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[33] **Germany**
[31] **P 16 21 428.1**

3,436,286 4/1969 Lange..... 156/345 X
3,489,608 1/1970 Jacobs et al. 134/25

OTHER REFERENCES

Duigon et al., RCA Technical Note Number 521, March 1962

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[54] METHOD OF TREATING SEMICONDUCTOR ELEMENTS OF CIRCULAR OUTLINE 11 Claims, 11 Drawing Figs.

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134/25, 134/33, 134/157, 134/161, 156/345,
259/73, 259/75

[51] Int. Cl..... **H011 7/00,**
B08b 3/10

[50] Field of Search..... **156/17,**
345; 134/157, 161, 32, 33, 25; 259/73, 75

[56] References Cited UNITED STATES PATENTS

3,041,225 6/1962 Emeis..... 134/33 X
3,342,652 9/1967 Reisman et al. 156/345 X
3,436,259 4/1969 Regh et al. 156/17 X

ABSTRACT: A method of and apparatus for treating elements of circular outline. A vessel is provided with guide grooves which are either straight and parallel to one another or are torus-shaped and concentric with one another. The vessel is mounted for tilting movement about a ball and socket joint and accommodates a bath of etching fluid. Disc-shaped elements to be treated are supported on edge in the respective guide grooves. A motor is mounted below the vessel and its output shaft drives a cam follower having at least one ascending and at least one descending surface portion, and in the case of straight parallel guide grooves two rod-shaped follower members are mounted for sliding movement in axial direction of the motor shaft with their ends resting on the cam disc surface and their upper ends engaging the bottom wall of the vessel so that, when they are shifted in axial direction of the motor output shaft, the vessel is tilted alternately to one side and the opposite side about the ball and socket joint. If the guide grooves are torus-shaped, then three such follower members are used which are circumferentially spaced about the axis at equiangular locations.

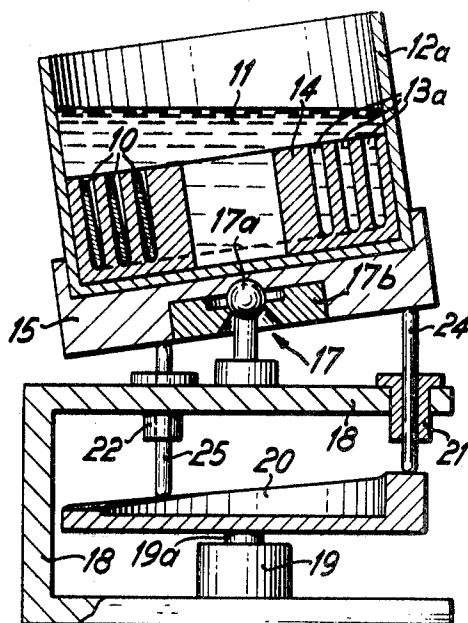


FIG. 1

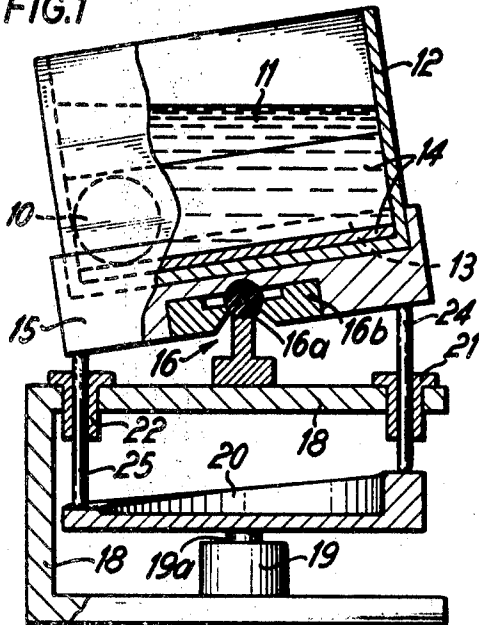


FIG. 5

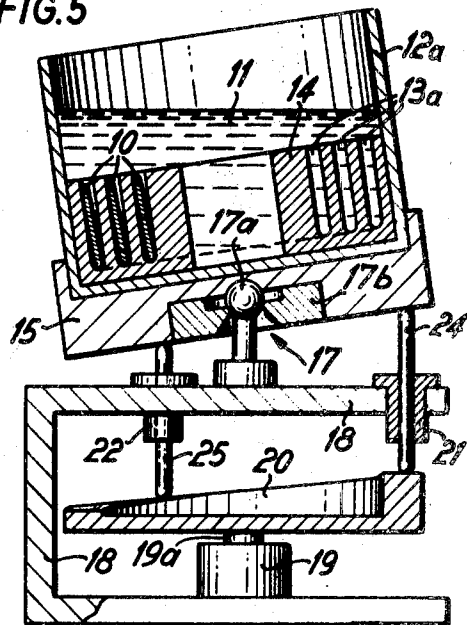


FIG. 2

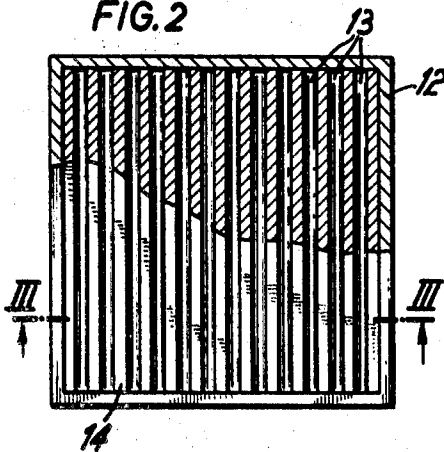


FIG. 6

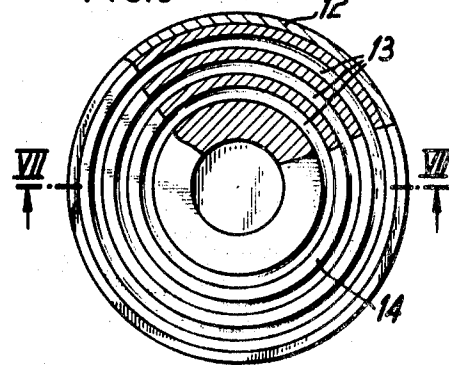


FIG. 3

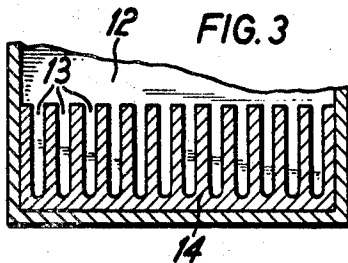
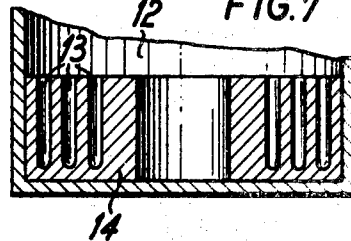


FIG. 7



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FIG. 4

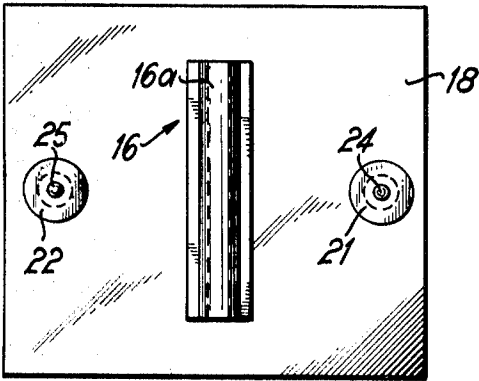


FIG. 8

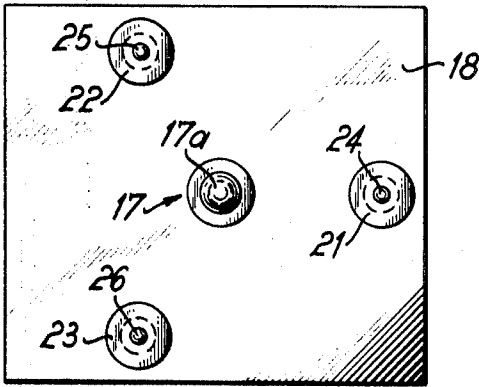


FIG. 11

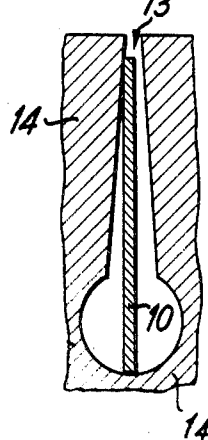


FIG. 10

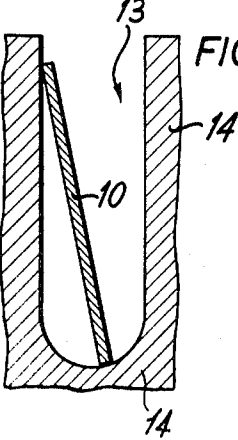
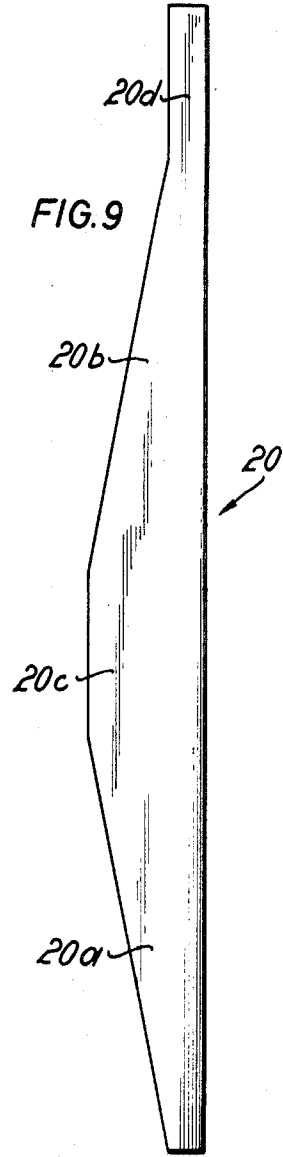


FIG. 9



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METHOD OF TREATING SEMICONDUCTOR ELEMENTS OF CIRCULAR OUTLINE

BACKGROUND OF THE INVENTION

The present invention is concerned with the treating of elements of circular outline, and more particularly with the polishing of surfaces of such elements by subjecting them to an etching treatment. Still more particularly, the present invention is concerned with a method of carrying out such treatment and with an apparatus for carrying out the method.

Certain elements of circular outline, and particularly semiconductor discs constituting a semifinished product for use in the manufacture of electronic components such as diodes, transistors, thyristors and integrated circuits, must be subjected to a polishing action. Conventionally, such semiconductor discs are manufactured by slicing disc-shaped blanks off longer rods of the crystalline semiconductor material, lapping the blanks, and thereupon polishing and etching them. The etching step is to remove the crystalline layers which have been disturbed by the mechanical operations, and on the other hand it is to assure that the surfaces so treated are to be as smooth and mirrorlike in finish as possible. Particularly the smoothness is highly important, especially if the completed blanks are thereupon to be further processed in the so-called planar method, because if the surface is not completely smooth there will be inadequate contact between the photo shield and the semiconductor disc and this in turn will result in unsharp contours which adversely affect the quality of the finished planar structures. In the event that the semiconductor disc surface is concavely curved, there is also the danger that the photo shield might be scratched by the sharp edge of the disc.

However, while etching of the surfaces is thus already known, it has been found that the known etching methods and apparatus for carrying out such methods will not produce the requisite total smoothness of the surfaces. To arrive at a smoothness which is anywhere near acceptable it is therefore necessary in the prior art approaches to subject the surfaces prior to etching to a multistage mechanical polishing process which may, for instance, have as its final step a polishing stage with Ceroyde or Zirkoniumoxide. However, once treated in this manner, the semiconductor discs may only be etched briefly because a prolonged etching would again adversely affect the smoothness obtained by the mechanical polishing steps.

It is the purpose of the present invention to overcome the aforementioned disadvantages.

More particularly, it is an object of the present invention to provide a method for etching semiconductor discs and analogous elements of circular outline, wherein the disadvantages just outlined above are not present.

Still more specifically, it is an object of the present invention to provide such a method which permits etching of the major surfaces of semiconductor discs so that they will become completely smooth and without encountering the aforementioned disadvantages.

An additional object of the present invention is to provide an apparatus for carrying out the novel method.

SUMMARY OF THE INVENTION

In accordance with the above objects, and others which will become apparent hereafter, one feature of our invention recites in providing a method of treating elements of circular outline, including disc-shaped semiconductor elements, which method comprises the steps of immersing at least one element of circular outline having other than planar major surfaces in a bath of etching fluid. Thereupon, relative movement is effected between the element and the bath and this includes imparting rolling movement to the element so that the etching fluid sweeps over the major surfaces thereof to thereby etch the same and impart to them a planar configuration.

Our novel invention is based on the realization that the local etching speed depends substantially from the relative speed of

any given surface point of the element to be treated with respect to the etching fluid. Accordingly, we provide for relative movement between the element to be treated and the bath etching fluid, and we accomplish this by imparting to the element a rolling movement to thereby control the relative speed of the element with respect to the fluid. Advantageously we periodically change the rolling movement so that the same is periodically repeated.

We carry out our invention by providing in a vessel for accommodating the bath of etching fluid, either a plurality of straight guide grooves arranged in parallelism with one another, and tilting the vessel about an advantageously normal axis, with respect to the elongation of the guide grooves, or by providing the guide grooves in a torus-shaped configuration and arranging them coaxially, in which case the vessel is subjected to a periodic tumbling movement about a point located on the axis of the guide grooves. It will be appreciated, of course, that a single guide groove will fulfill the purposes of the present invention, if for any reason a single element should be subjected to such treatment at one time, or if a small enough number of elements is simultaneously being treated which can be accommodated in a single such groove.

In any case, after being subjected to our novel method carried out in our novel apparatus, the surfaces of the elements, hereafter for the sake of convenience identified as semiconductor discs, will be completely smooth. Mechanical polishing as heretofore necessary, particularly multistage mechanical polishing, is therefore no longer necessary and the manufacture of semiconductor discs by resorting to our novel invention is accordingly considerably less expensive and more economical than heretofore possible. It is true that by resorting to our novel invention and eliminating the mechanical polishing procedure the duration of the etching step is somewhat longer than heretofore, but this does in no way adversely influence the smoothness of the surfaces which are obtained. A particular advantage is the fact that semiconductor discs etched, or rather polish-etched in accordance with our invention can be immediately used for further processing into semiconductor units, particularly of the type which is manufactured subsequent to the planar treatment or through epitaxial growing of semiconductor layers.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a somewhat diagrammatic vertical section through an apparatus according to our invention and illustrating a first embodiment of the invention;

FIG. 2 is a partially sectioned top plan view of the vessel shown in the apparatus of FIG. 1;

FIG. 3 is a section taken on the line III—III of FIG. 2, with parts broken away;

FIG. 4 is a top plan view of a portion of the drive arrangement for the apparatus in FIG. 1;

FIG. 5 is a view similar to FIG. 1 but illustrating an apparatus embodying a second embodiment of the invention;

FIG. 6 is a view similar to FIG. 2 but illustrating a top plan view of the vessel in the apparatus of FIG. 5;

FIG. 7 is a section taken on the line VII—VII of FIG. 6 with parts broken away;

FIG. 8 is a view similar to FIG. 4 but illustrating a part of the drive arrangement of the apparatus in FIG. 5;

FIG. 9 is a developed view of the cam disc used in the apparatus of FIGS. 1 and 5; and

FIGS. 10 and 11 illustrate preferred cross sections for the guide grooves in the apparatus according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Discussing firstly the apparatus according to the embodiment illustrated in FIGS. 1-4, to which FIGS. 9 and 10 have relevance as will be discussed subsequently, is pointed out that reference numeral 11 identifies a vessel of substantially quadratic cross section and accommodating a bath 11 of etching fluid. The etching fluid serves to etch semiconductor discs 10 of which one is illustrated in phantom lines to show it immersed in the bath 11. It might be pointed out here that different types of etching fluids are usable, but that we have found it advantageous to use a mixture of nitric acid, hydrofluoric acid and glacial acetic acid. Further, to prevent the possibility of uneven etching we prefer to add a wetting agent to the bath, and have found nitrium lauryl sulfate particularly advantageous for this purpose. This will be discussed in some more detail subsequently.

In the embodiment of FIGS. 1-4 there is inserted into the vessel 12 an insert 14 provided with straight guide grooves 13 which extend in parallelism with one another. The preferred cross-sectional configuration of these side grooves is shown in FIGS. 10 and 11 from which it is also evident that the height of the guide grooves 13 is somewhat in excess of the diameter of the semiconductor discs 10.

FIG. 1 shows that the vessel 12 is removably mounted on a support 15, here simply provided in form of an upwardly open cup-shaped member in which the vessel 12 is partially received so as to be retained therein. A pivot-and-socket joint is identified with reference numeral 16 and mounts the member 15 on a support 18 which, as is evident from the drawing, has the form of a U lying on its side. The portion 16a of the joint 16 is rigidly connected with the support 18 and its pivot part cooperating with the socket is in form of a cylindrical member. The socket is constructed by inserting a member 16b into a recess provided in the underside of the member 15 and rigidly connecting it with the latter. The axis of the joint, that is the axis about which the vessel 12 may thus pivot, is normal to the elongation of the guide grooves 13.

To effect the rolling movement of the members 10 which is required in accordance with the present invention, a drive arrangement is provided which serves to impart to the member 15 and thereby the vessel 12 with the insert 14 a periodically to-and-fro tilting movement about the axis defined by the joint 16. For this purpose we provide a drive motor 19 whose output shaft 19a extends upwardly towards the member 15. The drive motor 19 is in the illustrated embodiment so connected with the lower arm of the U-shaped support 18 that an extension of the axis of the shaft 19a will intersect the axis of the joint 16. A cam disc 20, which is illustrated in more detail in FIG. 9, is mounted on the output shaft 19a for rotation therewith. FIG. 9 shows that the upper side of the cam disc 20 is provided with a linearly ascending portion 20a and a linearly descending portion 20b, as clearly visible in the developed view in FIG. 9.

At opposite sides of the joint 16 the support 18 is provided with a bore or aperture in which sleeve bearings 21 and 22 are respectively mounted. Arranged for sliding movement in each of the sleeve bearings 21, 22 and in the axial direction of the output shaft 19a, are two follower members 24 and 25, respectively. These members 24 and 25 are located in a plane normal to the axis of the joint 16 which at the same time constitutes the plane of symmetry of the vessel 12; they are equally spaced from the axis of the joint 16, that is from the axis about which the vessel 12 may tilt. Their underside abuts against the upper surface of the cam disc 20 whereas their upper side or upper end abuts against the underside of the member 15. It follows from this that, when the cam disc 20 is rotated in response to actuation of the motor 19, the vessel 12 will be tilted to-and-fro about the axis defined by the joint 16 in response to transmission of motion by the members 24, 25 whose sliding movement, imparted to them by contact of their lower ends with the ascending and descending portions of the cam disc 20, is translated into tilting movement of the vessel 12. As a result, the semiconductor discs 10 which are sup-

ported on edge in the guide grooves 13, will roll in the bath 11 of etching fluid from left to right and then from right to left in the vessel. This results in the desired even and smooth etching of the surfaces of the elements or semiconductor discs 10.

The embodiment illustrated in FIGS. 5-8, to which FIGS. 9-11 have relevance as will be discussed, the etching vessel is identified with reference numeral 12a and is of circular cross section. In this embodiment elements which are identical with those of the embodiment in FIGS. 1-4 are identified with the same reference numeral, and accordingly the insert carrying the guide grooves is identified with reference numeral 13. Here, however, the guide grooves are identified with reference numeral 13a and it will be seen that they are of torus-shaped configuration and are coaxial with one another.

In accordance with the necessity to impart a different type of movement in the embodiment of FIGS. 5-8 than in the embodiment of FIGS. 1-4, the embodiment of FIGS. 5-8 utilizes a ball-and-socket joint 17 in place of the joint identified with reference numeral 16 in the preceding embodiment. Here, the portion 17a is again rigidly connected with the support 18 and its upper part is constructed not as a cylindrical member but as a ball. The socket is here constituted by a recess in the underside of the member 15 in which there is received a socket member 17b which is rigidly connected with the member 15.

As in the embodiment of FIGS. 1-4, the drive arrangement for the embodiment of FIGS. 5-8 includes the drive motor 19 having the output shaft 19a with which the cam disc 20 is rigidly connected for rotation therewith. The configuration of the cam disc 20 is the same as in the embodiment of FIGS. 1-4. An extension of the axis of the shaft 19a and the cam disc 20 passes through the center of the ball portion of the joint 17.

The motion-transmitting arrangement of this embodiment differs from that of FIGS. 1-4 in that three motion-transmitting follower members are utilized, rather than two as in the preceding embodiment. This is clearly visible in FIG. 8 where it will be seen that three follower members 24, 25 and 26 are provided which are located on the corners of an equilateral triangle whose center coincides with the axis of the motor output shaft 19a and the cam disc 20. As in the preceding embodiment, the follower members 24, 25 and 26 are arranged in sleeve bearings, here identified with reference numerals 21, 22 and 23, which are secured in bores or openings in the upper arm of the U-shaped support 18, so as to be slidable in the direction of elongation of the axis 19a.

It will be clear that as the disc 20 is rotated in response to actuation of the motor 19, the vessel 12a has imparted to it a tumble movement about the center of the ball-and-socket joint 17. Accordingly, the semiconductor disc 10 received on edge in the torus-shaped guide grooves 13a have imparted to them a rolling movement about the axis of the vessel 12a with the results mentioned before. It need not be emphasized, of course, that in all embodiments the guide grooves are filled with the etching fluid.

With respect to the cam disc 20 it should be noted that the lifting height, that is the extent to which the follower members 21 and 22, or 21, 22 and 23, are lifted and allowed to descend in response to rotation of the disc 20, is of importance. Excessive lifting height requires too great a quantity of etching fluid whereas inadequate lifting height will adversely affect the simultaneous initiation of rolling movement of all of the semiconductor discs 10 being treated and will also decrease their rolling speed. The most advantageous lifting height constitutes a compromise between these two factors which can be readily determined by experimentation on the part of those skilled in the art.

Furthermore, it is important that the impartation of movement to the etching vessel 12 or 12a, respectively, be such that the rolling movement of the semiconductor discs 10 in the guide grooves 13 remain substantially in phase with the movements of the vessel. Otherwise the inevitable mechanical friction between the semiconductor discs 10 and the guide grooves will result in statistical delay of individual ones of the elements then with respect to the remaining ones, and even-

tually these delayed discs will cease rolling movement completely. In accordance with the invention this is overcome by interrupting the periodicity of movement of the vessel through small pauses in which the delayed semiconductor discs 10 can catch up with the others. To this end we provide intermediate the ascending portion 20a and the descending portion 20b of the cam disc 20 short horizontal portions 20c and 20d, as shown in FIG. 9. In other words, these portions 20c and 20d are respectively provided between the trailing end of the ascending portion and the leading end of the descending portion on the one hand, and between the trailing end of the descending portion and the leading end of the ascending portion on the other hand. In the embodiment of FIGS. 1-4, for instance, these portions 20c and 20d result in momentary pauses in the movement of the vessel 12 before the same is subjected to a tilting movement contrary to the one it has just completed.

As already mentioned, we have found a mixture of nitric acid, hydrofluoric acid and glacial acetic acid advantageous, and especially for the etching of cerium semiconductor discs. However, we have found that on completion of the etching process the semiconductor discs at times have surface defects which under the microscope appear as groups of projections and crow's-foot type depressions and which may be distributed over the entire surface of the disc. This is avoided in accordance with the invention by adding a wetting agent, for example natriumlauryl sulfate, to the etching fluid, which can be accomplished at room temperature and under stirring of the bath of etching fluid. We have found it advantageous to use 10 ml. of wetting agent for every 600 ml. of etching fluid.

A semiconductor disc of cerium of approximately 26 mm. diameter and which had an initial thickness of 300 micron, was subjected to etching in accordance with the present invention and its thickness decreased to 183 microns. Measurements taken after the etching process was completed showed the maximum deviation from the ideal smooth surface to be 1.6 micron. The total thickness gradient measured on this disc was found to be approximately ± 2 micron and the median peak-to-valley height obtained for this disc was 0.12 micron when the disc was etched to a thickness of 183 microns, and only 0.07 micron when the disc was etched to a thickness of 157 microns.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of applications differing from the types described above.

While the invention has been illustrated and described as

embodied in an apparatus for etching semiconductor discs, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

1. A method of treating semiconductor elements, comprising the steps of providing a bath of etching fluid in a receptacle having a bottom wall, the inner surface of said bottom wall having at least one guide groove open to said bath; immersing in said bath, and placing on edge in said guide groove, at least one semiconductor wafer element of circular outline having other than planar major surfaces; and imparting to said receptacle movement requisite for agitation of said etching fluid with concomitant rolling of said semiconductor wafer element in said guide groove, so that the etching fluid sweeps over said major surfaces during such rolling to thereby etch them and impart to them a planar configuration.

2. A method as defined in claim 1; and guiding said element for rolling for rolling on edge in a straight path.

3. A method as defined in claim 2 and further comprising the step of periodically reversing the direction of rolling movement of said element in said straight path.

4. A method as defined in claim 2; further comprising immersing additional semiconductor wafer elements in said bath and effecting rolling movement of said additional elements in additional straight paths paralleling the first-mentioned straight path.

5. A method as defined in claim 1; and guiding said element for rolling in a torus-shaped path surrounding an axis.

6. A method as defined in claim 5; and further comprising the step of effecting periodic wobbling movement of said bath and said element immersed therein about said axis.

7. A method as defined in claim 5; further comprising immersing additional semiconductor wafer elements in said bath and effecting rolling of said additional elements in additional torus-shaped paths coaxial with the first-mentioned torus-shaped path.

8. A method as defined in claim 1, said bath comprising a mixture composed of nitric acid, hydrofluoric acid and glacial acetic acid.

9. A method as defined in claim 8; further comprising the addition of a wetting agent to said mixture.

10. A method as defined in claim 9, wherein said wetting agent is sodiumlauryl sulfate.

11. A method as defined in claim 9, wherein 10 ml. wetting agent are added per 600 ml. of said mixture.

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