(19)

PATENT SPECIFICATION (11) 1237695

1237695

DRAWINGS ATTACHED

(21) Application No. 40218/68 (22) Filed 22 Aug. 1968
(31) Convention Application No. 6711759 (32) Filed 25 Aug. 1967 in
(33) Netherlands (NL)
(45) Complete Specification published 30 June 1971
(51) International Classification H 01 I 15/00
(52) Index at acceptance
H1K 219 243 248 279 285 311 312 315 317 345 34Y
37X 37Y 412 41Y 424 441 460 514 578 579

(54) PHOTOSENSITIVE DEVICES

(71) We, PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2., a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

THIS INVENTION relates to photosensitive devices comprising a layer consisting of photosensitive grains which cohere by means of an insulating binder, said layer having a thickness of substantially one grain, and electrodes on said layer.

Photoresistors are known having a layer of a photosensitive material, in many cases an $A_{II}B_{VI}$-compound, for example, cadmium sulphide, two electrodes being arranged on the layer and having connection conductors secured thereto. For mass production purposes it is desirable that these electrodes, to which connection conductors are secured, are located on the same side of the layer.

In a known form of photosensitive device the layer consists of a so-called monograin layer, which is a layer of grains, thickness substantially one grain, in which the photosensitive grains cohere by means of an insulating binder. In controdistinction with other known photoresistors having a continuous photoconductive layer so that the electrodes can be located on the same surface of the layer, in a monograin layer photoresistor the electrodes and the connection conductors must be provided on opposite sides of the layer since the monograin layer does not show electrical conductivity in the lateral direction. In these devices at least one of the electrodes is permeable to radiation in the desired frequency range.

The fact that in these photosensitive devices the electrodes are located on opposite sides of the monograin layer may be disadvantageous from a point of view of manufacture. Series production of these devices would be considerably simpler and consequently cheaper if the two electrodes provided with connection conductors were located on the same side of the monograin layer.

According to the invention, a photosensitive device comprises a layer consisting of photosensitive grains which cohere by means of an insulating binder, said layer having a thickness of substantially one grain, at least two electrodes situated on one major side of the layer connection conductors secured on the said two electrodes on said one side of the layer, and an auxiliary electrode layer without a connection conductor on the opposite major side of the layer, the auxiliary electrode layer being permeable at least for a part of the frequency range of the electromagnetic radiation to which the layer of photosensitive grains is sensitive.

By the use of the auxiliary electrode the two main electrodes provided with connection conductors can be at the same side of the layer.

In a photosensitive device in accordance with the invention, a current which flows through the device will pass through the layer twice in a direction substantially at right angles to the major sides of the layer as a result of the addition of the auxiliary electrode layer. As a result of this the monograin layer thickness remains decisive for the effective distance of the electrodes; the actual distance between the electrodes is not critical and can be adapted without objection to the method of manufacture.

Furthermore in a device in accordance with the invention the breakdown voltage may be higher than in the known devices.

In addition the structure in accordance with the invention provides a compensating effect for undesired photoelectric and thermoelectric voltages. As the current flows through the layer first in one direction and then in the opposite direction, internal e.m.f.'s, if any, will occur both with one and the opposite polarity.

The auxiliary electrode layer being permeable enables the radiation to be incident

through the auxiliary electrode layer. The advantage of this is that the total surface area of the layer may be used as a photosensitive surface. In known photoresistors in which the electrodes are on the same surface, a part of the surface must be used for the connection of one or two connection conductors.

A further important advantage of the device structure in accordance with the invention is that the heat dissipation can be improved. In the first instance, the heat dissipation will have to take place through the connection conductors. When a connection conductor is to be secured to the surface on which the radiation is incident, the area required for said connection is minimized so as to be able to use the maximum part of the surface as a sensitive surface, as a result of which also the thermal contact between the connection conductor and the electrode is restricted. When using a transparent auxiliary electrode layer, a large area of the electrodes on the one major side of the layer may be used for securing the connection conductors so that the heat dissipation via said electrodes can be considerably improved.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawing, which shows diagrammatically a cross-sectional view of a photosensitive device in accordance with the invention.

In this example a photosensitive body 20 is constituted by a monograin layer 21, 22 which is a layer of photosensitive grains 21, having a thickness of substantially one grain, the grains cohering by means of an insulating binder 22. The grains 21 consist, in this example, of cadmium sulphide which is doped with 0.1 to 0.01 at .% of copper. The diameter of the grains is approximately 40 μm. The insulating binder 22 is a polyurethane resin and extends only over part of the layer thickness so that parts of the grains 21 project from the binder as a result of which contact with the electrodes 23 and 24 and an auxiliary electrode layer 25 is possible. The electrodes 23, 24 are provided with connection conductors 26 and 27 in a conventional manner. The auxiliary electrode layer 25 is not provided with a connection conductor, that is to say not with a connection conductor which is meant to set up a bias voltage at the auxiliary electrode layer.

The electrodes 23, 24 consist, in this example, of indium and have a thickness of approximately 0.3 μm. The auxiliary electrode layer 25 is an indium layer of 100 Å thickness and the device may be provided in a conventional manner with an envelope commonly used for a photosensitive device which envelope may consist, for example, of an embedding of a synthetic resin.

In a circuit arrangement which employs a photosensitive device in accordance with the invention, a potential difference is set up between the electrodes 26 and 27. The auxiliary electrode layer 25 is floating, that is, it is not connected to such a point in a circuit which would cause it to assume a potential which is different from that which it would assume in the absence of the said connection.

Many variations are possible to those skilled in the art without departing from the scope of this invention as defined in the appended claims. For example, other materials may be used. The electrodes may consist of aluminium or another commonly used electrode material. As photosensitive materials are to be considered in addition to cadmium sulphide, materials such as silicon, selenides and tellurides or mixtures of photosensitive materials in which said materials may be doped in the conventional manner with normal impurities.

WHAT WE CLAIM IS:—

1. A photosensitive device comprising a layer consisting of photosensitive grains which cohere by means of an insulating binder, said layer having a thickness of substantially one grain, at least two electrodes situated on one major side of the layer connection conductors secured on the said two electrodes on said one side of the layer, and an auxiliary electrode layer without a connection conductor on the opposite major side of the layer, the auxiliary electrode layer being permeable at least for a part of the frequency range of the electromagnetic radiation to which the layer of photosensitive grains is sensitive.

2. A photosensitive device as claimed in Claim 1, wherein the photosensitive grains consist of an $A_{II}B_{VI}$-compound.

3. A photosensitive device, substantially as herein described with reference to the accompanying drawing.

4. A circuit arrangement comprising a photosensitive device claimed in any of the preceding claims and means to apply a potential difference between the said two electrodes on the one major side of the layer, the auxiliary electrode layer being at a floating potential.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1971.
Published by The Patent Office, 25 Southam pton Buildings, London, WC2A 1AY, from which copies m ay be obtained.

through the auxiliary electrode layer. The advantage of this is that the total surface area of the layer may be used as a photosensitive surface. In known photoresistors in which the electrodes are on the same surface, a part of the surface must be used for the connection of one or two connection conductors.

A further important advantage of the device structure in accordance with the invention is that the heat dissipation can be improved. In the first instance, the heat dissipation will have to take place through the connection conductors. When a connection conductor is to be secured to the surface on which the radiation is incident, the area required for said connection is minimized so as to be able to use the maximum part of the surface as a sensitive surface, as a result of which also the thermal contact between the connection conductor and the electrode is restricted. When using a transparent auxiliary electrode layer, a large area of the electrodes on the one major side of the layer may be used for securing the connection conductors so that the heat dissipation via said electrodes can be considerably improved.

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The electrodes 23, 24 consist, in this example, of indium and have a thickness of approximately 0.3 μm. The auxiliary electrode layer 25 is an indium layer of 100 Å thickness and the device may be provided in a conventional manner with an envelope commonly used for a photosensitive device which envelope may consist, for example, of an embedding of a synthetic resin.

In a circuit arrangement which employs a photosensitive device in accordance with the invention, a potential difference is set up between the electrodes 26 and 27. The auxiliary electrode layer 25 is floating, that is, it is not connected to such a point in a circuit which would cause it to assume a potential which is different from that which it would assume in the absence of the said connection.

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