United States Patent [19]

Schulte et al.

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[45] **Date of Patent: Nov. 8, 1988**

[54] **RETICULAR DETECTOR ARRAY**

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[73] Assignee: **Santa Barbara Research Center**, Goleta, Calif.

[21] Appl. No.: **123,426**

[22] Filed: **Nov. 20, 1987**

[51] **Int. Cl.**[4] **H01L 25/00**; G01T 1/22; G01T 1/24

[52] **U.S. Cl.** **250/370.08**; 250/332; 357/30

[58] **Field of Search** 250/370, 371, 330, 331, 250/332, 333, 334, 352; 357/29, 30, 31, 32

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,087,687 5/1978 Bean 250/331

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Assistant Examiner—David Mis
Attorney, Agent, or Firm—W. C. Schubert; V. G. Laslo; A. W. Karambelas

[57] **ABSTRACT**

A detector assembly for reception of infrared radiation is formed as a composite structure of a detector array electrically connected by a set of contacts to a readout clip disposed on a backside of the assembly opposite a front side receiving incident radiation. Individual detectors are formed of layers of P-type and N-type semiconductor material, and are spaced apart from each other and from the readout chip by resilient electrically-insulating polymeric material which supports the detectors in their respective positions while allowing for thermally induced displacement of the detectors from their respective positions. A metallic grid on the front surface of the assembly provides a common electrical connection of the detectors to the readout chip. An antireflective coating may also be placed on the front surface of the assembly.

19 Claims, 3 Drawing Sheets

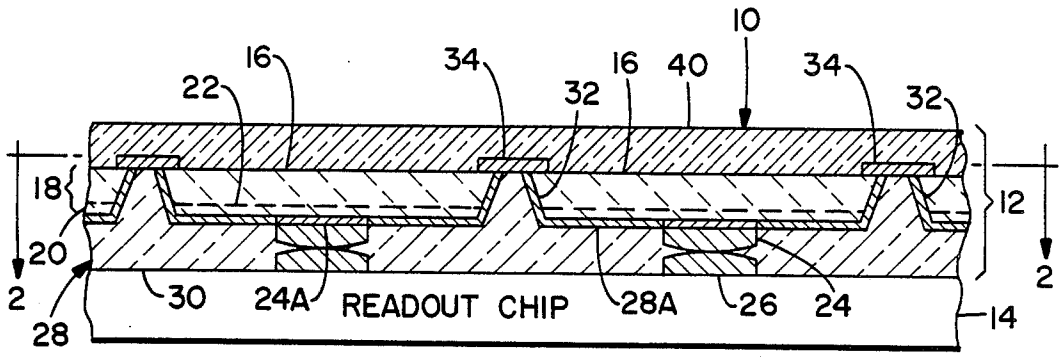


FIG. 1

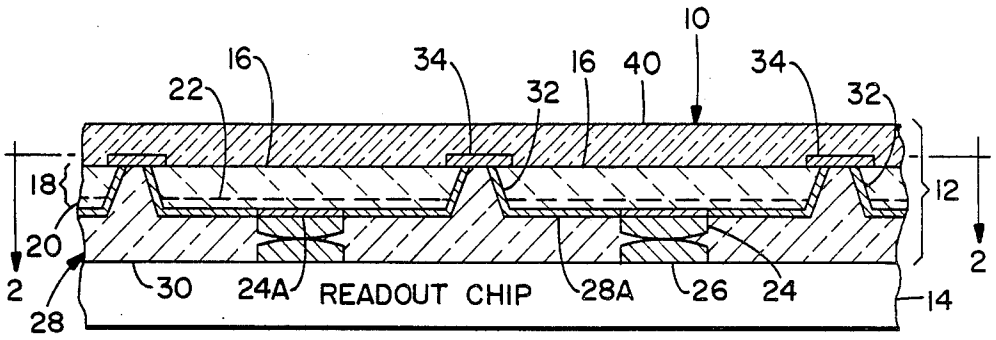


FIG. 2

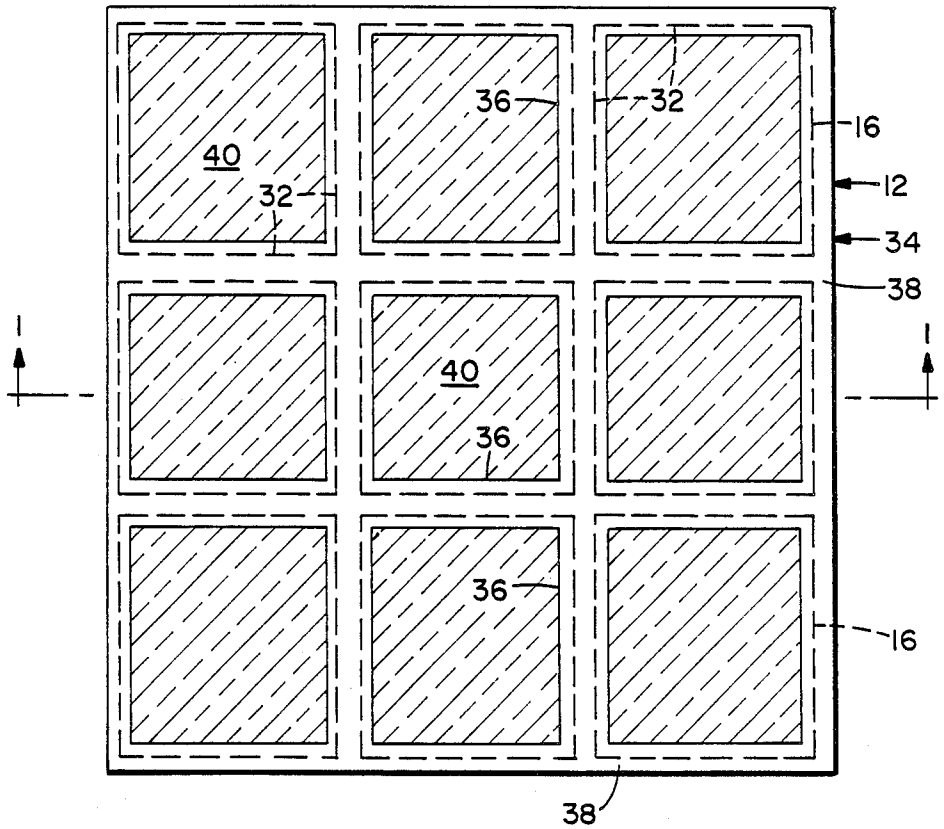


FIG. 3

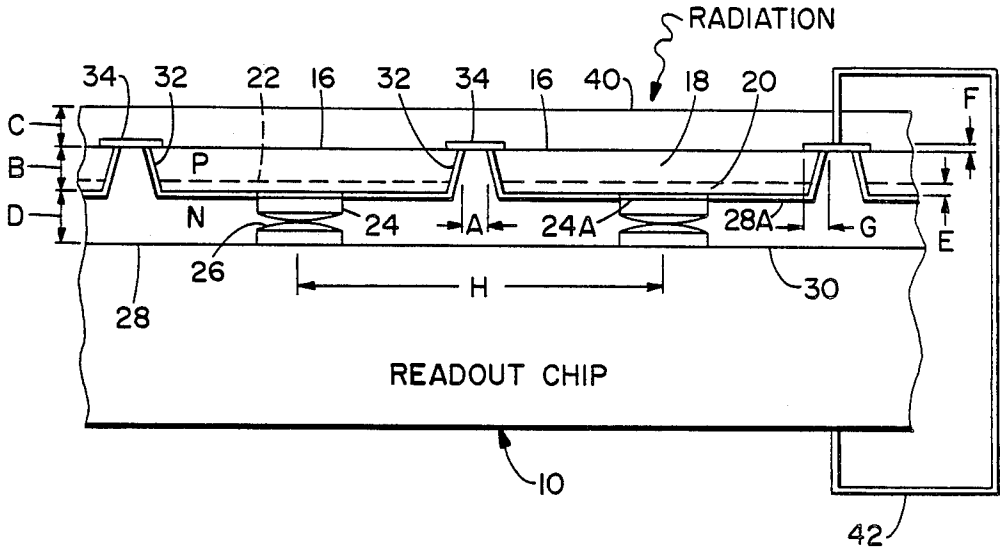


FIG. 4

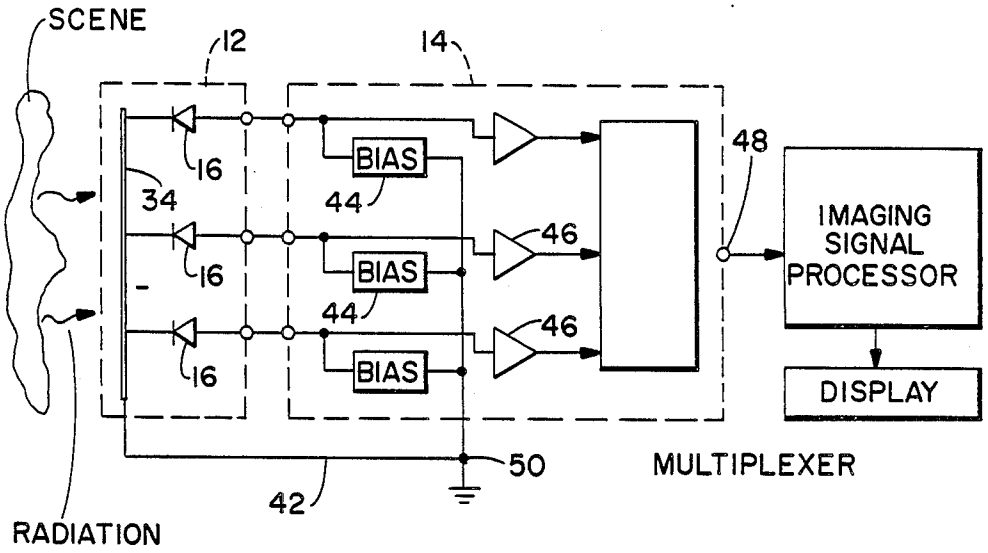


FIG. 5A

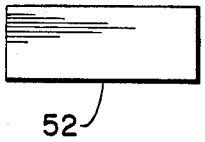


FIG. 5B

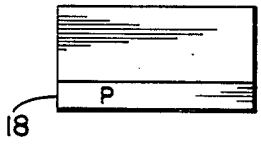


FIG. 5C

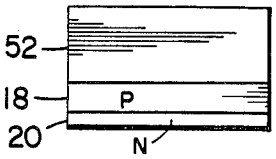


FIG. 5D

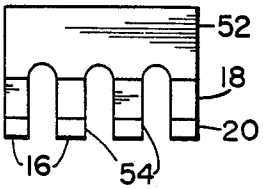
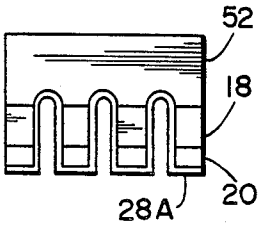


FIG. 5E



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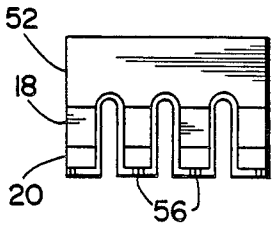


FIG. 5G

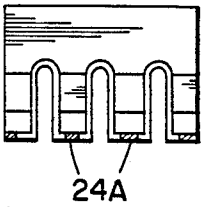


FIG. 5H

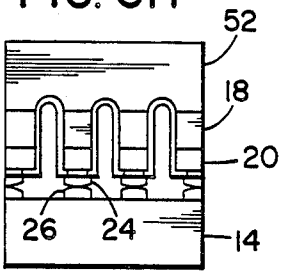


FIG. 5I

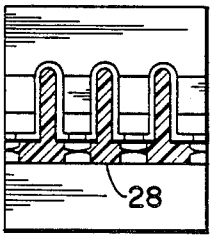


FIG. 5J

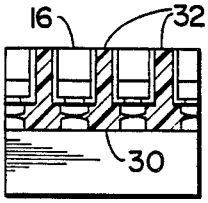


FIG. 5K

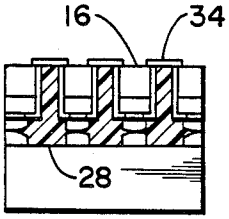
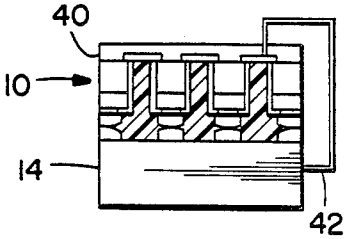


FIG. 5L



RETICULAR DETECTOR ARRAY

BACKGROUND OF THE INVENTION

This invention relates to the construction of an array of detectors suitable for imaging scenes emitting electromagnetic radiation and, more particularly, to the construction of a composite structure of a detector array and a semiconductor readout chip formed as a laminate with resilience to thermal expansion so as to permit thermal cycling for cryogenic operation without danger of inducing failures in metallic contacts between detector elements and the readout chip.

A detector array of particular interest is employed in the imaging of scenes emitting infrared radiation. Such detector arrays are operated at cryogenic temperatures, such as liquid nitrogen, during the detection of infrared radiation. Thus, there is always present a cycling of temperature between intervals of use and non-use of the infrared detector array. Such temperature cycling introduces expansion and contraction of components of the detector array, as well as in a semiconductor readout chip which is generally connected both physically and electrically to detectors of the array for extracting electrical signals from the detectors in response to the incident radiation.

One common form of construction of the infrared detector array provides for an electrically insulating substrate, such as a substrate of cadmium-zinc-telluride, upon which are grown epitaxially a P-type layer and an N-type layer of mercury-cadmium-telluride. The P-type and N-type layers of the mercury-cadmium-telluride provide a PN junction responsive to infrared radiation for introducing a current which varies in response to intensity of the radiation. The current is detected by circuitry of the readout chip. A composite construction of the laminate of the detector layers with the readout chip includes metallic contacts, typically of indium, which are located on both the detector array and the readout chip at the sites of terminals of the individual detector elements. As a practical matter in the construction of the indium contacts, the respective sets of contacts of the detector array and the readout chip are cold-welded together to form a permanent electrical and physical bond between the detector elements and the circuitry of the readout chip.

A problem arises in that the coefficients of thermal expansion of silicon, generally used in construction of the readout chip, the layers of the photodetector material and the substrate layer differ so as to introduce sufficient differential displacement between the indium contacts of the detector elements and the indium contacts of the readout chip to stress these contacts to the point of rupture. As a result, care must be employed in an environment of thermal cycling which may occur during use of the detector array so as to reduce a tendency to rupture. However, in spite of such care, contact rupture does occur with a resulting impairment of the utility of the detector array.

SUMMARY OF THE INVENTION

The foregoing problem is overcome and other advantages are provided by a construction of a composite structure of a laminated detector array and semiconductor readout chip. In accordance with the invention, individual ones of the detector elements are spaced apart and supported by a layer of resilient polymer material instead of the rigid crystalline semiconductor material employed heretofore. The polymer material envelops the indium contacts, and also surrounds the individual detector elements, except on the front face of the detector elements which is exposed to incident infrared radiation. The front faces of the detector elements contact the arms of a grid of electrically conducting material, such as metal, which forms a common return contact to the readout chip for all of the detector elements. While the polymer material has a different thermal coefficient of expansion than does silicon of the semiconductor chip, the resiliency of the polymer material absorbs any differential displacement caused by temperature variation, and thereby prevents significant buildup of stress in the indium contacts. Thus, the construction of an infrared detector array in accordance with the invention is able to withstand thermal cycling.

In accordance with a method of construction, the construction process begins by preparing a substrate of cadmium-zinc-tellurium which serves as a base upon which the detector layers are grown. In a preferred embodiment of the invention, a layer of mercury-cadmium-tellurium (HgCdTe), doped with arsenic to provide for a P-type characteristic, is grown epitaxially upon the substrate. This is followed by a further epitaxial growth of mercury-cadmium-tellurium doped with indium to provide an N-type characteristic. The foregoing two layers provide a PN junction and serve as the detector material. The detector material is then divided into an array of individual detector elements by etching troughs into the detector material all the way up to the substrate. Thereupon, the surface of the HgCdTe is covered with an insulating layer of silicon dioxide, and contact windows are etched through the silicon dioxide for subsequent contact metallization with a metal such a palladium.

The construction process continues with a building of an indium contact on each of the detector elements. Similar contacts are also provided at the terminals of a readout chip to be connected to the array of detectors. The resulting composite structure of substrate with array of detectors thereon is then electrically and physically connected to the readout chip by aligning the indium contacts of the array with the indium contacts of the chip, applying pressure and cold welding the two sets of contacts together.

In accordance with the invention, the construction process continues by filling in the voids between the readout chip and the detector array and the troughs between the detectors of the array with a resilient polymer material, such as silicone elastomer. The polymer material serves as a support and means for positioning the detectors in the array. The polymer material is electrically insulating and, therefore, serves to electrically insulate the individual detector elements from each other.

The construction procedure continues with a removal of the substrate by a milling operation or by chemical etching, the removal process being continued so as to remove a small portion of the detector material which lays at the interface with the substrate to remove any irregularities in crystal structure in the detector material. It is noted that the polymer material extends between the detectors up to the front face of the array of detectors. Thereupon, the metal grid is deposited on the front face of the array with the arms of the grid situate at the polymer material and having sufficient width to overlap edge portions of each of the detector

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