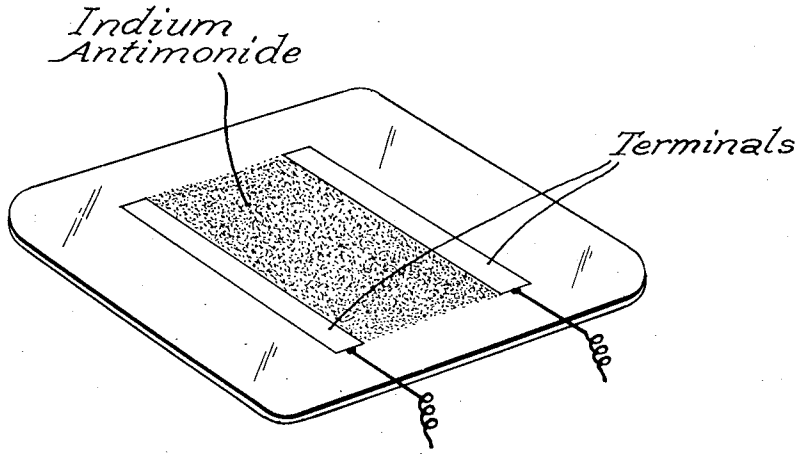
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PHOTOCONDUCTIVE CELL

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PHOTOCONDUCTIVE CELL

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1 Claim. (Cl. 201—63)

(Granted under Title 35, U. S. Code (1952), sec. 266)

This invention may be used by or for the Government for governmental purposes without the payment to us of any royalty thereon.

The invention described herein relates to the photoelectric art and more particularly to a photoconductive cell utilizing a novel photosensitive element.

It is accordingly a broad object of our invention to provide a novel photoconductive cell.

It is a more specific object of our invention to provide a photoconductive cell which will respond to radiation in the infrared region.

It is a still more specific object of our invention to provide a photoconductive cell which will respond to radiation in the region of the infrared spectrum beyond 5μ.

Other objects and advantages will be obvious from the following description.

The single figure of the drawing illustrates an isometric view of an embodiment of the invention.

In the last few years, particularly because of the wartime military applications, there has been a considerable effort to develop photosensitive elements that would respond to radiation in the infrared region of the spectrum, the most desirable region being at wavelengths between 8 and 14μ where the atmospheric absorption is low. The most promising photo cells for infrared work have been of the photoconductive type. The thallium sulphide cell, which was used in some numbers in our forces, responds only to wavelengths of 1.4μ or shorter; another recent discovery, the lead sulphide cell, goes to 3.6μ. Since the war, a lead telluride cell that extends the range to ca. 8.0μ has been developed, largely by the British at the Telecommunications Research Establishment, and at Northwestern University in the United States.

The theory of these cells is not well understood, but apparently their sensitivity is not due to a true intrinsic photoconductivity in which each incident photon raises one electron from the filled to the conduction band, but rather it is a grain boundary effect depending very sensitively on the mode of preparation, especially the exposure to oxygen. While this requires a cookbook procedure in the cell manufacture and necessitates keeping the film inside a vacuum tube, it does have a compensating benefit in that the quantum efficiency, the number of electrons transferred per incident photon, is much greater than the unity expected for an intrinsic photoconductor, being of the order of 10^3. This gives a great sensitivity to the cells. In regard to the spectral response, there is evidence that the energy required from the photon to transfer the electron across the grain boundary is determined by the energy gap observed for intrinsic conduction so that the primary requirement for a far infrared photoconductor is that it have a very small energy gap, circa 0.1 electron volts, between the filled and conduction bands. At the start of our investigation only one semiconductor was known for which this is true, namely grey tin.

We have noticed the striking similarity in crystal structure and lattice constant of the compound indium antimonide, InSb, and grey tin. They are, in fact, identical except for the alternation of indium and antimony in the compound structure, making it of the ZnS type, while grey tin has the diamond lattice. In addition, the trivalent indium combined with pentavelent antimony will produce an average electron density corresponding to the tetravalent tin, and, since the atomic radii of In, Sb and Sn are almost the same, a strong similarity in the band structure may be anticipated. This physical resemblance suggested a possible similarity in the electrical and photo properties.

The intermetallic compound indium antimonide, InSb, was prepared by melting together stoichiometric amounts of commercial indium and Baker's analyzed grade of antimony in a vycor vessel evacuated to a pressure of ca. 10^{-6} mm. Hg. The best results were obtained if the melt was heated for several hours at about 850° C. This material, InSb, was previously prepared in essentially this manner and its crystal structure determined. The appearance of the resulting material is very much like germanium, i. e. shiny, dark grey, and it is very brittle as is germanium.

The first photo cell was made with a supporting means in the form of a small Dewar flask circa 1" O. D. and 3" long. A small heater and crucible is in the vacuum so that a small amount of InSb may be vaporized and condensed onto the vacuum side of the inner wall of the Dewar near the bottom. Aquadag electrodes were previously painted on this wall and electrical leads brought out. A similar arrangement is conventional and used in the preparation of some types of lead sulphide photo cells. The cell was of pyrex glass. After evaporating a layer of InSb onto the space between the electrodes, the resulting cell was tested for photo response to visible light with the cell at liquid nitrogen temperature and a conclusive observation of photo conduction was noted. It should be noted that the type of cell used is well known in the art and no novel features are here present. See for example T. S. Moss "Photoconductivity in the elements;" Butterworth's Scientific Publications, London 1952.

Three series of measurements were made of the temperature variation of resistance of the cell. These measurements indicated that the material was an extrinsic semiconductor at temperatures below 350° C.; above this temperature the material entered its intrinsic range. The slope of the plot of log R vs $1/Tk$ where R is the resistivity and Tk is the absolute temperature indicates an activation energy for conduction of 0.11 e. v. This is important because it means that photons of energies equal to or greater than 0.11 e. v. can excite an electron from the filled to the conduction band of the material giving rise to photoconductivity. A photon with this energy corresponds to light with a wavelength of 11μ.

A number of evaporated films of InSb on glass supporting means were prepared as shown on the drawing. These films ranged from 0.2 to 12μ in thickness and, when leads were soldered to them, had resistances of from 20,000 to 10 ohms. The thickest of these films showed a photoconductive response at room temperature in air when illuminated through a filter that transmits only wavelengths between 2.0 and 2.3μ.

A second group of evaporated films have been prepared. These films were evaporated onto glass slides on which aquadag electrodes had been previously applied. The resistance of the cell was measured during the course of evaporation and cells with desirable high resistances obtained. One such film with a resistance of 1 megohm in vacuum was found to increase in resistance to 1.5 megohm after exposure to air, indicating some effect of the oxygen on the film. This film was tested for photo response and a considerable effect was found at room temperature in

air with visible light, radiation transmitted through the 2.0 to 2.3μ filter, and radiation from a metal body at circa 600° K.

In view of the above it will be seen that the several objects of the invention are achieved and other advantageous results attained.

We claim:

A photoconductive cell comprising a supporting means, a body of indium antimonide supported by said supporting means and two electrical terminals connected to said body and adapted to complete an electrical circuit through said body.

References Cited in the file of this patent

Zweistofflegierungen, 1943, page 826.