United States Patent

Veith

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[54] **TARGET STRUCTURE FOR A VIDICON TUBE AND METHODS OF PRODUCING THE SAME**

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[51] **Int. Cl.**..**H01l 15/00**

[58] **Field of Search**
1317/235 N, 235 R, 235 AJ, 235 AK

[56] **References Cited**

UNITED STATES PATENTS

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[57] **ABSTRACT**

A vidicon tube target structure wherein a n-conductive signal plate has a target surface thereof provided with a p-conductive layer and an array of fine grooves extend from this layer downwardly beyond the p-conductive layer into the signal plate to define an array of mesa-like p-conducitve land areas. The peripheral groove walls are coated with an insulator material while the land areas are coated with a conductive metal. The grooves and lands are configured to provide an increased amount of utilizable effective target surface area for a scanning electron beam.

7 Claims, 4 Drawing Figures

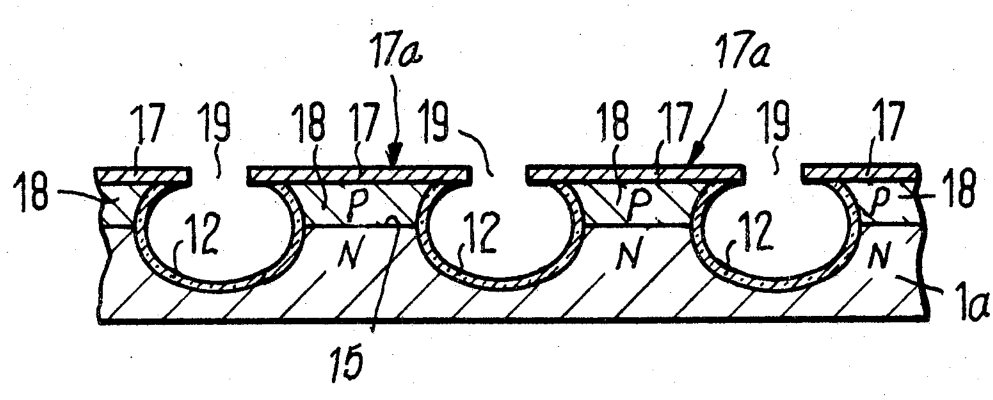


Fig.1 (PRIOR ART)

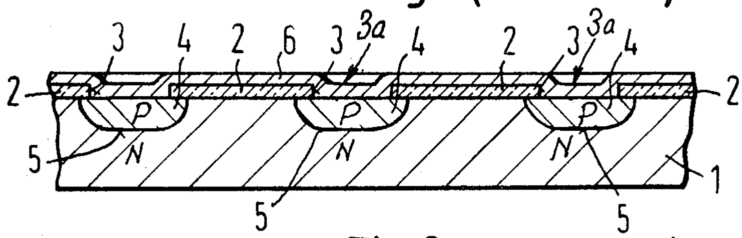


Fig.2 (PRIOR ART)

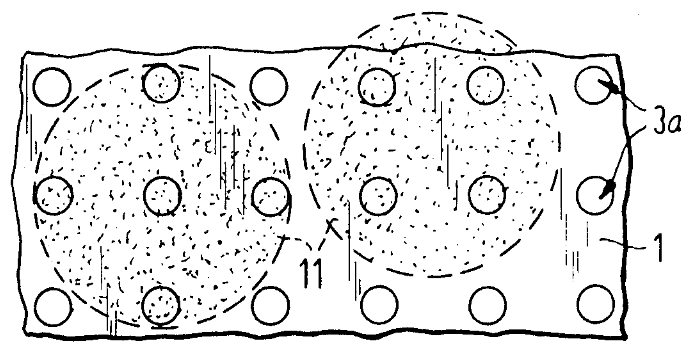


Fig.3

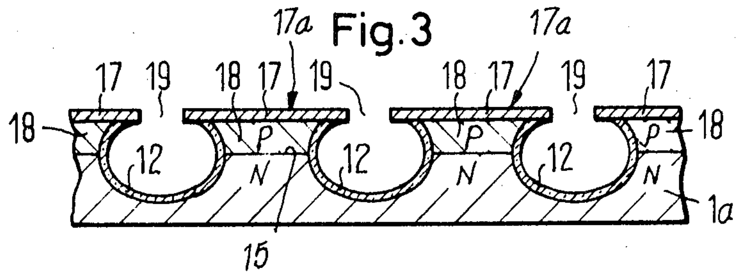
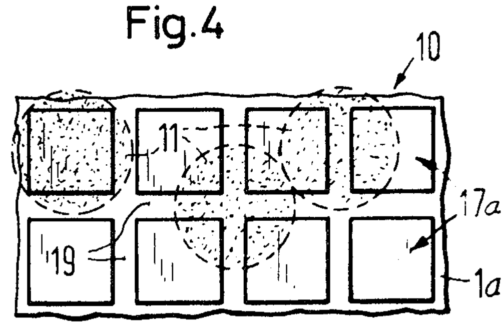


Fig.4



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TARGET STRUCTURE FOR A VIDICON TUBE AND METHODS OF PRODUCING THE SAME

BACKGROUND OF THE INVENTION

1. Field Of The Invention

The invention relates to a light sensitive storage target structure for television camera tubes, and more particularly to a vidicon target structure.

2. Prior Art

Vidicon target structures are known. For example, U. S. Pat. No. 3,403,284 describes a particular form of a vidicon target structure comprised of a Si-diode vidicon that has pn-junctions at circular openings of a n-conductive signal plate. Such prior art structures are formed by photo-screen techniques so that the resultant diodes have pn-junctions that are somewhat spherical or curved. The exposed target surface areas between such diodes (which define the utilizable target surface area) are coated with an insulator material in a manner so as to somewhat overlap peripheral edges of the diodes. This type of vidicon target structure has found some utility since it has mechanical sturdiness, fair sensitivity and a relatively short decay time associated with silicon, i.e., a low smearing effect.

Nevertheless, these prior art target structures have a number of serious drawbacks. For example, the insulator layer between the array of individual diodes carries a negative potential or load. This negative potential produces such an interfering effect to the scanning process by a slow electron beam that the positive potential or load formed on the diodes by the incoming photons is extremely difficult to neutralize, and normally is only partially neutralized. Further, a capacitance is formed at the (i.e., boundaries defining the circular openings of the Si-plate i.e., the signal plate) and noticeably interferes with proper picture storage.

An equalization layer has been proposed for alleviating such interference effect, which is exemplarily composed of an antiminous trisulfide. However, use of an equalization layer materially impairs the quality and reliability of the resultant target structure. It is difficult to obtain the correct conductivity within such an equalization layer to achieve the desired potential or load neutralization. Further, the equalization layer has its own photo effect and thus causes an interfering smearing effect to be noted during operation. Additionally, the equalization layer materially limits the bake-out temperatures of tubes containing them and thereby reduces the useful life period of such tubes.

Further, the prior art target structures have somewhat spherical or curved pn-junctions which are self-formed during the evaporation of a suitable p-conductive material. Such curved pn-junctions exhibit a high field strength at their thin edges which tends to destroy the pn-junctions and produce a short circuit within the target structure.

Yet further, the prior art structure has a very unfavorable resolution power in regard to a scanning electron beam. Apparently, this is due, at least in part, to the circular form of the diodes utilized and to the large insulating distances between such diodes. In accordance with the prior art, the diameter of a scanning electron beam in an ideal situation is of a size encompassing five diodes. However, in the least ideal situation, the same size beam will only encompass four

diodes (i.e., photo-electrical cells). Accordingly, the ratio of the target surface utilized in these two instances is about 5:4. Assuming a uniform illumination, this relation causes a brightness fluctuation of about 25 percent and in practice, this tends to be very disturbing during the operation of a camera tube (i.e., an electron tube that converts an optical image into an electrical television signal).

Accordingly, it is an object of the invention to overcome the aforesaid prior art drawbacks and to provide a novel target structure for camera tubes having greatly improved properties and to provide methods of producing the same.

SUMMARY OF THE INVENTION

In general, the invention provides a camera tube target structure comprised of a n-conductive signal plate exemplarily composed of Si on which a p-conductive layer is created or formed (i.e., as by diffusion of boron). An array of relatively narrow deep grooves are provided so as to extend from the p-conductive layer into the signal plate and intersect the p-conductive layer so as to define an array of p-conductive regions having plane surfaces with end edges over-lying side walls of the grooves. The peripheral grooved walls are coated with an insulator material, exemplarily composed of SiO_2, while the island-like p-conductive regions are coated with a conductive metal, exemplarily composed of Au. The grooves and p-conductive regions are configured to define distinct plane-like pn-junctions that provide relatively large individual diodes so that the effective target surface area for a scanning electron beam is materially increased and the resolution power likewise increased.

Additionally, the invention provides methods of producing such camera tube target structures wherein n-conductive signal plate is first provided with a suitable p-conductive material. Then a plurality of individually distinct metal islands or the like are provided on the p-conductive layer and the resultant structure is subjected to a suitable etch treatment whereby the areas between the metal islands are removed to define an array of narrow deep grooves extending through the p-conductive layer and into the signal plate so as to distinctly cleave or separate the pn-junction into a plurality of pn-junctions each corresponding to a discrete diode. The peripheral grooved walls are then coated with an insulator layer. In certain embodiments, the metal islands are galvanically reinforced with a suitable etch-resistant metal prior to the etch treatment. Additionally, the metal islands are configured into a regular or irregular configuration dependent upon the means utilized to provide the same.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an enlarged partial view of a prior art target structure;

FIG. 2 is a partial plane view of the target surface of the structure illustrated at FIG. 1;

FIG. 3 is an enlarged partial elevational view of a target structure in accordance with an embodiment of the invention; and

FIG. 4 is a partial plane view of the target surface of the structure illustrated at FIG. 3.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

Description of the operational principles of a camera tube target structure is well known to workers in the art and description thereof can be ascertained from a number of sources, including the aforesaid U. S. Pat. No. 3,403,284 (which is incorporated herein by reference).

As shown in FIG. 1, prior art target structures comprise a n-conductive Si-plate 1 having an insulator layer 2 (composed of SiO_2) along a surface thereof (i.e., the target surface). An array of recesses 3 extends below the coated surface and into the body of the signal plate 1. A p-conductive material 4 is diffused into the recesses so as to form a plurality of diodes 3*a*. Such prior art target structures are formed by the Planar technique. Accordingly, the pn-junctions 5 that are formed thereby are somewhat sperically shaped. These curved surfaces or junctions cause a high field strength to occur at their thin edges, i.e., the peripheral edges defining the recesses. Such high field strengths tend to destroy the pn-junctions during operation, i.e., causing a break-through to occur. In addition, a capacitance forms at the ring-shaped edges of the recesses 3 that cause an additional interference of picture storage during operation. This capacitance forms between the upper and lower surfaces of the ring-shaped edges of the insulator layer 2 at the mouths of the recesses 3; these edges of layer 2 limit the pn-junctions. The formed capacitance produces an unfavorable time constant with the resistance of an equalization layer 6, formed by the evaporation of Sb_2S_3.

As indicated earlier, the equalization layer 6 is utilized to lessen the interfering effects which the negative potential of the insulator layer 2 positioned between the various diodes has during a scanning operation by a relatively slow electron beam. While some potential equalization is achieved, it is nevertheless extremely difficult to obtain correct conductivity within the layer 6 for the proper potential neutralization or equalization. Further, the equalization layer 6 has a photo-effect that causes a smearing effect during the scanning process. Additionally, the equalization layer 6 materially limits the bake-out temperature of a camera tube having such a target structure construction and thereby limits the life of the camera tube.

Additionally, as seen at FIG. 2, prior art target structures have an unfavorable resolution power, primarily due to the circular shape of the diodes 3*a*. In accordance with the prior art, the diameter of an electron beam 11, shown in dotted line, is equal to about double the grid constant of the raster division. Accordingly, in an ideal alignment (as shown at the left hand side of FIG. 2) five diodes are encompassed by the beam 11 while in the least favorable alignment (as shown at the right hand side of FIG. 2) only four diodes are encompassed by the beam 11. Disregarding the fact that the target surface area covered by such diodes 3*a* is unfavorable, the relationship between such alignment, assuming a uniform illumination, results in a brightness fluctuation of about 25 percent. This degree of fluctuation is generally unacceptable.

While a possible solution to such a problem might appear present in merely enlarging the dimension of the target and the diameter of the electron beam, it must be noted that such modification results in diminishing the resolution power. On the other hand, brightness fluctuation would increase catastrophically if only the electron-beam diameter was decreased, since then a modulation of up to 100 percent would result.

FIG. 3 illustrates a somewhat schematic cross-sectional view of a portion of a target structure 10 constructed and operated in accordance with the principles of the invention.

The vidicon target structures of the invention are produced in accordance with the Mesa-technique. A light-permeable n-conductive signal plate 1*a*, exemplarily composed of Si, is suitably provided with a layer 18 of a suitable p-conductive material, such as by evaporation or the like. In this manner, a distinct plane-like pn-junction 15 is formed along the target surface of the structure 10. Thereafter, a conductive metal, such as a noble metal, for example gold, platinum or the like, is suitably provided as an array of discrete individual metal island 17. Metal island 17 can be provided by the use of a mesh-wire mask or grid (not shown) applied to the target surface prior to the evaporation of a conductive metal, with subsequent removal of such mask; or islands 17 can be provided by a technique similar to the one utilized for the production of rasters in iconoscopes whereby a conductive metal, such as silver, is provided as a continuous coating and then disrupted or torn-up into a large number of irregularly shaped metal islands forming a mosaic on the target surface.

In certain instances, such as when a non-etch resistant metal is utilized, i.e., silver, to provide the metal islands, it is desirable to provide (galvanically) a protective coating (not shown) of an etch-resistant material, such as gold, platinum or the like onto such islands prior to etching. This latter means of providing distinct metal islands yields a target surface area having a very high percentage thereof covered by diodes 17*a* and thus allows the production of a target structure having a very high resolution power with a very low brightness fluctuation.

After the array of metal islands 17 has been provided, a matching array of grooves 19 are provided between the various distinct island 17 so as to define an array of discrete diodes 17*a*. The grooves 19 are relatively narrow and deep. The grooves 19 have somewhat concave peripheral side walls so that the distance between opposite walls is sufficient to insulate the individual pn-junctions (or diodes). The depth of the grooves 19 extends sufficiently through p-conductive layer 18 and into the body of signal plate 1*a* to insure that a complete separation or cleavage of the plane pn-junction 15 occurs at the groove areas and provides an array of individual diodes 17*a*. The grooves 19 are provided, for example, by an etching process utilizing, for example, a mixture of hydrofluoric acid and nitric acid. As shown on the drawings, the grooves 19 each have a relatively narrow mouth portion with interconnecting concaved peripheral walls. The concave walls of grooves 19 are coated with a layer 12 of an insulator material, such as SiO_2 formed by an anodic oxidation during a gas discharge.

In the embodiment wherein a mesh grid or mask is utilized to provide the discrete individual metal islands, the mask is preferably selected so as to have extremely thin wires having diameters of only a few microns (i.e., μ). In the preferred embodiment, the mask is so selected as to provide a linear distance ratio of about 1:5 to 1:10 of the groove axial dimension to the diode axial dimension. In other words, the groove areas define only about 10 to 20 percent of the target surface area while the diode areas define about 80 to 90 percent of the target surface areas.

In a preferred embodiment, the mesh or mask structure is so selected that it provides metal islands having dimensions (i.e., a surface area), which as an average are only slightly smaller than the cross-section dimension or diameter of a scanning electron beam. In other words the electron beam diameter is adjusted to barely encompass the surface area of a metal island so as to provide a target structure having improved the solution power.

The insulator layers formed between the adjacent diode of the invention are preferably produced by means of an anodic oxidation in a gas discharge.

In the embodiment wherein a mask is utilized to define the discrete metal islands during the evaporation of a conductive metal, generally only metal island configurations of a geometrically regular shape, i.e., rectangular, hexagonal, etc., are provided. However, even in their simplest shape, i.e., rectangular, the target surface area covered thereby yields a much better covering factor as compared to the circular shape provided in accordance with the Planar technique.

In the embodiment wherein the irregular mosaic metal islands are provided, a coherent or continuous metal layer, such as silver, is applied to the p-conductive layer without the use of any mask. Thereafter, this continuous metal layer is thermally split or torn open in a known manner, such as exemplified in the production of rasters for iconoscopes. This method produces metal islands having highly irregular shapes which provide an extremely high covering factor on the target surface area. However, a silver mosaic of such metal islands is not sufficiently etch or acid resistant to allow the production of the grooves. Accordingly, such non-etch resistant islands are galvanically covered or strengthened by the use of an electrolytical known process wherein a suitable etch-resistant material, such as gold, platinum or the like is applied as a protective layer on top of the silver islands. This method of providing metal islands on the target structure is extremely advantageous since it is relatively simple and economical, and provides a highly increased resolution power due to the high covering factor of the metal islands and does not produce any interfering effect or brightness fluctuations.

The target structures of the invention have extremely favorable properties for the operation of camera tubes, for example a Si-diode vidicon tube. When compared to prior art target structures (i.e., FIGS. 1 and 2) the target structure of the invention has a much greater utilizable effective surface area, as best seen at FIG. 4. In accordance with the invention, the electron beam **11** (shown in dotted line) is selected to have a diameter of about 17.5 μ so as to just encompass the surface area of one of the metal islands **17**. As can be visualized from the showing at FIG. 4, this relation insures that even maximum modulation is less than about 10 percent. The relatively fine groove axial dimension of openings **19** and the relatively large useful surface areas of the diodes **17***a* provide a resolution factor of two on equal grid constants as compared with the relatively small round useful surface areas of diode members **3***a* formed with the Planar methods.

In accordance with the principle of the invention, one can easily comply with the normal or common television standard of 625 by utilizing a number of one million cells (i.e., diodes) and a grid constant of about 12 μ. With the target structure of the invention the maintenance of a particular electron beam diameter is much less critical since it is only be decreasing the beam diameter to about 3 μ that a modulation of up to 100 percent would result.

One of the principle advantages of utilizing the described mesa-like configurations of islands **17** is that the formation of interfering capacitance is avoided. The configuration provided by the invention allows a scanning electron beam to primarily strike metal surfaces (of islands **17**) and thereby directly discharge the individual diodes **17***a*. In those instances where an electron passes through the mouth of a groove **19** and strikes the surface of insulator layer **12**, the portion of the current influenced thereby is very small in spite of the strong negative potential present at such insulator layers. Such negative potential cannot cause an interfering effect at the target surface to a slow scanning electron impinging thereagainst, since it is confined within the groove. Storage capacitances such as that occurring with the prior art structures at the ring-like edges of the diode recesses are avoided with the target structure of the invention.

Another advantage of the invention resides in the excellent protection for the individual mesa-like diodes **17***a* from all types of pollution by the protective metal islands. Of course, this protection is established relatively early during the production of the diodes and is then continuously present. The mesa-type diode configuration also insures that relatively large distances are provided therebetween with regard to a mutual influencing of respective space-charge clouds. Accordingly, the rastering is adjustable, if desired, to such a fine size that it is much smaller than the finest rastering available with prior art Planar techniques.

A practical means of achieving such fine rastering is by the utilization of a fine grid mask in the method embodiment utilizing the same. In that instance, the suitably sized grid mask is applied directly to the target surface of the Si-plate (i.e., signal plate) in a known manner and then removed after the evaporation of a suitably conductive metal.

Another practical means of achieving even finer rastering is by the application of a thermally torn or split metal mosaic in accordance with the method embodiment utilizing the same. In this instance, the formed p-conductive layer (i.e., as by diffusion of B or the like) and which is suitably doped, defines the surface of the Si-plate and is covered or coated with a continuous layer of a suitable metal, such as silver, without the use of any mask or the like. The silver coating is then thermally disrupted into a very large number of irregularly shaped completely separated metal islands so as to provide a metal mosaic on the target surface. The destruction of the silver coating is similar to that utilizaed in the production of raster for iconoscopes.

In certain instances, the metal applied for the mosaic production as described is insufficiently etch-resistant and must be provided with a suitable etch-resistant protective coating. Such protective coating is readily provided by galvanic application of a suitable metal, such as gold, platinum or some similar material. The metal mosaic thus produced covers a very large area of the target surface (i.e., has a large covering factor) and thus provided a very high resolution power with very low brightness fluctuation.

The semiconductor-type diodes of the invention are composed of materials both from the III–V groups and the II–VI and are particularly useful as connecting semiconductors.

The invention is very versatile and finds a wide area of usage, over and beyond the described embodiments.

In general, some of the principal advantages of the target structure of the invention are: that plane-like pn-junctions are provided, which lessens the danger of a break-through or a short circuit of the pn-junctions at points or areas of curvature; that no additional semiconductor layers (i.e., equalization layers) are required for the elimination of interfering loads or potentials; that improved spacing of the pn-junctions of the individual diodes is achieved; that extremely fine rasters are utilizable; and that improved resolution power is achieved by the improved covering factor and the smaller electron-beam diameter which is utilizable, in comparison with the prior art structure.

In summation, the invention provides a storing light sensitive target structure for camera tubes, such as semiconductor-type diode vidicon tubes having a plurality of layers each having different conductivity so as to define individual diodes having pn-junctions which are insulated from one another arranged on a light-permeable n-conductive semiconductor signal plate wherein the pn-junctions are of a plane configuration sufficiently separated from one another by relatively deep grooves to define discrete large surface area diodes, which are covered with a corresponding sized insulated metal island.

In terms of construction, the target structure of the invention comprises a n-conductive signal plate having a plane target surface with an array of grooves extending below such surface. The target surface areas between the grooves have a p-conductive layer thereon so that plane pn-junctions form and define an array of individual diodes. The p-conductive layer extends slightly beyond the peripheral side walls of each of the grooves and this layer is coated with a conductive metal so that the metal coating extends somewhat further beyond the peripheral side walls of each of the grooves but does not close or block the mouths thereof. The side wall portions of the signal plate and the p-conductive layer exposed within the grooves have a coating of insulator material thereon. The total effective surface area of the plurality of individual diodes is equal to about 80 to 90 percent of the target surface area while the surface area of the groove mouths only equals about 10 to 20 percent of the target surface area.

In terms of production, the invention comprises forming a layer of a p-conductive material onto a plane target surface of a n-conductive signal plate and then providing an array of distinct metal islands or the like of a given surface area on such p-conductive layer. Thereafter a corresponding array of grooves are etched between the metal islands for a depth sufficient to provide plane pn-junctions and define mesa-like individual diodes having an effective surface area corresponding to the area of the metal islands. The peripheral groove walls are coated with an insulator layer. The diodes are of regular or irregular size depending upon the configuration of the metal islands provided and provide a scanning beam an effective target surface that is substantially larger than the exposed insulator layer surface.

In somewhat different terms, the invention provides an electron beam storage light-sensitive target structure for a camera tube comprised of a n-conductive signal plate having a target surface. An array of grooves are provided on this surface spaced from one another and extend below the surface. An array of mesa-like p-conductive regions are provided on the target surface between each of the grooves so that each of the mesa-like regions define with the underlying target surface a plane pn-junction. A layer of a conductive metal is provided on each of the mesa-like regions and a layer of an insulator material is provided along the peripheral walls of the grooves. The invention also provides methods of producing such target structures comprising forming a p-conductive layer onto a target surface of a n-conductive signal plate so that a plane pn-junction is formed at the interface of the layer and the target surface; providing an array of discrete conductive islands on the p-conductive layer of the target surface and etching grooves between the discrete islands so as to define individual diodes on the target surface, and then coating the peripheral walls of the openings with an insulator layer.

Various modifications and alterations can be effected as desired without departing from the scope and spirit of the novel concepts of the present invention.

I claim

1. An electron beam storage light-sensitive target structure for a camera tube comprising a n-conductive signal plate having a target surface, an array of grooves on said target surface having peripheral walls and extending below said target surface, an array of p-conductive regions each having a plane surface on said target surface between each of said grooves, each of said p-conductive regions defining with the underlying target surface a plane pn-junction, a layer of a conductive metal on the plane surface of each of said p-conductive regions to define a plane uppermost target surface, and a layer of an insulator material on the peripheral walls of said grooves.

2. An electron beam storage light-sensitive target structure as defined in claim 1 wherein the p-conductive regions have a larger surface area exposed to a scanning electron beam than the similarly exposed surface area of the grooves.

3. An electron beam storage light-sensitive target structure as defined in claim 1 wherein the grooves have concave peripheral walls terminating in a relatively narrow mouth portion and the p-conductive regions have peripheral side edges which extend over said concave walls of the grooves.

4. An electron beam storage light-sensitive target structure as defined in claim 1 wherein the ratio of an axial linear dimension of a groove to an axial linear dimension of a p-conductive region is in the range of about 1:5 to 1:10.

5. An electron beam storage light-sensitive target structure as defined in claim 1 wherein each of the p-conductive regions have a surface area of a size that is at least encompassed by the diameter of a scanning electron beam.

6. An electron beam storage light-sensitive target structure as defined in claim 1 wherein the p-conductive regions have a geometrically regular surface configuration.

7. An electron beam storage light-sensitive target structure as defined in claim 1 wherein the conductive metal layer has a geometrically irregular surface configuration.

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