching solutions; and

FIG. **6** is an enlarged sectional view of a portion of a finished shadow mask manufactured according to the method of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

According to this invention, a shadow mask blank consisting of a multi-layer metal plate is prepared by bonding together a first metal layer, to be located in the tube envelope facing the phosphor layer, and a second metal layer having a lower melting point than the first metal layer, to be located facing the electron guns, and small perforations are formed through the blank. The configuration of each perforation is selected such that it has a diameter corresponding to the desired electron beam diameter at the junction between the two metal layers; while, in the first metal layer the diameter of the perforation gradually increases from the junction

toward the surface facing the phosphor surface and in the second metal layer the diameter of the perforation is smaller than the desired diameter at least at a portion thereof. The diameter of the perforations in the second metal layer is selected to determine the diameter of the phosphor dots on the phosphor surface which are formed when the perforated shadow mask blank is used as a mask pattern for forming the phosphor dots by a photo-etching technique. Then the shadow mask blank is heat treated to melt the perforations through the second metal layer to cause an enlarging of the perforations through the second metal layer.

With reference now to FIG. **2** of the accompanying drawing, which shows a cross-section of a shadow mask blank utilized in this invention, the shadow mask blank comprises a first metal layer **4** and a second metal layer **5**, having a lower melting point than the first metal layer and being laminated thereon. Bonding of the first and second metal layers is accomplished by plating, or spraying or rolling, the second metal layer **5** onto the first metal layer. In this embodiment, the first metal layer **4** comprises an iron sheet having a thickness of about 100 microns and the second metal layer comprises a film formed by a plating of molten tin and having a thickness of about 50 microns. A plurality of small perforations are formed through the shadow mask blank by well known etching technique utilizing an etching solution. As shown by the enlarged sectional views of FIGS. **3** to **5**, the configuration of each one of the small perforations is selected such that it has a diameter D corresponding to the desired beam diameter at the junction **45** between the iron sheet **4** and the tin layer **5**; while, the diameter in the iron sheet **4** gradually increases from D at the junction **45** towards the surface **41**, thus forming a frustum of a cone, and the diameter in the tin layer **5** gradually decreases from D at the junction **45** towards the surface **51** to reach a minimum at least at a portion of the perforation. The difference in the configurations of the perforations shown in FIGS. **3** to **5**, which depends upon the selection of the etching solution, is caused by the difference between the solubilities of the iron sheet **4** and the tin film **5** in the etching solution. More particularly, the condition shown in FIG. **3** corresponds to a larger solubility of the tin film **5** than that of the iron sheet **4**; that shown in FIG. **4** corresponds to an equal solubility of both metals; and that shown in FIG. **5** corresponds to a larger solubility of the iron sheet **4** than that of the tin film **5**. The minimum diameter *d* of the perforations through the tin film **5** formed by etching of the shadow mask blank is dependent upon the magnitude of the phosphor dots formed by the photo-exposure described later.

The shadow mask blank perforated as above described is used as an exposure mask pattern for depositing a black coating and phosphor dots on the phosphor surface. In this case, the tin film **5** of the shadow mask blank is located to face a light source for exposure, whereas the iron sheet **4** is located to face the phosphor surface.

The shadow mask blank, which has been used as the mask pattern, is then subjected to heat treatment. The temperature of the heat treatment is higher than the melting point (232°C) of tin but lower than the melting point of iron. As a consequence the tin layer **5** of the shadow mask blank melts with the result that the surface tension of molten tin eliminates the projection that has been defining the minimum diameter *d* of the perforations shown in FIGS. **3** to **5**, thus changing the cross-sectional configuration of the perforations to that shown in FIG. **6**. Thus, the heat treatment of the shadow mask blank produces a shadow mask having perforations of the minimum diameter D that corresponds to the desired electron beam diameter and has been formed at the junction **45** by the previous etching process.

As above-mentioned, since the temperature of heat treatment is lower than the melting point of iron, the inner wall of the perforations through the iron sheet **4** formed by the etching operation is never deformed.

Although in the foregoing embodiment the first and second metal layers of shadow mask blank were comprised by iron and tin, respectively, it is to be understood that the invention is never limited to these particular metals and that any metals having different melting points can also be used. Further, one or both of the metal layers may be a metal alloy.

While we have shown and described several embodiments in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to a person skilled in the art, and we therefore do not wish to be limited to the details shown and described herein but intend to cover all such changes and modifications as are obvious to one of ordinary skill in the art.

We claim:

1. A method of manufacturing a shadow mask for use in a color cathode ray tube having a phosphor surface formed of a mosaic of phosphor dots comprising the steps of preparing a shadow mask blank including laminated layers of iron and tin having different melting points, the layer of tin having a thickness of about 50 microns, forming a plurality of small perforations through said shadow mask blank such that each of said perforations has a first predetermined diameter at the junction between said iron and tin layers and a second predetermined diameter within the layer of tin, said second diameter being smaller than said first diameter, forming said phosphor dots through said perforated shadow mask blank by a photo-exposure technique with the diameter of said phosphor dots being determined by said second diameter, and then subjecting said perforated shadow mask blank to heat treatment for melting the layer of tin to enlarge said second diameter of said perforations.

2. The method according to claim **1**, wherein said small perforations are formed such that the diameter of each perforation through said layer of said first metal gradually increases from said junction to the opposite surface of said layer.

3. The method according to claim **1**, wherein said first predetermined diameter of said perforations is dependent upon the diameter of an electron beam that passes through said perforations and said second diameter is dependent upon the diameter of said phosphor dots.

4. The method according to claim **1**, wherein said shadow mask blank is prepared by applying a coating of second metal on the layer of said first metal.

5. The method according to claim **1**, wherein said shadow mask blank is prepared by plating the layer of said first metal with said second metal.

6. The method according to claim **1**, wherein said perforations are formed in said shadow mask blank by a photo-etching process.

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