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LAPPING DEVICE FOR SEMICONDUCTOR WAFERS

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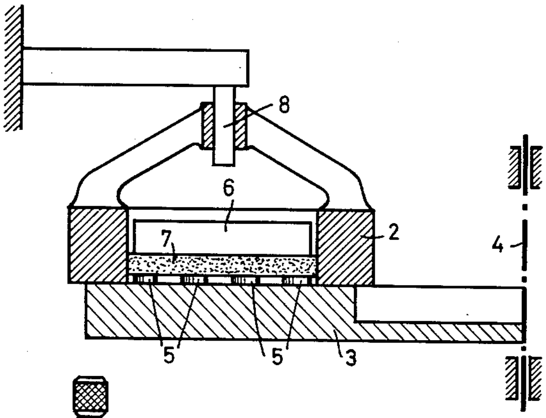

Fig. 1

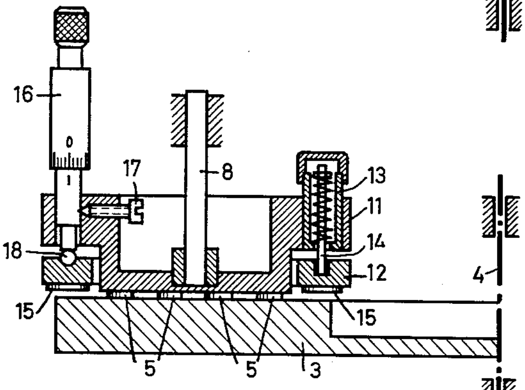

Fig. 2

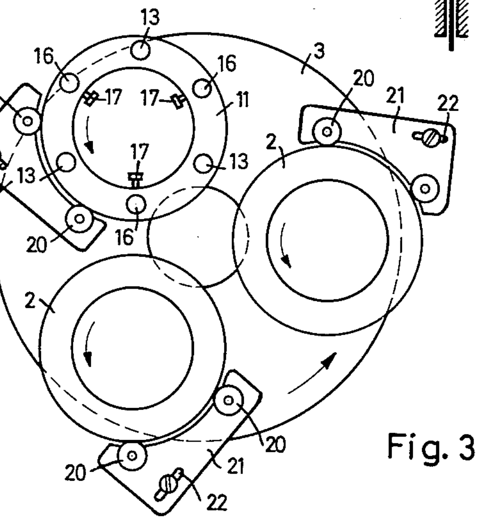

Fig. 3

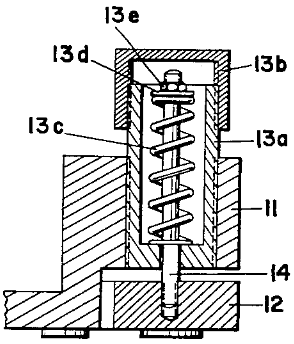

Fig. 2a

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LAPPING DEVICE FOR SEMICONDUCTOR WAFERS

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My invention relates to rotating lapping tables for reducing electric semiconductor elements to a desired small and uniform thickness.

The semiconductor element in electric devices such as rectifiers, transistors or photodiodes consist in most cases of a monocrystalline pellet, disc or plate of wafer thickness, for example in the order of tenths of millimeters. Semiconductor wafers of silicon must be particularly thin as compared with germanium, because of the small lifetime of the electric charge carriers.

The conventional method of producing semiconductor wafers of the prescribed slight thickness and best possible uniformity, is to grind the raw wafers on a two-disc lapping table which has a number of guide discs located between the two lapping discs and provided with gear teeth in meshing engagement with an inner sun gear and an outer orbit gear whose rotation relative to one another causes the guide discs to travel in planetary-gear fashion. Such machines leave much to be desired because the guide discs must be just as thin as the semiconductor wafers to be processed and hence are subjected to grinding together with the wafers. This reduces the strength of the gear teeth and renders the guidance progressively unreliable. Each new batch of wafers to be lapped requires the insertion of new planetary guide discs.

It is an object of my invention to eliminate these shortcomings and to devise a thin-lapping machine of improved reliability which does away with the need for frequent replacement of guiding inserts.

To this end, my invention is based upon the design of a single-disc lapping machine of known type in which several eccentrically mounted guide rings slide under their own weight on the rotating lapping table so that the rotary motion of the table imparts rotation to the rings. The material to be processed is distributed within the guide rings as uniformly as possible and is loaded by an elastic intermediate layer, for example a disc of felt. During operation, the entire inserted assembly rotates continuously together with the guide ring about its own axis. The guide rings may have any desired thickness. The lapping table has a recess in its center so as to form an annular disc, and the guide rings have such a diametric size that they project beyond the inner and outer edge of the lapping disc. This secures uniform wear of all grinding planes, and any occurring irregularities in the plane or grinding surface are automatically eliminated by the preferred wear of the protruding spots. Each individual guide ring and the workpieces placed therein are guided at the proper location by means of a central shaft. Such guidance however, may also be effective by laterally mounted rollers.

Now, according to a feature of my invention, I replace in such a single-disc lapping machine at least one of the guide rings by a guide body whose bottom side consists mainly of a surface plane on which the workpieces are to be fastened. The guide body also carries several spacer pieces consisting preferably of hard metal such as used for the carbide tips of cutting tools, one of these materials being available under the trade name Widia. The use of such materials prevents excessive wear of the spacer pieces. The guide body is preferably given a circular shape and the same size as the guide ring. The guidance of the body at the proper location can be effected in the same manner as in the known single-disc lapping table described above.

According to another feature of my invention, a further advantage is achieved by subdividing the guide body into two portions, namely an inner portion which carries the workpieces, and an outer portion which carries the spacer pieces and is displaceable relative to the inner portion as to axial position or height. Preferably the two portions of the guide body are resiliently pressed against each other in the vertical direction and are displaceable relative to each other by means of screw bolts. By using the known micrometer spindles instead of the screw bolts, a great accuracy can be attained with respect to the adjustment in height of the spacer pieces and hence with respect to the thickness of the wafers to be lapped.

The above-mentioned objects, advantages and features of the invention will be more fully understood from the following description in conjunction with the drawing in which:

Fig. 1 is a partial sectional view of the above-mentioned known single-disc lapping machine.

Fig. 2 shows a corresponding sectional view of a machine according to the invention.

Fig. 2*a* represents in cross section a portion of Fig. 2 on an enlarged scale, and

Fig. 3 is a plan view of a similar but somewhat modified machine.

In the machine, according to Fig. 1, a guide ring **2** glides on a lapping table **3** which rotates about a vertical axis schematically indicated at **4**. The wafer workpieces **5** to be grounded are located within the guide ring **2** in uniform distribution and are pressed against the lapping table by a weight **6** placed upon an intermediate disc **7** of felt. The guide ring **2** is kept in proper position by a pivot pin **8** mounted on the stationary machine frame structure. The rotating motion of the lapping table **3** causes the guide ring **2** to rotate about the pivot pin **8**. As illustrated, the guide ring **2** projects beyond the outer and inner peripheries of the plane annular top surface of the lapping table **3** and thus affords uniform wear of the planar grinding surfaces.

The machine according to the invention shown in Fig. 2 is likewise provided with a single lapping disc **3** rotating about the vertical axis **4** when in operation. The guiding body for the wafer workpieces **5** comprises an inner portion **11** and an outer portion **12**. The wafers **5**, which preferably are previously lapped on one side thereof, are fastened at their machined side to the planar bottom surface of the inner portion **11**, for example by means of an adhesive. The unfinished side of the workpieces **5** rests upon the planar grinding surface of the lapping disc **3**. The inner portion **11** and the outer portion **12** of the guiding structure are connected with each other by spring sleeves **13**, which press the two portions vertically against each other while centrally located guide pins **14** provide some guidance.

The outer ring-shaped portion **12** has an annular planar surface to which a number of spacer pieces **15** are fastened. These pieces consist preferably of hard metal such as mentioned above.

The adjustment in height between the two portions **11** and **12** of the guide body is effected by means of micrometer screws **16** whose nut portions are fastened, for example by set screws **17**, in bores of a shoulder flange on the inner guide portion **11**. The counter bearings for the micrometers are formed by respective steel balls **18** mounted in cavities of the outer ring portion **12**. For providing an unequivocal three-point engagement, it is preferable to use three micrometer screws **16** uniformly distributed about the axis of the guide ring. For reasons of symmetry, it is further preferable to provide three spring sleeves **13** which are likewise uniformly distributed along the periphery of the guide structure as is apparent from Fig. 3. The portions of the guide structure are preferably circular and occupy, in totality, the same place as the guide ring **2** described above with reference to Fig. 1. The composite guide body according to Fig. 2 is centrally guided for rotation on a pivot pin **8**. The construction of the spring sleeves **13** and the guide pins **14** is apparent from Fig. 2*a*. The spring sleeve **13** consists of an elongated inner portion **13***a* which forms the sleeve proper and is fastened in the inner portion **11** of the guide body by means of a screw thread. The sleeve further comprises a cap **13***b*. The spring **13***c* within the sleeve pushes a washer **13***d* against a nut **13***e* on the upper end of the guide pin **14**. Thus the guide pin **14** is pressed upwardly and hence also the outer portion **12** of the guide body into which the guide pin **14** is screwed. This imparts to the pin **14** some guidance in the bottom of the elongated portion **13***a* of the spring sleeve. In this manner, the parts **11** and **12** are pressed against each other in the vertical direction. Due to the counter action of the micrometer screws **16**, they are kept in the desired distance from each other.

The top view shown in Fig. 3, illustrating most of the features described above with reference to Fig. 2, represents a modified machine in which the guide structures are not journalled by means of a central pivot but by rollers **20** which engage the outer periphery of the annular portion **11** and keep the guide body in proper rotational position with respect to the lapping table **3**. The use of such rollers facilitates mounting the guide structures onto the table or disassembling them therefrom. The rollers **20** are journalled on holder plates **21** which can be adjusted by means of a set screw that passes through an elongated slot **22** and engages a part (not illustrated) firmly joined with the stationary frame structure of the lapping machine.

In the zero position, shown in Fig. 2, the planar front face of the inner portion **11** and the free planar sides of the spacer pieces **15** are located in one and the same radial plane. This starting position can be produced with great accuracy by an initial, idle grinding operation. Prior to the lapping operation, the workpieces, consisting of semiconductor wafers that are plane on one side, are fastened at their planar side to the underside of the portion **11**, preferably by means of an adhesive. The outer portion **12** is then displaced downwardly by means of the micrometer screws **16** an amount corresponding to the prescribed wafer thickness. The micrometer screws **16** are preferably such that they require considerable force for adjustment so that inadvertent displacements are avoided. After the outer portion **12** is thus displaced downwardly toward the grinding surface of the lapping table **3**, the machine is set in operation.

While the semiconductor wafers are ground down to smaller thickness, the spacer pieces **15** ultimately abut against the table surface. When this occurs the prescribed wafer thickness is obtained. Since the spacer pieces are extremely hard, any further reduction in thickness of the workpieces is impeded to such an extent that no excessive reduction need be feared. The engagement of the spacer pieces with the table surface can readily be observed optically. After the occurrence of engagement is observed the lapping operation is preferably continued for a short interval of time in order to make certain that all workpieces are machined down to prescribed thickness.

Since during the lapping operation with the aid of a guide body according to the invention, the workpieces do not reach the edges of the lapping table, the accurately planar shape of the table surface can be preserved by providing the machine at least at one location with a guiding ring **2** with which such machines were originally equipped and of which one is shown in Fig. 1. This guiding ring **2** may run idle or may also be used in the known manner for lapping purposes. In lieu thereof, or in addition thereto, the lapping table can also be kept in planar condition by inserting between active runs of the machine an idle run in which the original guiding rings are inserted. In a similar manner, the original planar condition of the surfaces on portion **11** of the guide body can be reconditioned from time to time by an idle grinding run in which the micrometer screws are set to zero position.

I claim:

1. Single-disc lapping machine for producing semiconductor wafers of predetermined slight thickness, comprising a lapping disc having a lapping surface and mounted for rotation about a vertical axis, guide ring means disposed eccentrically to said lapping disc surface, means for supporting said guide ring means spaced from and laterally fixed relative to said vertical axis for rotation about other respective vertical axes in moving relation to said surface, said guide ring means being adapted for retaining workpieces of semiconductor material therewithin during the lapping operation, means within said guide ring means for pressing said workpieces against said lapping disc surface, said guide ring means comprising a guide body having a planar surface on the underside thereof for receiving said workpieces to be removably fastened thereto, and a plurality of spacer pieces carried by said guide body for spacing said guide body from said lapping disc surface to determine the final lapping thickness of said workpieces, said guide body comprising an inner portion for carrying the workpieces to be lapped and an outer portion for carrying said spacer pieces, biasing means resiliently pressing said inner portion and said outer portion toward each other, and screw means for displacing said outer portion in height relative to said inner portion and relative to said lapping disc surface.

2. A single-disc lapping machine according to claim 1, said screw means comprising a micrometer device for measuring and adjusting the relative displacement in height between said inner and outer portions of said guide body and for moving said outer portion relative to said lapping disc surface.

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