NASA CASE NO. NPO-15,539

PRINT FIG. 1

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NRO-JPL

303,670
9/18/81

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AWARDS ABSTRACT

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~~JPL Case No. 15530~~
NASA Case No. NPO-15539-1

Employer : Caltech/JPL
Pasadena, CA

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Serial No. 303,670
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SCRIBER FOR SILICON WAFERS

The invention relates to a method and apparatus for dividing silicon wafers into a plurality of rectangular chips without a need for lubricants and/or coolants.

A method and device for dividing silicon wafers into rectangular chips. The device is characterized by a base 12 including a horizontally oriented bed 16 having a planar support surface, a vacuum chuck 18 adapted to capture a silicon wafer W seated on said support and supported thereby for translation in mutually perpendicular directions, a stylus support 110 mounted on the bed including a shaft 12 disposed above and extended across the bed and a truck 16 mounted on the shaft and supported thereby for linear translation along a path extended across the bed, a vertically oriented scribe 120 including a diamond tip supported by the truck adapted to engage a silicon wafer captured by the chuck and positioned therebeneath for forming score lines in the surface of the wafer as linear translation is imparted to the truck, and chuck positioning means mounted on the base and connected to the chuck for positioning the chuck relative to the stylus.

Through the use of the invention, it has been found possible to provide a simple device which readily can be employed in separating and dividing silicon wafers into rectangular chips without a need for lubricants, coolants, and the like, as commonly used with diamond saws or a use of bonding materials, having a propensity to contaminate the chips.

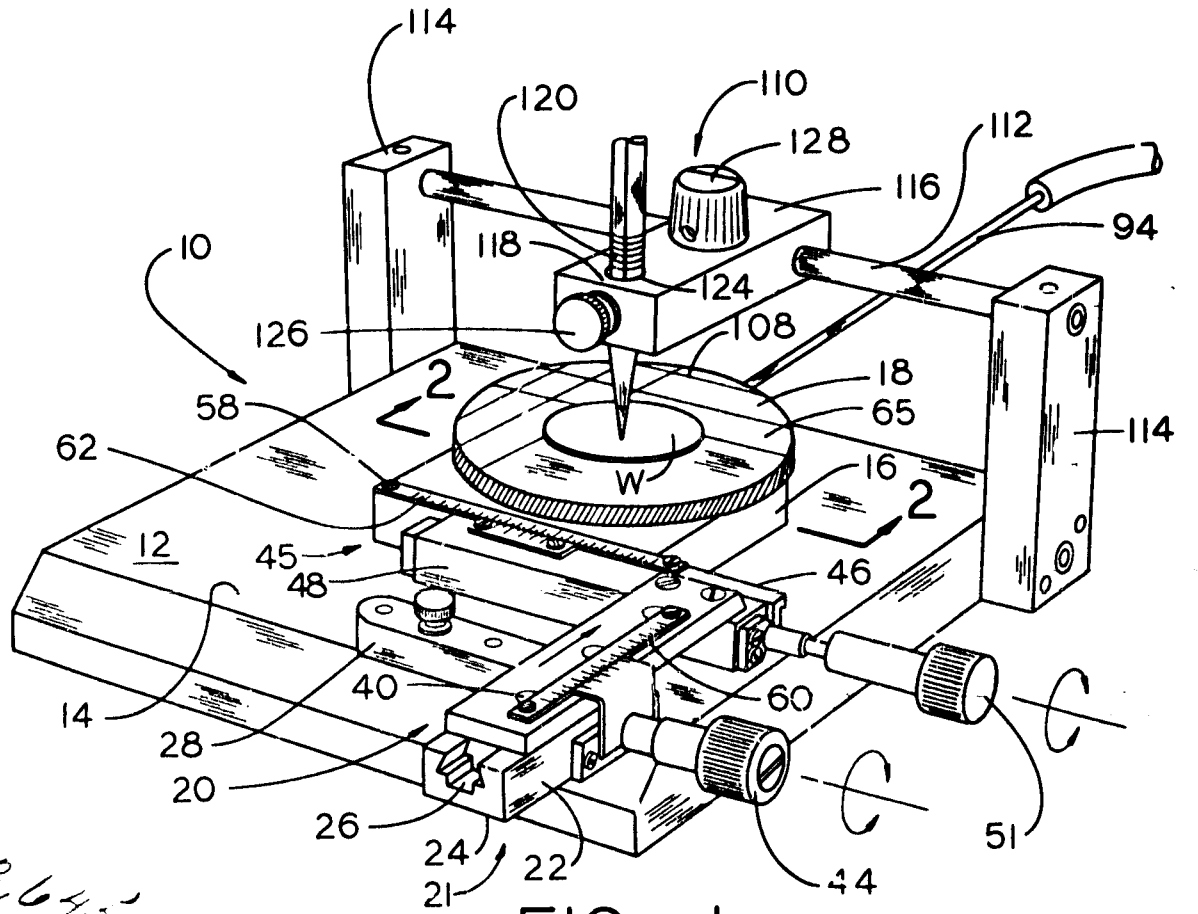

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FIG. 1

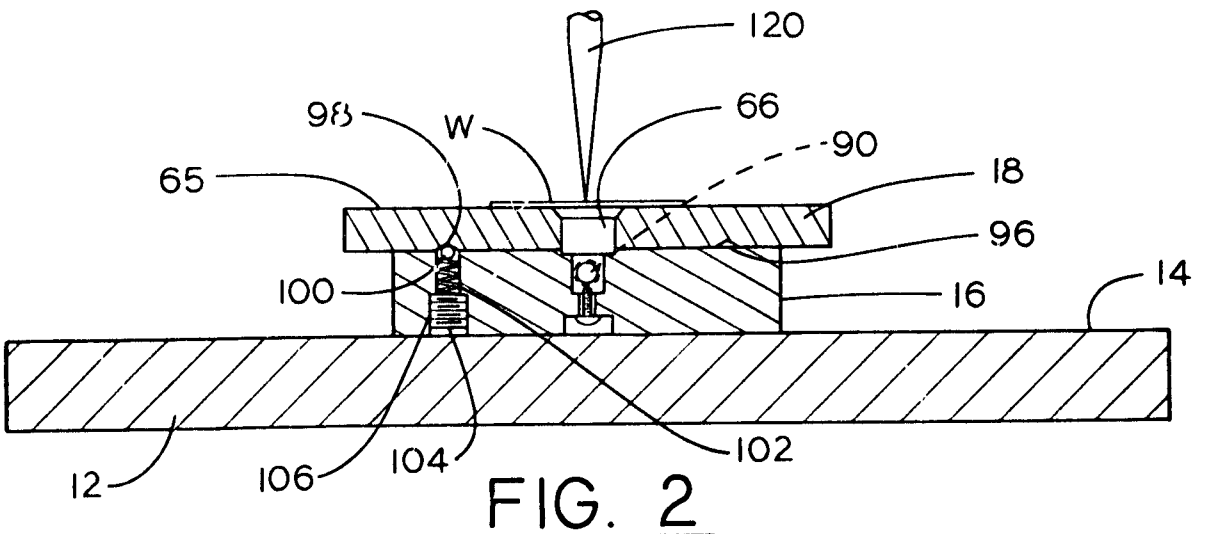

FIG. 2

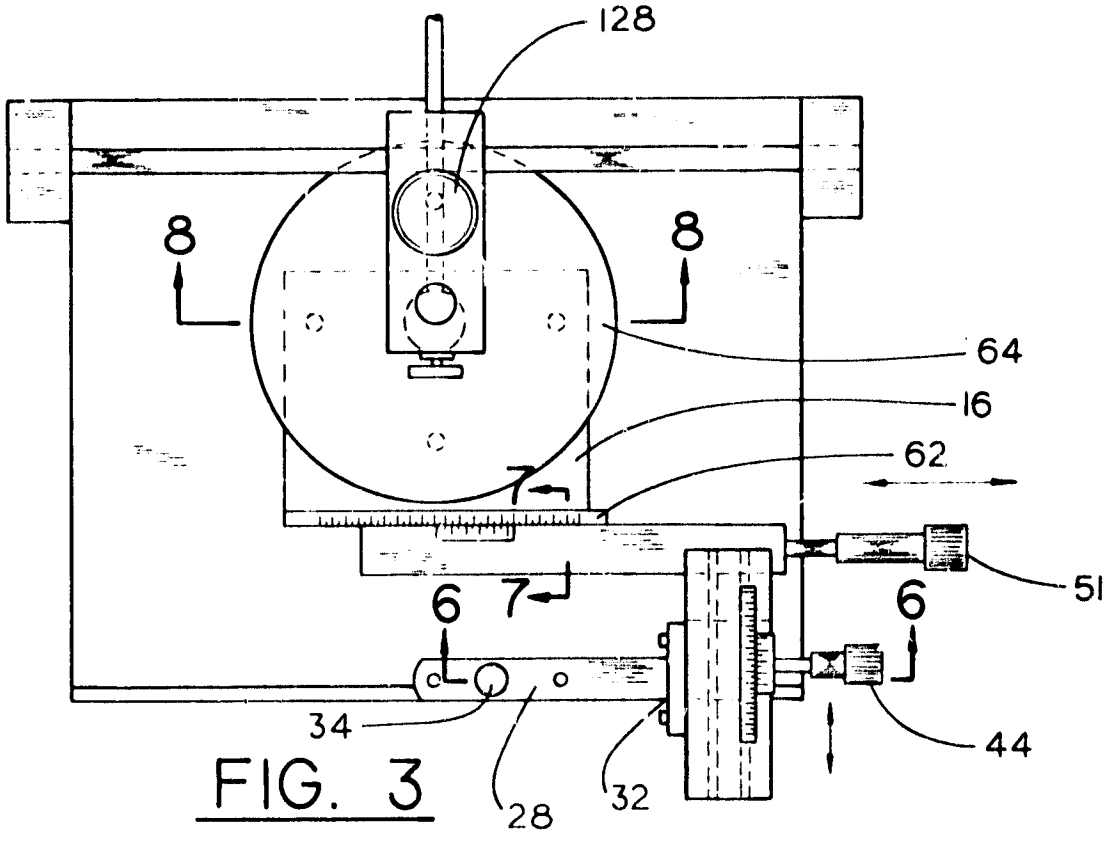

FIG. 3

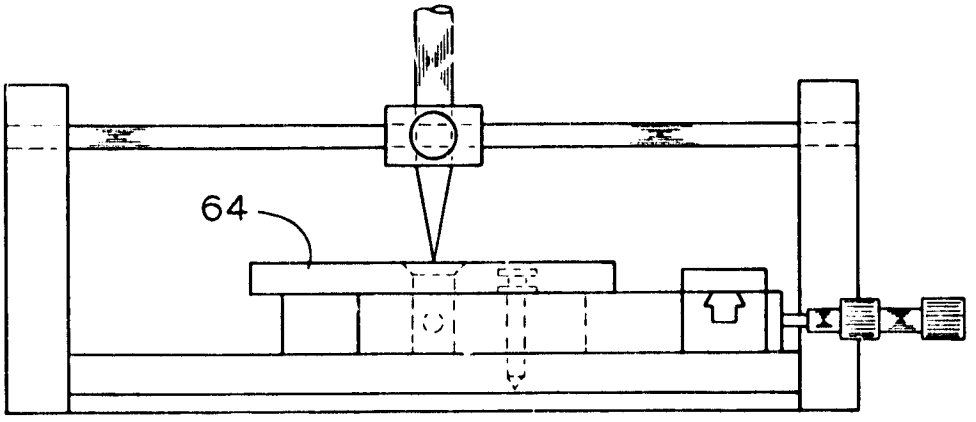

FIG. 4

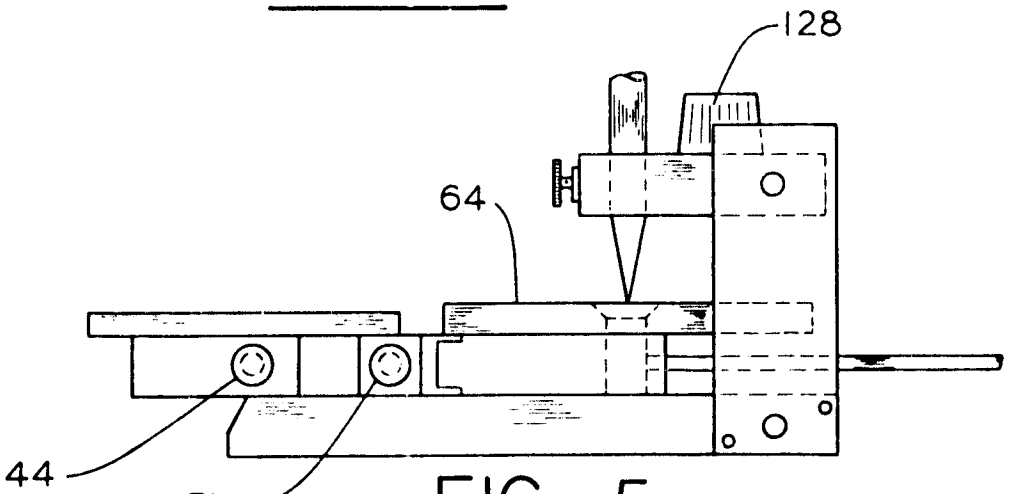

FIG. 5

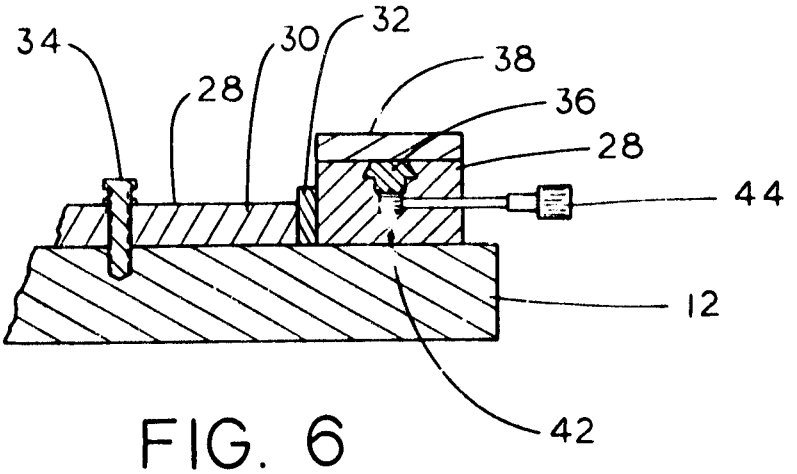

FIG. 6

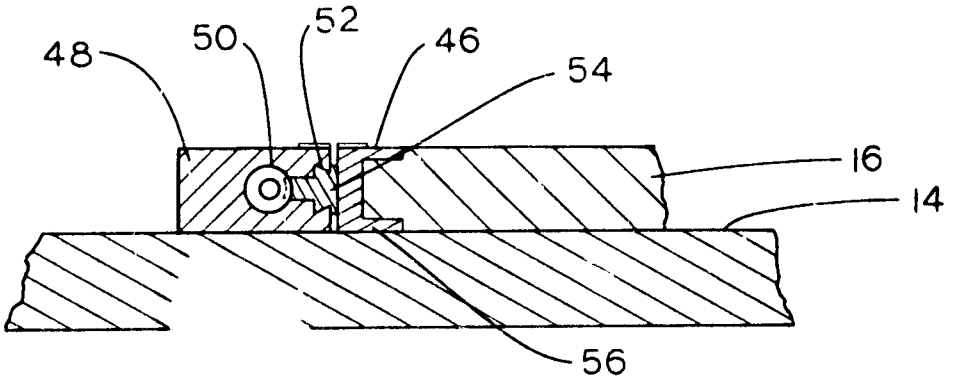

FIG. 7

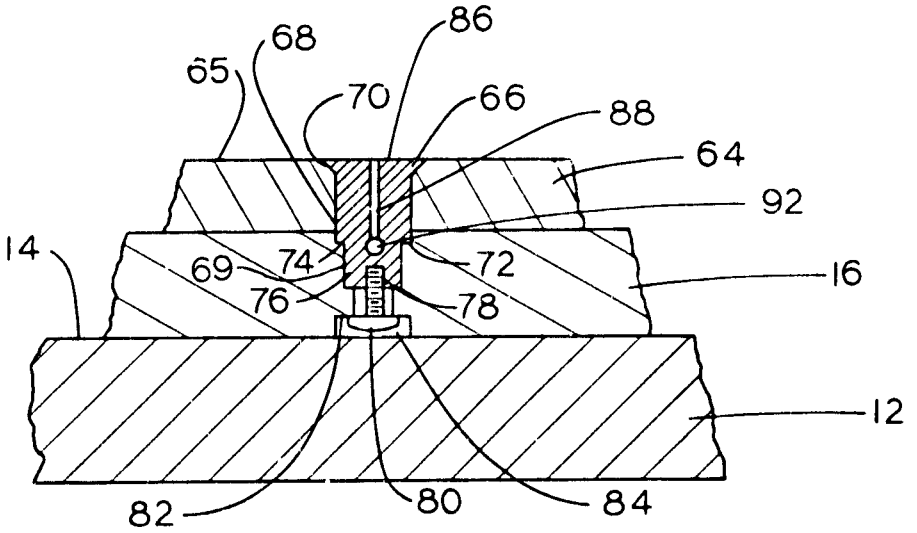

FIG. 8

~~JPL Case No. 15539~~
NASA Case No. NPO-15539

S P E C I F I C A T I O N

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT Kazuo A. Yamakawa and Edward P. Fortier are citizens of the United States of America, residing at Monterey Park and La Crescenta, respectively, both County of Los Angeles, State of California, have invented a new and useful

SCRIBER FOR SILICON WAFERS

of which the following is a specification:

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA Contract and is subject to the provisions of Section 305 of the National Aeronautics & Space Act of 1958, Public Law 85-568 (72 STAT 435; U.S.C. 2457).

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The invention generally relates to a method and apparatus for dividing silicon wafers into a plurality of rectangular chips without a need for lubricants and/or coolants.

2. Description of the Prior Art:

Silicon wafers "sliced" from boules tend to be extremely brittle and often fracture under normal handling conditions. Heretofore, when dividing wafers into rectangular chips, it has been common practice to utilize diamond saws. As can be appreciated by those familiar with

such techniques, lubricants and coolants generally are required for cooling the diamond saws during the division of the wafers. Such lubricants or coolants frequently contaminate or degrade the resulting chips rendering them unfit for certain purposes, typified by testing operations.

As a consequence of the aforementioned inadequacies of the prior art devices and techniques utilized in separating silicon wafers into chips, it should be apparent that there currently exists a need for a simple and practical method and device which readily can be employed in accurately and safely separating silicon wafers into rectangular chips, without requiring a use of lubricants or coolants, as is commonly employed when utilizing diamond saws for this purpose.

During the course of a preliminary search conducted for the invention hereinafter more fully described, the patents listed on the enclosed Form PTO-1449 were discovered. It is believed that the patent containing the most pertinent teaching discovered in the course of the search is United States Letters Patent No. 3,545,325 which discloses a frame containing a plurality of mutually spaced saw blades, defining a blade pack employed for sawing wafers into chips. While this patent mentions that "scribing" of a wafer, preparatory to breaking, is known in the prior art, it is clear that this patent fails to disclose structure suitable for readily and safely scribing wafers.

It is therefore the general purpose of the instant invention to provide a simple device which readily can be employed in separating and dividing silicon wafers into rectangular chips without a need for lubricants, coolants, and the like, as commonly used with diamond saws, or a use of bonding materials, having a propensity to contaminate the chips.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved method for dividing silicon wafers into rectangular chips.

It is another object to provide an improved device for use in dividing silicon wafers into rectangular chips without a need for lubricants or coolants.

It is another object to provide a device particularly adapted for manually separating silicon wafers into rectangular chips.

It is another object to provide a simplified manually operable device which is particularly adapted for use in separating silicon wafers into rectantular chips without requiring the use of lubricants, coolants, and the like, which tend to contaminate or otherwise degrade the resultant chips.

These and other objects and advantages are achieved through the use of a device characterized by a method and device characterized by a base including a horizontally oriented bed having a planar support surface, a vacuum chuck adapted to capture a silicon wafer seated on said support and supported thereby for translation in mutually perpendicular directions, a diamond-tipped stylus supported by a shaft disposed above and extended across the bed and a carriage mounted on the shaft and supported thereby for linear translation along a linear path adapted to engage a silicon wafer captured by the chuck and positioned therebeneath for forming parallel lines in the surface of the wafer as linear translation is imparted to the carriage.

DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a device embodying the principles of the instant invention.

Fig. 2 is a cross-sectional view taken generally along lines 2-2 of Fig. 1.

Fig. 3 is a top plan view of the device.

Fig. 4 is a side elevational view of the device.

Fig. 5 is a side elevational view of the device, taken at 90° with respect to the view shown in Fig. 4.

Fig. 6 is a cross-sectional view taken generally along lines 6-6 of Fig. 3.

Fig. 7 is a cross-sectional view taken generally along lines 7-7 of Fig. 3.

Fig. 8 is a cross-sectional view taken generally along lines 8-8 of Fig. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, with more particularity, wherein like reference characters designate like or corresponding parts throughout the several views, there is shown in Fig. 1 a device, gererally designated 10, which embodies the principles of the instant invention.

The device 10 includes a base 12 having an upper, planar surface 14 characterized by a coefficient of friction substantially consistent with that of a bearing surface. Seated on the planar surface 14 is a translatable bed 16, the purpose of which is to support a rotatable vacuum chuck 18.

The position of the bed 16 is controlled through an X-Y positioning system, generally designated 20. This system includes a first positioning assembly 21. In order to reposition the bed 16 in a Y direction, the positioning system 21 is provided with a first drive mechanism 22. This mechanism includes a base 24 having a way 26 of a dovetail configuration machined therein and extended in the Y direction, relative to the bed 16. The base 24, as shown, is secured in place by an anchor assembly 28 of a T-bar design. As shown in Fig. 6, the anchor assembly 28 includes a base plate 30, Fig. 6, welded or otherwise rigidly secured to a traverse bar 32 bolted or otherwise rigidly secured to the

base 24.

The base plate 30, in turn, is positionally supported by a lock-screw 34 threaded to the base 12, as also shown in Fig. 6. While only one lock-screw 34 is shown, it is apparent that additional lock-screws may be employed where so desired. Moreover, suitable and mutually spaced apertures, not designated, are formed in the plate 30 in order to accommodate a repositioning of the plate in order to facilitate a lateral repositioning of the drive assembly.

Seated in the way 26, Fig. 6, is a tongue 36 configured to mate with the configuration of the way 26, in a conventional fashion, for securing the tongue against vertical displacement while accommodating linear displacement thereof. Affixed to the upper surface of the tongue 36, is a drive plate 38. Suitable screws 40 are employed in securing the drive plate 38 to the tongue 36 and projects linearly therefrom. Beneath the tongue 36 there is a rack and pinion drive assembly, generally designated 42, of suitable design. As shown, the drive assembly 42 includes a thumb screw 44, the purpose of which is to advance and retract the tongue 36, upon manipulation of the thumb screw 44, so that the plate 38 is advanced and retracted in a Y direction with respect to the base 24.

In order to reposition the bed 16 in an X direction, there is provided a second positioning system 45 connected to the first positioning assembly 21, through the plate 38. At the projected end of the drive plate 38, there is affixed, through the use of screws or the like, a second drive mechanism 46. The mechanism 46 includes a base within which a worm-gear drive assembly 50 is mounted, Fig. 7, the purpose of which will hereinafter become clear. The base 48 also includes a way of a suitable dovetail configuration, designated 52, having seated therein a tongue 54 configured to be received by the way 52 in secured relation therewith. The tongue 54 is supported for linear displacement in an X

direction relative to the bed 12.

The tongue 54 is affixed to a plate 46, Fig. 7, which is in turn connected with the bed 16 through suitable coupling means, including fasteners, such as screws 58 or the like. Linear motion is imparted to the tongue 54 and thus the bed 16, through a manipulation of the thumb screw 51 which serves to activate worm-gear drive assembly 50, aforementioned, for advancing or retracting the tongue. Consequently, a positioning of the bed 16 in an X direction, perpendicularly with respect to the Y direction, is readily accommodated through a manipulation of the thumb screw 44.

A vernier scale 60 is employed for purposes of measuring incremental displacement of the bed in a Y direction while a similar scale 62 is provided for measuring displacement of the bed 16 in an X direction. It should now be apparent that the bed 16 is secured to the base 12 through the X-Y positioning system 20 and changes in the position of the bed 16 along the surface 14 readily is facilitated through a manipulation of the thumb screws 44 and 41. The distances through which the bed is moved may be determined through a use of the vernier scales 60 and 62.

Rotatably mounted on the bed 16 is a vacuum chuck 64. The vacuum chuck 64 is of a generally disk-shaped configuration and includes a planar surface 65 for receiving thereon a silicon wafer W, Fig. 1. Extended vertically through the vacuum chuck 64 is a ported center pin 66, best illustrated in Fig. 8, the purpose of which is to unite the vacuum chuck 64 with the bed 16 and to accommodate an application of a vacuum to the underside of a silicon wafer W supported by the surface 65 of the chuck, Fig. 2.

The pin 66 is provided with a flat head configured to be received in a countersunk bore. A bore 68, having a countersunk entrance 70, is extended through the chuck 64, along the axis thereof, and serves to receive the pin 66 in a manner such that the vacuum chuck 64 may be rotated about

the pin without imparting angular displacement thereto. Thus the pin 66 also functions as a bearing pin.

With reference to Fig. 8, it can be seen that the bed 16 also includes a bore 69 of multiple diameters defining segments having progressively dimensioned diameters with annular shoulders being defined at the junctions thereof.

The pin 66 includes an annular shoulder 72 received within a relief 74 formed by the upper segment of the bore 69. Extended downwardly from the shoulder 72 of the pin there is a segment 76 the purpose of which is to afford a coupling of the pin with the bed 16. The distal end of the segment 76 rests on an annular shoulder separating the upper segment of the bore 69 from its adjacent segment. At the distal end of the pin 66 there is provided an internally threaded axial bore 78 which serves to receive a screw 80 projected axially upwardly into the bore 69. The screw includes a pan head seated on a shoulder 82 defined in a relief 84 provided by a terminal segment of the bore 69.

It is important to appreciate that the depth of the relief 84 is such that the pan head screw does not engage the upper surface 14 of the bed 16 as motion is imparted to the bed 16 via the X-Y positioning system 20. It is also to be understood that simply by tightening the screw 80, for thus threading the screw into the internally threaded bore 78, the pin 66 is drawn into a snug engagement with the shoulder 72, as well as with the surface of the countersunk relief 70. When properly assembled, the upper surface of the pin, designated 86, is flush with the surface 65, whereby an air-tight seal may be established between the surface 65 and the flat lowermost surface of a wafer W resting on the surface 65.

The pin 66 includes a vertical air passage 88 through which a vacuum is drawn between the surface 65 and the lowermost surface of the wafer W. The air passage 88 communicates with a source of vacuum, not shown, via a

radial aperture 90 defined in the pin 66 and disposed in communicating relation with the air passage 88, as well as a port 92 connected with a tubular conduit 94 which in turn is connected with the source of vacuum. Consequently, once vacuum is applied to the conduit 94, air is drawn from the passage 88, via the port 92 and the aperture 90. Thus a vacuum is applied to the undersurface of a wafer W seated on the surface 65 of the chuck 64, as illustrated in Fig. 2. It will be appreciated, of course, that the conduit 94 includes suitable lengths of flexible tubing, not designated, sufficient to accommodate motion of the bed 16.

In order to limit rotation of the vacuum chuck 18 to 90° of angular displacement, detents 96 and 98, Fig. 2, are provided at the undersurface of the chuck 18. These detents receive a ball 100 which serves as a releasable stop for the chuck. The ball 100 compreises a spring-loaded ball, spring-biased by spring 102. A set screw 104 is threaded into an internally threaded bore 106 for securing the spring in place.

It will now be appreciated that the chuck 18 having captured thereon a wafer W may be rotated through 90° for purposes of accommodating a scribing of the upper surface of the wafer in a manner hereinafter more fully described. Additionally, it should be noted that the upper surface 65 of the chuck is provided with orthagonally related score lines 108 which serve as optical guides when positioning the wafer W relative to a stylus, generally designated 110, utilized for scribing lines on the upper surface of a wafer W as it is supported by the chuck.

The stylus 110 is supported for translation by a traverse rod 112 mounted on vertical supports 114, located at each of its opposite ends and secured to the base 12. The particular manner in which the traverse rod 112 is connected with the vertical supports is deemed a manrer of convenience only. However, suitable, axially aligned bores

formed in the supports may be employed for this purpose, as shown. Similarly, the particular manner in which the vertical supports are connected with the base 12 also is deemed a matter of convenience and is varied as desired.

The stylus 110 includes a block, comprising a truck 116, having a bore, not designated, extended therethrough for receiving the traverse rod 112 in sliding engagement. The truck 116 extends perpendicularly from the traverse rod 112 and is provided with a receptacle 118 for an elongated scribe 120. The scribe 120 extends through a vertical bore 124, formed in the truck 116, downwardly into engagement with the upper surface of the wafer W seated on the vacuum chuck 18. A set screw 126 is utilized for securing the scribe with respect to the truck 116. Additionally, it is to be understood that the scribe 120 comprises a diamond-tipped scribe having a capability of scoring the surface of the wafer W as it is captured and supported by the vacuum chuck 18. A hand-knob 128 is mounted on the truck 116 and provides a suitable means for accommodating a manual grasping of the truck for imparting linear displacement thereto along the traverse rod 112.

OPERATION

It is believed that in view of the foregoing description, the operation of the device will readily be understood and it will be briefly reviewed at this point.

With the device 10 assembled in the manner hereinbefore described, it is prepared for operation simply by seating the wafer W on the upper surface 65 of the vacuum chuck 64 in coaxial alignment with the air passage 88 formed in the pin 66. Vacuum is now drawn down in the passage 88, through the port 92, aperture 90 and conduit 94. Thus the wafer 10 is secured to the upper surface of the vacuum chuck 18. The vacuum chuck is now positioned beneath the tip of the scribe 120 of the stylus 110 through a manipulation of

the thumb screws 44 and 51 until the diamond tip of the stylus 120 approaches a desired starting point along the radius of the wafer, preferably the center of the wafer. Once a proper position is established between the wafer and the stylus, the stylus is drawn across the surface of the wafer simply by grasping the knob 128 and forcing the truck 116 to advance along the traverse rod 112. A suitable number of passes is made with the stylus thus to form a score line on the surface of the wafer. Having thus formed a first score line, the stylus is raised, the thumb screw 44 is manipulated for repositioning the wafer beneath the stylus in a manner such that a further score line may be formed in parallelism with the first score line. The truck 116 is again advanced for drawing the diamond tip of the scribe along the surface of the wafer W for thus forming a second score line across the upper surface of the wafer W. This operation is continued until a multiplicity of parallel score lines, mutually spaced, have been formed across the upper surface of the wafer W. The distance between the score lines may be uniform or varied as desired.

Having completed the formation of a plurality of parallel score lines across the upper surface of the wafer W, the chuck 18 is rotated through 90°, determined by the stop formed by the spring-loaded ball and detent. A multiplicity of score lines perpendicular to the score lines aforementioned are now formed on the upper surface of the wafer employing the technique herein aforedescribed. Once the multiplicity of perpendicular score lines have been formed in the upper surface of the wafer W, the vacuum is released, the wafer lifted and separated by a simple breaking technique, preferably manual, which divides the wafer into a multiplicity of rectangular chips, determined by the number of score lines formed on the wafer.

In view of the foregoing, it is believed that the instant invention provides a practical solution to many of

the problems heretofore encountered when attempting to separate or divide silicon wafers into chips.

ABSTRACT OF THE DISCLOSURE

A method and device for dividing silicon wafers into rectangular chips. The device is characterized by a base 12 including a horizontally oriented bed 16 having a planar support surface, a vacuum chuck 18 adapted to capture a silicon wafer W seated on said support and supported thereby for translation in mutually perpendicular directions, a stylus 110 support mounted on the bed including a shaft 12 disposed above and extended across the bed and a truck 16 mounted on the shaft and supported thereby for linear translation along a path extended across the bed, a vertically oriented scribe 120 including a diamond tip supported by the truck adapted to engage a silicon wafer captured by the chuck and positioned therebeneath for forming score lines in the surface of the wafer as linear translation is imparted to the truck, and chuck positioning means mounted on the base and connected to the chuck for positioning the chuck relative to the stylus.