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PROCESS OF PREPARING GALLIUM SULFIDE FLAKES AND PHOTOCONDUCTIVE DEVICE USING SAME

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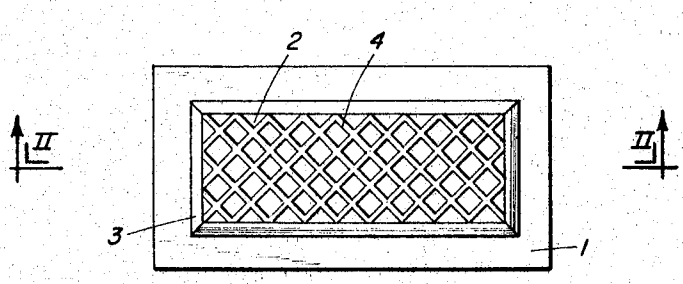


Fig - 1

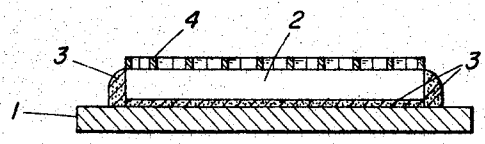


Fig - 2

INVENTORS.
EMANUEL MOOSER
HANS-ULRICH BOELSTERLI
BY
John E. Hanrahan
ATTORNEY

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PROCESS OF PREPARING GALLIUM SULFIDE FLAKES AND PHOTOCONDUCTIVE DEVICE USING SAME

Emanuel Mooser, Geneva, and Hans Ulrich Boelsterli, Vesenaz, Switzerland, assignors to American Cyanamid Company, Stamford, Conn., a corporation of Maine

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This invention relates to photoconductive devices, as for example photoconductive cells.

As is well known, a photoconductive material is one whose electrical conductivity is increased by the absorption of light. A photoconductive material is to be distinguished from a photovoltaic material in that in the latter absorption of light results in the generation of a voltage.

Photoconductivity and in particular photoconductivity of solids is an area that recently has been the subject of intense investigation, although photoconductive materials and devices employing same are generally known. Thus, for example, in the field of duplicating or reproduction, important commercial devices employing photoconductive devices are widely used, e.g., amorphous selenium in the Xerox process. While many of the known photoconductive materials and devices are generally suitable for particular end uses, there are areas where improvements are most desirable.

Thus, many materials which may be described as being photoconductive have specific resistance and sensitivity ranges which render them unsuitable or undesirable for certain specific end applications. Accordingly, new photoconductive materials which are characterized by different resistances and sensitivity ranges than known materials open up new areas for the adaption of processes involving photoconductivity.

Some materials demonstrating photoconductive properties are not available in a physical form whereby they may be readily employed in photoconductive devices or may not be readily employed without substantial and economically wasteful losses of such material in preparation of said devices. Thus, for example, for many photoconductive devices it seems most desirable for the photoconductive material to be in the form of thin plates, flakes or sheets and to be characterized by a molecular structure which enables it to be readily employed in the making of photoconductive devices of large area but small volume.

Thus, it is the principal object of the present invention to provide photoconductive devices in which the photoconducting material is ideally adapted both as to photoconductivity values and physical properties to employment in photoconductive devices.

A still further object of this invention is to provide photoconducting devices employing a photoconductive material whose crystal habit is such that it may be readily worked with and employed in the preparation of photoconductive devices without the loss of substantial amounts of material.

These and other objects and advantages of the present invention will become more apparent from the detailed description thereof set forth hereinbelow.

In accordance with the present invention a photoconductive device is provided which comprises a pair of conductive elements at least one of which is at least partially transparent or light transmitting and having positioned between said elements as a photoconductive material, flakes of gallium sulfide.

The photoconductive device may, for example, be any of the devices employing photoconductive materials which are available today. Thus, for example, the device may

be any of the various duplicating or copying equipment employing photoconductive elements, photoconducting pick-up tubes, image converters such as X-ray imaging tubes, light meters, and the like.

The conductive elements may be metallic plates, films, conductive films on insulator plates or base materials and the like. Regardless of their nature, at least one of these conductive elements must be at least partially transparent or light transmitting so that the photoconductive element is subject to excitation by light. It will be apparent that both of the conductive elements may be at least partially transparent and preferably fully transparent and that they may be plates, grids, or films and may be in direct contact with the gallium sulfide photoconductive layer or they may be associated with said layer through various conductive adhesive materials as will readily suggest themselves to those in the art.

The accompanying drawing will illustrate the present invention.

FIGURE 1 is a top plan view of a simple photoconductive cell.

FIGURE 2 is a sectional view along the line 2—2 of FIGURE 1.

Referring to the drawing, a plate 1 of suitable conductive material such as copper has bonded thereto thin flakes 2 of photoconductive gallium sulfide, said flakes being bonded by means of a layer 3 of conductive paste or adhesive type material such as a silver paste. Positioned on top of the flakes of gallium sulfide in a grid 4 which is formed of a suitable conductive material such as silver paste.

The following example is given primarily by way of illustration. No specific details or enumerations contained therein should be construed as limitations on the present invention, except insofar as they appear in the appended claims.

EXAMPLE

Gallium sulfide in flake form, ideally suited for use in photoconductive devices such as described above, may be prepared by what is termed a transport reaction. In such a reaction, a sealed quartz tube approximately one foot long and an inch and one-half in diameter has positioned at one end a fixed amount of gallium sulfide in the presence of a fixed amount of iodine. At this one end the temperature is maintained illustratively at 910° C. The mixture of gallium sulfide and iodine is heated for a period of 48 hours and at the opposite end of the tube which is maintained at a lower temperature, typically 840° C., single crystals or flakes of gallium sulfide are formed which are ideally suited for use in the photoconductive devices of the type illustrated and described above.

Typically in such a preparation five grams of gallium sulfide in admixture with five milligrams of iodine will yield one gram of flaked gallium sulfide after 48 hours under the conditions specified above. Crystals or flakes prepared in this manner are typically 10^{-1} to 10^{-2} millimeters thick and 5 x 5 in area, although crystals as large as 2 centimeters and larger have been prepared. In general, crystals may be prepared which are as large as the transport reactor employed.

In carrying out the transport reaction the temperatures employed at both ends of the reactor are below the melting point of the gallium sulfide. The temperature at those portions of the reactor in which the crystals are forming is normally less than at portions where the nutrient gallium sulfide is being heated. In this connection, the halogens, i.e., chlorine, bromine and iodine, are excellent transport reagents readily forming vaporous gallium halides which decompose at the cooler portion of the reactor or tube in the presence of sulfur to form

the desired flakes of gallium sulfide. It is believed that these reagents and in particular the halogens are present in the resulting crystals inherently and by virtue of their presence the photoconductive properties of gallium sulfide are improved. Usually they will be present in from trace amounts up to amounts of about 1% by weight.

Flakes of these dimensions form readily because of the unusual nature of the molecular structure of gallium sulfide and enable full use to be made of the photoconductive properties of the material. Since the light absorption which is responsible for the generaton of charge carriers (i.e. the photoconductive current) occurs primarily near the surface of the material, the maximum change in conductivity between the dark and the illuminated condition is to be expected when the largest possible surface to volume ratio can be presented to the source of the light. This can be achieved with some difficulty in other photoconductive materials by elaborate processes, but in gallium sulfide the crystal habit provides the desired geometrical situation quite well as a result of nature.

The electrodes of a photoconductive device of the type referred to in the drawings above, employing flakes of gallium sulfide prepared as described above, were connected to a source of D.C. voltage. Employing suitable measuring equipment, in the dark, a resistance larger than 10^{11} ohms was observed. Upon exposure of this device to the light in ordinary room light (not in direct sunlight) the resistance dropped to 10^{7} ohms when subjected to the identical voltage. Such measurements have readily established the highly sensitive photoconductive nature of the device and the usefulness of gallium sulfide in photoconductive devices.

We claim:

1. A process for preparing gallium sulfide in flake form, suitable for use in photoconductive devices, which comprises heating in an area of a transport reaction vessel gallium sulfide in the presence of a halogen transport reagent and at a temperature below the melting point of gallium sulfide and collecting said gallium sulfide in a second area of said vessel said second area being initially free from gallium sulfide at a temperature below the melting point of gallium sulfide and below that at which the gallium sulfide is heated in said first area of said reaction vessel.

2. Single crystals consisting solely of gallium sulfide grown by the transport reaction process of claim **1**.

3. A photoconductive device comprising a pair of conductive elements, at least one of which is light transmitting, having positioned therebetween as a photoconductive material flakes of gallium sulfide, grown by the transport reaction process of claim **1**.

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MURRAY KATZ, *Primary Examiner.*

WALTER STOLWEIN, RICHARD D. NEVIUS, *Examiners.*

J. P. McINTOSH, *Assistant Examiner.*