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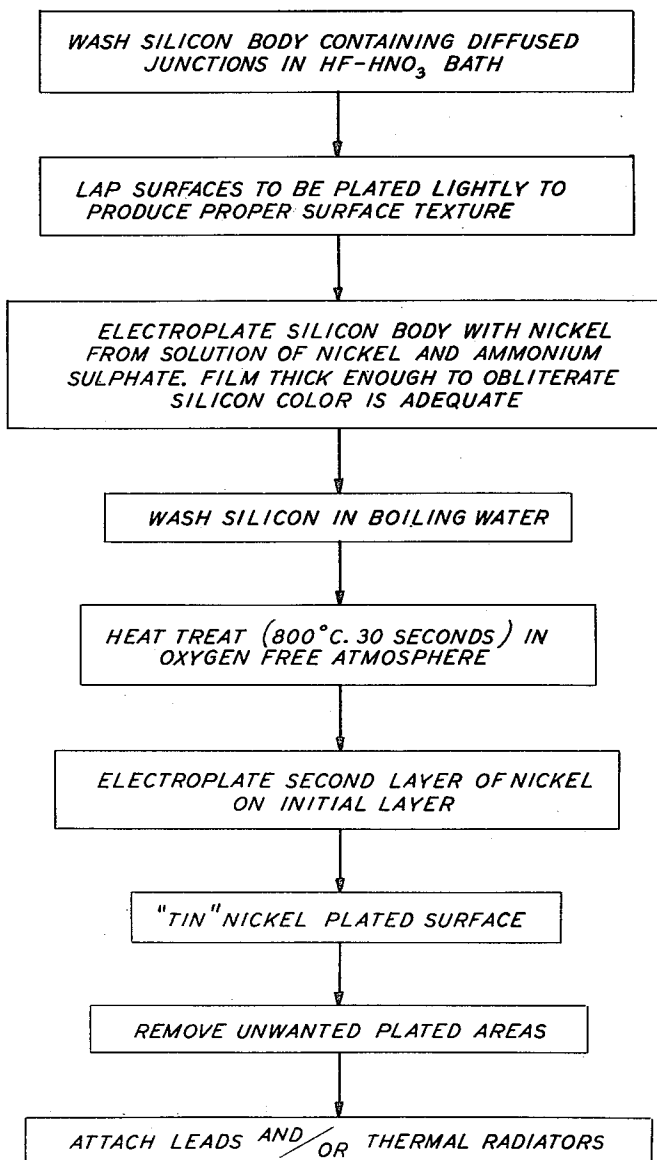
R. L. JOHNSTON ET AL
ELECTRICAL CONTACTS TO SILICON

2,793,420

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FIG. 1



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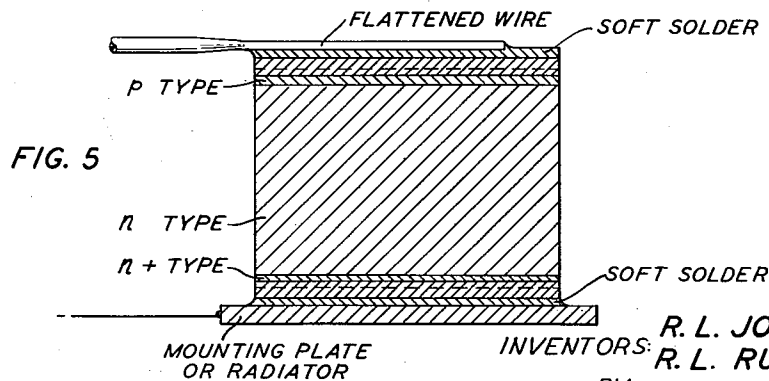
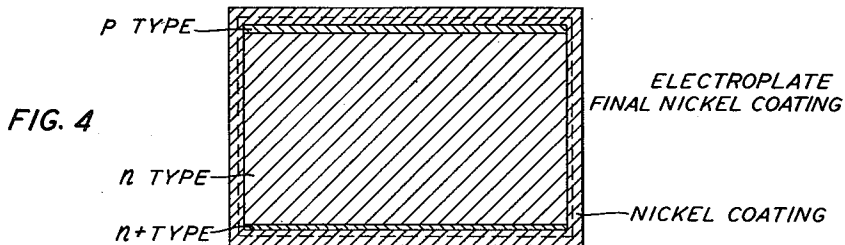
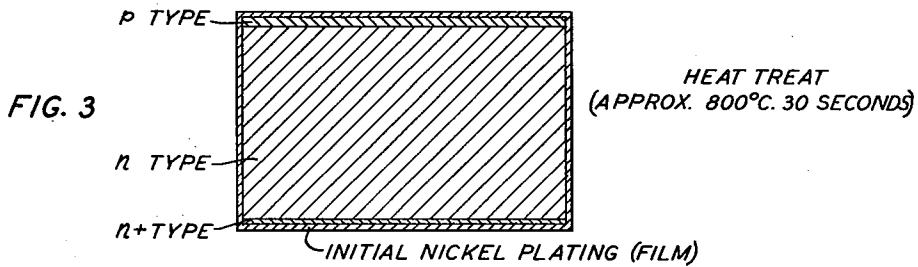
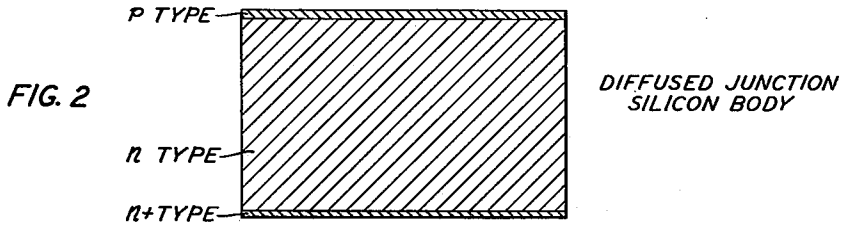
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ELECTRICAL CONTACTS TO SILICON

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ELECTRICAL CONTACTS TO SILICON

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3 Claims. (Cl. 29—155.5)

This invention relates to electrical contacts on semiconductor material and more particularly to a method of fabricating large area low resistance contacts to silicon semiconductors.

It is important in many types of semiconductive devices to make contact thereto in a manner which is advantageous both electrically and mechanically. This is particularly so in the case of certain silicon devices, such as disclosed in the applications of G. L. Pearson, Serial No. 414,275, filed March 5, 1954, now abandoned, and Serial No. 491,908, filed March 3, 1955, wherein the efficiency of the device hinges materially upon the electrical resistance of the contact. Hence, for such devices an electrical contact combining good mechanical strength with a resistivity of the order of thousandths of an ohm is extremely desirable.

It is, therefore, an object of this invention to produce improved electrical contacts to silicon.

Ancillary objects are to produce large area low resistance contacts to semiconductive bodies of silicon by facile and cheap means.

This invention is based to a considerable extent upon the discovery that improved large area contacts to silicon are achieved by electroplating a metal, such as nickel, in two distinct steps with an intervening heat treatment. Thus, in accordance with the method of this invention, a silicon body containing suitable junctions, which may be advantageously formed by the diffusion therein of significant impurity elements, is treated in a nickel solution to an electroplating of relatively short duration and low intensity, sufficient merely to provide a film obliterating the color of the silicon. The body of silicon is then heated briefly, generally less than one minute, at a temperature between 700° C. and 950° C., while maintaining a controlled, oxygen-free atmosphere. After this heat treatment a further and heavier layer of nickel is electrodeposited, forming a surface which is readily tinned preparatory to the application of contact leads or thermal radiators.

The above and other objects and features of this invention will be appreciated more fully when considered in conjunction with the accompanying drawing, in which:

Fig. 1 is an operational diagram of one form of the method of this invention, employed for producing improved ohmic contacts to silicon; and

Figs. 2, 3, 4, and 5 represent, in exaggerated cross-sectional views, the appearance of a silicon rectifier device at various stages of fabrication in accordance with this invention.

Referring to Fig. 1, the method of this invention as applied to a typical silicon semiconductor body comprises first, washing the silicon in a suitable bath to remove the surface film, which presumably is silicon dioxide. It will be understood that the semiconductor already contains the desired regions of conductivity produced by techniques known in the art, for example, such as those disclosed in the applications of C. S. Fuller, Serial No. 414,272, filed March 5, 1954, and Serial No. 432,638, filed May 27,

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1954, and N. B. Hannay, Serial No. 432,792, filed May 27, 1954, now Patent No. 2,743,200.

Such a device may be as depicted in Fig. 2, comprising a body of n-type conductivity silicon having a thin zone of p-type conductivity on one boundary and a region of n+ type, indicating greater n-type conductivity than the body material, on the opposite boundary. As disclosed in the aforementioned applications of G. L. Pearson, the structure described is advantageously used as a rectifier of greatly improved characteristics.

The next step, as shown in Fig. 1, involves further preliminary surface preparation and may consist of applying the silicon surfaces to be plated to a lapping plate treated with #1800 Alundum abrasive. Generally, a few strokes are sufficient to provide a proper surface texture.

The initial plating operation is accomplished by mounting the silicon body in a suitable jig or holder which is then immersed in a plating bath. A bath suitable for plating may comprise 105 grams of nickel ammonium sulfate, 15 grams of ammonium chloride, and 15 grams of boric acid dissolved in one liter of distilled water. With the semiconductor body made cathode, current is passed to deposit a film of nickel heavy enough to obliterate the characteristic silicon color. A current density of 0.10 ampere/cm.² for about 20 seconds has been found suitable.

The lightly plated silicon body, as represented in Fig. 3, is cleaned in boiling water and is then inserted slowly into a furnace at a temperature of 800° C. The atmosphere within the furnace is positively maintained oxygen-free, as by the application of a nitrogen atmosphere or the use of so-called "forming gas" composed of twenty percent hydrogen and eighty percent nitrogen. After holding in the furnace for about one-half minute, the silicon body is slowly withdrawn to avoid thermal shock and again placed in the plating bath.

A second layer of nickel is then electrodeposited to a depth heavier than the initial layer as illustrated in Fig. 4. Application of the same current density as used for the first film for a period of about thirty seconds produces a satisfactory surface.

Solder tinning of the plated surfaces to which contact is to be made is readily accomplished by forming a puddle of solder on a hot flat copper plate. The surfaces are "fluxed" and placed in the puddle until tinning occurs, after which the semiconductor body is removed and cooled slowly.

Electrodes may be applied by other means known in the art, for example, silver paste may be used in lieu of solder. Another alternative is to affix a metallized frit of glass to the plated area by means of an additional firing. It is also possible to achieve a satisfactory electrode connection simply by the application of sufficient pressure to force a base metal wire into the plated layer.

Final steps in device fabrication comprise removal of unwanted plated areas to eliminate shorting of junctions. This procedure may involve grinding or combined masking and etching treatments or the like. It is also practical to accomplish the steps of this method on a relatively large area body of silicon which may then be cut or diced into smaller units.

As shown in Fig. 5, the final form of the rectifier will include a flattened wire contact 11 to the p-type zone and a mounting plate 12 of copper, "sweated" to the n+ type zone.

While other plating metals, such as rhodium and copper may be employed in the practice of this invention, nickel has been found particularly suitable from the standpoint of electrical and mechanical results. For a series of twenty-five silicon devices of the type disclosed hereinabove, each having a contact area of about 1.75 square centimeters, the contacts made in accordance with

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this invention had average resistances of about one-thousandth of an ohm.

What is claimed is:

1. The method of fabricating a low resistance contact to a body of semiconductive silicon which comprises electrodepositing a first layer of nickel sufficient to just obliterate the color of said silicon body, heating said body at about 800° C. for about one-half minute in an oxygen-free atmosphere, electrodepositing a second layer of nickel, and applying a coating of solder to said nickel plating.

2. The method of fabricating a low resistance contact to a semiconductive body of silicon which comprises electrodepositing a thin film of nickel from a plating solution, washing said body, heating said body at about 800° C. for about one-half minute in a slightly reducing atmosphere, electrodepositing a layer of nickel relatively heavier than the said thin film, applying a solder coating to said nickel plating, and affixing electrodes to said solder.

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3. The method of fabricating a low resistance contact to a semiconductive body of silicon which comprises cleaning and polishing the contact surfaces of said body, electrodepositing a first layer of nickel just sufficient to obliterate the silicon body color, washing said body, heating said body at about 800° C. for about one-half minute in an oxygen-free atmosphere, electrodepositing a second layer of nickel heavier than said first layer, applying a solder coating to said nickel plating, and affixing electrodes to said solder.

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