Aug. 19, 1958 J. B. LITTLE 2,848,665

POINT CONTACT TRANSISTOR AND METHOD OF MAKING SAME

Filed Dec. 30, 1953

FIG. 1

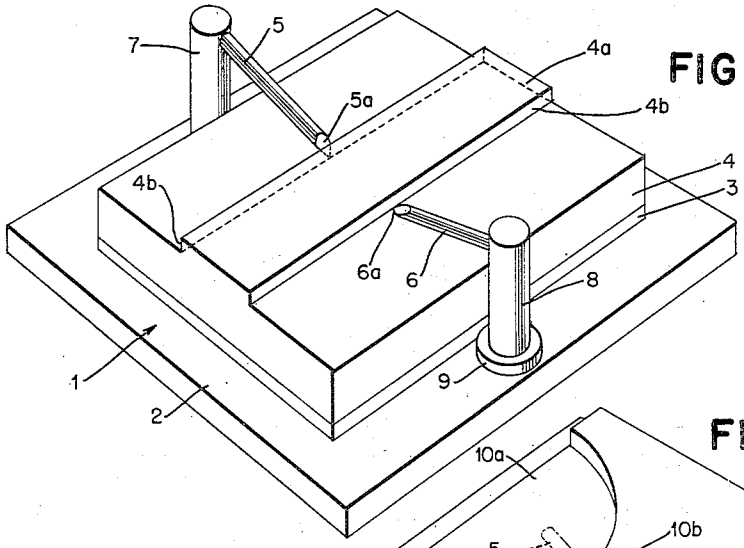


FIG. 2

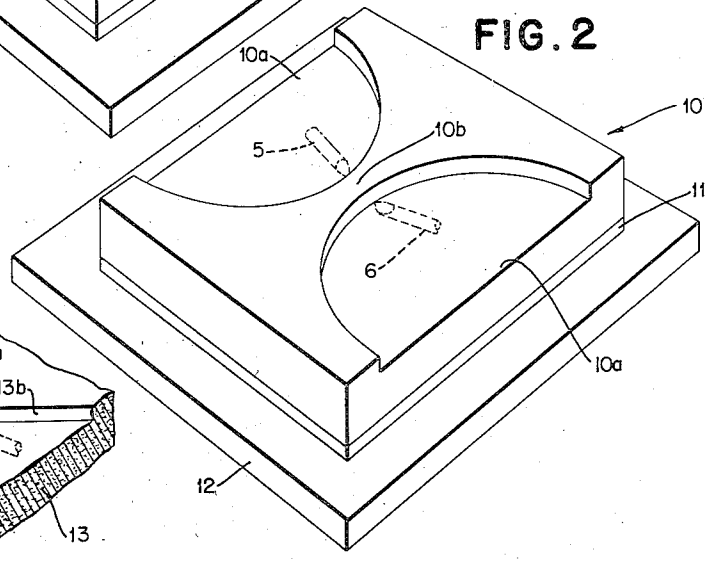
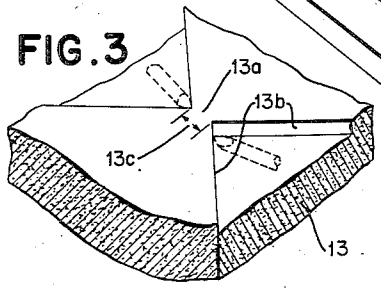


FIG. 3



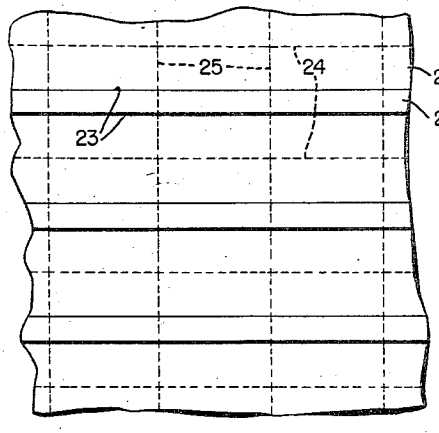
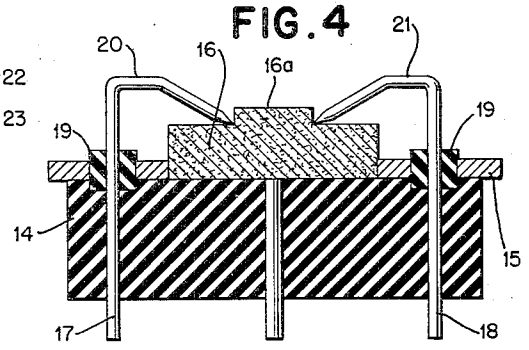


FIG. 5

FIG. 4



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POINT CONTACT TRANSISTOR AND METHOD OF MAKING SAME

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3 Claims. (Cl. 317—235)

This invention relates to point contact transistors and is particularly concerned with novel structures for maintaining a fixed spacing between the point electrodes and with novel methods for making transistors having such structures.

Point contact transistors commonly comprise a small block of monocrystal semi-conductive material, usually germanium, provided with a base electrode, an emitter electrode and a collector electrode. The base electrodes usually cover a substantial surface on the semi-conductive body, whereas the emitter and collector electrodes are substantially point contacts formed by light wires or whiskers engaging the surface of the semi-conductive material.

Transistors are very sensitive to variations in the spacing between the point contact electrodes. This spacing is commonly required to be of the order of one or two thousandths of an inch, and it is usually required that the spacing be maintained fixed within a margin of error of the order of one ten thousandths of an inch or less. The electrical characteristics of a transistor vary considerably with changes in the spacing of the emitter and collector electrodes. In order to secure uniformity in transistors, i. e., between one transistor and another of the same model, it is necessary that uniformity in the emitter-collector electrode spacing be maintained. Furthermore, in order to maintain uniformity in one transistor, i. e., in order that the characteristics of a given transistor may not change with age, it is necessary that the spacing between its point electrodes be maintained fixed under all conditions of use.

Many expedients have been tried in an effort to hold the electrode spacing fixed. One of the more common expedients is to embed the semi-conductive bodies with attached electrodes in a matrix of plastic material. However, such expedients are not entirely successful under all conditions of use, such as severe temperature and vibration conditions.

An object of the present invention is to provide a transistor having improved structure for maintaining the electrode spacing fixed. A further object is to provide such a transistor in which the spacing between the electrodes is maintained fixed by the structure of the semi-conductive body and of the electrodes themselves.

The foregoing objects are attained by forming the semi-conductive body of the transistor with a ridge having sharply defined sides, and placing the contacts against the sides of the ridge. The dimensions of the ridge are carefully determined, and the contacts are placed firmly against the sides of the ridge.

The ridge may be formed so that in plan view its opposite sides are concavely curved or angular. Curved and angular ridge structures tend to hold the contacts against lateral displacement along the ridge.

A block of semi-conducting material having a ridge of the type described may be made by applying a protective coating or covering to the surface locality where the ridge is desired and etching or sandblasting away the unprotected portions of the surface. Alternatively, the ridge may be formed by some of the recent high frequency cutting techniques such as the magnetostrictive or supersonic methods.

Other objects and advantages of the present invention will become apparent from a consideration of the following specification and claims, taken with the accompanying drawings, in which:

Fig. 1 is a perspective view of one form of prior art transistor;

Fig. 2 is a perspective view of one form of semi-conductive body embodying the invention which may be used in a transistor such as that of Fig. 1;

Fig. 3 is a fragmentary perspective view, similar to Figs. 1 and 2, showing a modified form of semi-conductive body embodying the invention;

Fig. 4 is a cross-sectional view through another form of transistor embodying the invention; and

Fig. 5 is a plan view of a block of semi-conductive material, having ridges formed thereon and lines scored to facilitate the cutting of the block into individual transistor bodies.

Referring to the drawing, there is shown in Fig. 1 a transistor generally indicated by the reference numeral 1, and mounted on a base 2. On the base 2 is supported a plate 3 of conductive material, for example copper. On the upper surface of the plate 3 is attached, as by soldering, a block of semi-conductive material, for example germanium. The block 4 is formed with a ridge 4*a* extending across the middle of its upper surface. The ridge 4*a* has plane parallel sides 4*b*. Two wire electrodes 5 and 6 are mounted on supporting posts 7 and 8 respectively. The posts 7 and 8 are mounted in the base 2, but are insulated from it by collars, such as the collar 9. The electrodes 5 and 6 have pointed ends 5*a* and 6*a*, formed in the conventional manner by grinding the ends of the electrodes at an angle of 45° to the axes of the wires 5 and 6. These ends are held firmly in the dihedral angle formed at the base of the ridge 4*a* by the sides of the ridge and the adjacent horizontal surfaces of the block 4.

Fig. 2 shows a semi-conductive body 10 attached to a base plate 11 and mounted on a base 12. The body 11 has formed in its upper surface recesses 10*a* defining between them a ridge 10*b*. The recesses 10*a* are generally semi-circular in horizontal cross-section, so that the sides of the ridge 10*b* are concave.

When electrodes are brought into contact with the base of the ridge 10*b*, and held in position, for example, in the same manner that the electrodes 5 and 6 of Fig. 1 are held in position, then those electrodes are held against lateral movements along the ridge 10*b* by the curvature of the sides of the ridge. It will be readily understood that the radius of curvature of the ridge sides may be varied over a considerable range.

Fig. 3 shows a fragmentary view of still another form of ridge structure which may be used. Fig. 3 shows part of a semi-conductive body 13 on which is formed a ridge 13*a* having at each end oppositely tapered sides 13*b*. The two ridge ends are tapered with the ridge width decreasing toward the center, the ridge sides approaching each other closely at a narrow neck portion 13*c*, defined by the opposed peaks of two V's formed in the opposite sides of the ridge. It will be readily understood that point electrodes placed in the angles of the V-shaped sides of the ridge 13*a* will be firmly held against displacement in any direction.

Fig. 4 shows a cross-sectional view of another type of transistor constructed in accordance with the invention. This transistor is mounted on an insulating base 14, whose top is covered by a metal plate 15. A body 16 of semi-conductive material is fastened to the top of the plate 15,

A pair of wires **17** and **18** extend through the base **14** and through insulating sleeves **19** which pass through the plate **15**. On their upper ends, the wires **17** and **18** support electrodes **20** and **21**, respectively. These electrodes are pointed at their ends and engage the upper surface of the semi-conductive body **16**, on opposite sides of a ridge **16***a*.

In order to form a semi-conductive body having a ridge, that portion of the surface of a block of suitable material which is to form the ridge is first protected, for example, either by bonding a strip of metal to the germanium block, or by applying a coating of a suitable material, e. g., enamel, over the area in question.

The entire surface in which the ridge is to be formed is then subjected to an eroding treatment to wear away the unprotected portions of the surface between the ridges defined by the lines **23**. This eroding treatment may, for example, take the form of a chmical or electrolytic etching process. Alternatively, if the protective coating applied over the ridges is structurally suitable, the eroding process may take the form of sandblasting. During the erosion process, the sharpness of the ridge sides and the sharpness of the angles at the base may be controlled by directing streams of the eroding agent—i. e., the sand blast or the chemical solution, along the edges of the ridge.

When the surface has been eroded to the desired depth, the protective covering on the ridge is then removed by a suitable treatment. The body then has the appearance of body **22** in Fig. 5, with ridges **23** formed thereon. On the body **22** are then drawn, by means of a ruling engine or other instrument, lines **24** which outline the sides of individual transistor blocks which are parallel to the ridges and lines **25** which outline the sides of the transistor blocks extending at right angles to the ridges. The body **22** is then cut into individual transistor blocks along the lines **24** and **25**.

An alternative method of forming the ridges is to cut the surface of the block in the desired locations by means of a high frequency cutting technique. In these techniques, a forming tool is used having a contour the inverse of that which it is desired to produce (e. g., a cutting tool for a ridged transistor would have a groove in place of a ridge). The surface to be cut is coated with a mixture of abrasive material, such as emery paste, the tool is then applied to the surface with a very small amplitude at a very high frequency until the reverse of the pattern of the forming tool is cut in the face of the body. The operation of such tools has been suggested by means of magnetostrictive or piezoelectric oscillations at supersonic frequencies.

Regardless of the method employed to form the ridges, it is preferred to make the transistor bodies in quantities by taking a relatively large block, forming the ridges over one whole surface of the block, then cutting the block transversely to form the individual transistor bodies.

While I have shown and described certain preferred embodiments of my invention, other modifications thereof will readily occur to those skilled in the art and I therefore intend my invention to be limited only by the appended claims.

I claim:

1. A transistor comprising a semi-conductive body having formed in one surface thereof a ridge with a cross-sectional contour providing sharp corners at the base of the ridge, said ridge having portions increasing in width in either direction from an intermediate locality of said ridge and thereby defining a narrow neck portion at said locality between said portions of increasing width, point electrodes contacting the corners of the opposite sides of the base of the ridge at said neck portion, said ridge being effective to prevent movement of the point electrodes toward each other, and means supporting said point electrodes firmly in the corner at the base of the ridge at said neck portion, said supporting means being effective to prevent movement of the point electrode away from the ridge, and cooperating with said portions of increasing width to prevent displacement of the point electrodes lengthwise of the ridge.

2. A transistor as defined in claim 1, in which said neck portion and said portions of increasing width are defined by opposed side surfaces of the ridge which are symmetrically and continuously curved throughout said neck portion and said portions of increasing width.

3. A transistor as defined in claim 1, in which said neck portion and said portions of increasing width are defined by symmetrically opposed plane side surfaces of the ridge which, on each side of the ridge, comprise two plane surfaces extending at different angles to the longitudinal dimension of the ridge and intersecting with the main body of the transistor in an inside trihedral angle at the base of the ridge, said point electrode engaging the apices of said trihedral angles.

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