PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Semiconductor Device

We, TEXAS INSTRUMENTS INCORPORATED, of 6000, Lemmon Avenue, Dallas, Texas, United States of America, a corporation organized and existing under the laws of the State of Delaware, United States of America, 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 semiconductor devices having a plurality of zones of opposite conductivity type, and more particularly to such devices which may operate as switches in electrical circuits, and still more particularly to such switch devices which exhibit a thyratron-type activity.

The widespread and increasing tendency of the industry to supply complex electromechanical equipment which is transistorized has given rise to a need for transistor switches which operate the various output components of such equipment, for example relays.

It is an object of this invention to provide a semiconductor device which exhibits thyratron-like characteristics, and which is capable of operation as a switch in a unique manner in circuits such as relays.

Another object of this invention is to provide a multi-junction semiconductor device which is readily manufactured and structurally stable.

The present invention is a semiconductor device comprising a body of semiconductor material having a zone of one type of conductivity which is located between two zones of opposite type of conductivity, a first electrode in low resistance contact with one of said two zones, a second electrode in low resistance contact with the other of said two zones, and a third electrode which forms a rectifying contact with said one of said two zones, said rectifying contact being located at a distance from the intermediate zone equal to about one diffusion length for minority charge carriers in said one of said two zones so that said semiconductor device is able to operate with thyratron-like characteristics.

Preferably, said one of said two zones serves as a base zone and said other of said two zones serves as a collector zone.

The sharpness (flatness) of the grown PN junctions which lie between the base and collector regions and the intermediate region of opposite conductivity type is preferably provided by utilizing a conductivity affecting impurity in the intermediate region of opposite conductivity type which has the lowest possible diffusion coefficient.

A semiconductor device constructed in accordance with the present invention will operate as a switch, if properly connected in an electrical circuit, in the manner of a thyratron. That is, once the switch is turned on the base loses control and the switch remains on. This distinctive operative feature of the device of the present invention is accomplished by proper bias relationship between emitter, base and collector. By adjustment of the base bias, i.e., the voltage applied to the base, the firing point of the switch may be varied. Generally speaking, an increase in the voltage applied to the base will increase the firing point. The variation of the firing point (point at which the device is turned on) or its exact setting will depend on the circuit in which the device is to operate and the sensitivity, to a negative voltage pulse applied between the emitter and collector, which is either desired or necessary in the circuit.

In the embodiment to be described below, a negative going pulse, emitter to collector, fires the device, and the base then loses control and the switch remains "on" until either a large pulse is applied to the base or a radical removal of voltage from the collector is affected.

Further details of the requirements of the device and various modifications are discussed in connection with the description of the

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attached drawing which is a schematic sectional view of a semiconductor device according to the present invention.

Referring to the drawing, there is illustrated a body 10 of semiconductor material, which may be silicon or germanium, in the form of a bar obtained from a grown single crystal. Suitable single crystal growing techniques are available and well known to those skilled in the art. Body 10 comprises two end zones 11 and 12 of N type conductivity acting as collector and base regions, respectively, and a relatively narrow zone of P type conductivity 13 intermediate zones 11 and 12. In growing the semiconductor crystal, PN junctions 14 and 14^1 are formed using any acceptable technique, such as double doping, rate grown, and grown diffused. To form the region 13, indium is the preferred acceptor impurity material used. Due to its low diffusion coefficient the use of indium ensures a sharp or flat P-N junction 14. A metal electrode 15 is in low resistance ohmic contact with N type collector zone 11 and a similar electrode 16 is in low resistance ohmic contact with N type base zone 12. A third electrode, emitter electrode 17 is in rectifying contact with base region 12 at a critical distance from P-N junction 14^1.

In accordance with the present invention emitter electrode 17 is preferably an aluminium wire, the end of which, 19, is fused to and forms a rectifying junction 20 with base region 12 at a distance from PN junction 14^1 of one diffusion length of the charge carriers (holes) supplied by aluminium. In the case of aluminium this distance, (diffusion length), 18 is between 0.2 and 0.3 mils. The aluminium wire could also be wrapped or extended around the periphery of zone 12 at the critical distance of 0.2—0.3 mils from the junction 14^1 but the fusion contact of the end of the wire is preferred.

Other suitable emitter electrodes 17 could be obtained by use of a gold-gallium wire or an indium dot. In any case it is essential that the emitter electrode 17 be in rectifying contact with base region 12 so that the emitter P region is at a distance equal to one diffusion length of its charge carriers from P-N junction 14^1.

Assuming a constant base voltage, a signal, negative going pulse of calculated voltage applied between emitter and collector will turn on or fire the device and it will remain "on" until a much greater voltage is applied to the base or a radical withdrawal of voltage from the collector is effected.

Although the invention has been described in terms of a single preferred embodiment, nevertheless, changes and modifications which do not depart from the spirit, scope and contemplation of the inventive concepts embodied herein are deemed to fall within the purview of the invention.

Thus, for example, it is not necessary that the structure be of the grown junction variety, for other types known in the art could be embodied in a P-N-P-N three-lead device. Such might include structures produced by solid state diffusion in which three layers would be diffusion-formed within a doped wafer of semiconductor material. Still another might involve the formation of two regions by solid state diffusion and another by alloying. Yet other structures will suggest themselves to one skilled in the art.

WHAT WE CLAIM IS:—

1. A semiconductor device comprising a body of semiconductor material having a zone of one type of conductivity, which is located between two zones of opposite type of conductivity, a first electrode in low resistance contact with one of said two zones, a second electrode in low resistance contact with the other of said two zones, and a third electrode which forms a rectifying contact with said one of said two zones, said rectifying contact being located at a distance from the intermediate zone equal to about one diffusion length for minority charge carriers in said one of said two zones so that said semiconductor device is able to operate with thyratron-like characteristics.

2. Semiconductor device according to Claim 1 wherein said one of said two zones serves as a base zone and said other of said two zones serves as a collector zone.

3. A semiconductor device according to Claim 1 or 2 wherein said third electrode is an aluminium wire which is alloyed with the surface of said one of said two zones at a point which is from about .005 to about .008 mm. from the central zone.

4. A semiconductor device according to any of the preceding claims wherein the intermediate zone is doped with an acceptor impurity which has a low coefficient of diffusion.

5. A semiconductor device according to Claim 4 wherein the intermediate zone is doped with indium.

6. A semiconductor device according to any of the preceding claims wherein the semiconductor body is a grown germanium crystal.

7. A semiconductor device according to any of the preceding claims wherein said two zones have n-type conductivity.

8. A semiconductor device according to any of the preceding claims wherein said third electrode is an emitter electrode.

9. A semiconductor device substantially as hereindescribed with reference to the accompanying drawing.

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