United States Patent Office

3,434,885

Patented Mar. 25, 1969

3,434,885

METHOD OF MAKING ELECTRICAL CONTACT ON SILICON SOLAR CELL AND RESULTANT PRODUCT

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No Drawing. Filed May 17, 1966, Ser. No. 551,846

Int. Cl. H01m *13/10*

U.S. Cl. 136—89 **7 Claims**

ABSTRACT OF THE DISCLOSURE

An electrode connection for a n on p silicon solar cell is made by depositing a layer of cerium on the surface of the cell and then depositing a layer of silver on the cerium. The solar cell with the two layers deposited thereon is then sintered at a temperature between 500° C. and 800° C.

Statement of government ownership

The invention described herein was made by employees of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

This invention is concerned with making an improved electrical contact to a surface of a semiconductor device. More particularly, the invention relates to the fabrication of an electrode connection for an improved n on p silicon solar cell.

Certain problems have been encountered with the electrical contacts on semiconductor devices. At least one surface of such a device is normally very smooth, and satisfactory contacts are difficult to achieve on such a surface.

It is important that the contact on a semiconductor surface be ohmic. That is, when an electrical potential is applied between any two surfaces to which contact is made and an electrical current is permitted to flow the voltage-current relationship should be linear and show no dependence upon the polarity of one surface with respect to the other. The contact-to-surface resistance should be as low as possible to minimize parasitic power losses. The contact should adhere strongly to the surface, and there should be no change in the electrical behavior of a contact during or after specified environmental device tests. The process for making the contact should neither degrade the characteristics of the device nor limit the surface contact to a small area.

In the past, semiconductor contacts were made by alloying a pellet or an evaporated deposit of a metal or a metal alloy into semiconductor surfaces. The semiconductor material would be heated to create the alloyed ohmic contact, and the depth to which alloying took place was controlled by varying the thickness of the evaporated deposit as well as the time and temperature of alloying. However, it was extremely difficult to make a satisfactory contact by this method to surfaces having p-n junctions less than one micron below the surface without shorting out the junction. This occurred when the alloy penetrated below the junction depth.

An additional problem encountered in making alloy contacts to the surfaces of silicon semiconductors was concerned with the attainment of a uniform contact. Silicon surfaces oxidize in air, and the surface oxide formed is not uniform. Therefore, the pellet or evaporated metal deposit does not lie on a silicon surface but on an oxide surface. When heat is applied to bring about the alloying, the pellet or deposited layer does not wet the silicon surface uniformly and a non-uniform surface contact results.

It has been suggested that an evaporated layer of silver could make an ohmic adherent contact to a smooth silicon surface if a layer of titanium was first evaporated onto the surface prior to the deposition of the silver. To assure strong adherence to the surface, the silicon is heated to a temperature below the alloying temperature of the silver-titanium-silicon. While the heating or sintering process does not produce any alloying, adherence of the contact is dependent upon the sintering temperature and the time at this temperature. The high temperatures of sintering required for good adherence of the silver-titanium contact degrades the junction characteristics of shallow junction devices.

Various modifications of conventional contacts have been proposed to produce satisfactory contacts on the smooth surfaces of semiconductor devices. However, each modification involved limitations and compromises between strength of adherence of the contact and degree of degradation of the junction characteristicse. The shallower the junction beneath the surface to which the contact is made, the more difficult it is to achieve a satisfactory contact.

These problems have been solved for silicon solar cells having extremely shallow p-n junctions by utilizing contacts prepared in accordance with the present invention. These contacts have a layer of a rare earth metal interposed between the surface of the semiconductor and a film of an electrically conducting metal.

It is, therefore, an object of the present invention to provide a method of fabricating a strongly adherent semiconductor contact which can be used on smooth surfaces having p-n junctions less than 0.5 micron below the surface without degrading the electrical characteristics and performance of the junctions.

Another object of the invention is to provide an improved semiconductor contact which utilizes a layer of cerium to react with an oxide layer on the semiconductor surface thereby insuring strong adhesion of the contact to the surface without changing the electrical characteristics of any junction below this surface.

Still another object of the invention is to provide an electrical contact for a semiconductor device in which rare earth metals or compounds are utilized to react on the semiconductor surfaces to obtain strong adhesion of non-alloyed contacts without degrading the characteristics of shallow p-n junctions below the surface.

These and other objects of the invention will be apparent from the specification which follows.

According to the present invention, a continuous layer of a rare earth metal is deposited onto the portion of the smooth surface of a semiconductor device where the electrode connection is to be made. This layer is deposited by thermal evaporation techniques which are well known in the art. A continuous layer of an electrically conducting metal is then evaporated onto the rare earth metal layer in a similar manner.

The semiconductor device with the two metal layers deposited thereon is then heated to an elevated temerature below that at which alloying occurs in an inert or a reducing atmosphere. This temperature is maintained for a period of about five minutes to sinter the metal layers. Various times and temperatures can be used. For example, temperatures in the 500–800° C. range for times of 5–60 minutes will produce satisfactory contacts.

In order to demonstrate the advantages of electrode connections fabricated in accordance with the present invention, silver-cerium contacts were made on n on p silicon solar cells having extremely shallow junctions. Silver-titanium contacts were also made on similar solar