An improved apparatus for examining the crystal lattice of a semiconductor wafer utilizing x-ray diffraction techniques. The apparatus is employed in a method which includes the step of recording the image of a wafer supported in a bent configuration conforming to a compound curve, produced through the use of a vacuum chuck provided for an x-ray camera while the entire surface thereof is illuminated simultaneously by a beam of incident x-rays which are projected from a distant point-source and satisfy conditions of the Bragg Law for all points on the surface of the wafer.
Although numerous attempts have been made to identify lattice defects using x-ray diffraction, no totally satisfactory solution has resulted from these efforts. For example, the Berg-Barrett technique was first introduced about 1945 in which diffracted rays are caused to leave specimens on the same side as the incoming rays enter. In most current applications of this technique, the specimen and the film are supported in a stationary relationship during exposure. Another technique is the so-called Lang method which was first introduced in 1959 in which the diffracted rays travel through the specimen in reaching a photographic plate. This technique normally requires the specimen and photographic plate be translated to and fro during exposure in order to form an image of a relatively large portion of the specimen. In each of the aforementioned techniques, only an extremely small portion of the total radiation from a small x-ray source is used in the production of an x-ray topograph, thus the costs per x-ray topograph are undesirably high.

Of course, one of the major reasons that x-ray topography is not more widely used as an analytical tool for detection of lattice defects in semiconductor wafers is the high cost per x-ray topograph. In addition to the foregoing reasons for high costs per topograph, high cost of production of a useful x-ray topograph also is due to factors such as the relatively expensive equipment and materials required, as well as in the production thereof, and the necessity that highly trained personnel be employed over relatively long periods.

It is therefore the general purpose of the instant invention to provide an apparatus through a use of which reductions in costs per x-ray topograph of semiconductor wafers is realized.

OBJECTS AND SUMMARY OF THE INVENTION

An object of the invention is to provide an economic apparatus for use in examining the crystal lattice of semiconductor wafers.

It is another object to provide a simple, economic device particularly suited for use in topographically examining the crystal lattice of semiconductor wafers for defects introduced during the production thereof.

It is another object to provide in an apparatus for use in producing an x-ray topograph of a semiconductor wafer a step through which a Rowland focusing condition is achieved by bending the wafer to a compound curved configuration.

It is another object to provide a chuck for use with a topographic camera in which a semiconductor wafer is bent to a compound curved configuration and supported in its bent configuration as x-ray diffraction is employed in examining the lattice defects thereof.

It is another object to provide an improved chuck for bending a semiconductor wafer and supporting the bent wafer in a beam of incident x-rays.

These and other objects and advantages are achieved through a use of a chuck having a vacuum chamber for deforming a semiconductor wafer and supporting the deformed wafer in a beam of incident x-rays, whereby a Rowland focusing condition for x-ray topography is achieved by bending the wafer itself, as will hereinafter become more readily apparent by reference to the following description and claims and in light of the accompanying drawings.
of achieving a coupling of the chuck 16 to the receiver 20, the chuck is provided with a cylindrical base 26 having an outside diameter substantially equal to the inside diameter of the chamber 22, whereby a friction fit coupling therebetween is achievable. An O-ring 28 is interposed between the contiguous surfaces of the chuck and receiver in a suitably formed groove, not designated. Thus the chuck 16 is supported by the receiver for rotation about an axis, designated A, FIG. 4, passing axially through the wafer W. It is to be understood that the receiver 20 is suitably mounted on a plate 30 affixed to a base 32, by means not shown, so that the chuck 16 is supported to be rotated about an axis, not designated, passing through the wafer's center, perpendicular to the plane of the drawing. Thus the chuck is supported for rotation about a pair of perpendicularly related axes passing through the wafer's center for accommodating Bragg scattering.

The chuck 16 includes a retainer 34 defined by an annular lip 36. Symmetrically related with the axis A is a dish-shaped relief 40, defined by a curved surface 42. The surface 42 is of a compound curved configuration having a singular radius of curvature. Where desired, the surface is of a spiral cross section configuration conforming to a specific curvature for purposes of satisfying Bragg conditions at all points on the surface thereof for rays diverging from a distant point-source.

Adapted to be seated in the retainer 34, spanning the relief 40, is a flexible mount 44 which cooperates with the relief 40 to define a vacuum chamber, not designated. The mount 44, preferably, comprises a disc of 150 inch plexiglass, sufficiently flexible to permit it to attain a compound curved configuration having a continuously variable radius of curvature decreasing from infinity to substantially that of the relief 40, in response to a vacuum introduced into the vacuum chamber. This accommodates custom bending of wafers of a variety of crystallographic orientations for satisfying the Rowland condition for some set of diffracting planes. Disposed in an annular array in concentric relation with the center portion of the mount 44 there is a plurality of apertures 46 through which atmosphere is drawn as a vacuum is introduced into the chamber 40. It is important here to understand that the diameter of the array of apertures is slightly less than the diameter of a wafer W to be supported by the mount 44. Thus the apertures 46 are arranged to be positioned near the periphery of the wafer W as the wafer is mounted in the chuck 16.

It should be apparent that as a vacuum is introduced into the chamber 40 a wafer positioned in contiguous relation with the face of the mount 44, in coaxial alignment with the array of apertures 46, will be caused to adhere to the surface of the mount in response to the vacuum introduced between the juxtaposed surfaces of the wafer and the mount.

In order to introduce a vacuum into the chamber 40, the chamber 22 of the receiver 20 is slightly recessed, whereby a plenum chamber, not designated, is caused to be defined in the bottom of the chamber, as best shown in FIG. 4. The chamber 22 is connected in communication with a suitable source of vacuum, not designated, by a tubular conduit 48. The conduit 48 is connected to the receiver 20, by a suitable fitting 50, so that the chamber 22 may be readily vacuumized as a vacuum is introduced therein via the conduit 48.

Similarly, the chuck 16 includes a bore 52 forming a conduit extending between the recess of chamber 22 and the relief 40. Consequently, as a vacuum is drawn-
down in the chamber 22, the resulting vacuum is introduced into the relief 40, via the conduit 52. It will be appreciated that the vacuum is responsively applied through the array of apertures 46 to the face of the wafer W for holding the wafer in a face-to-face relationship with the mount 44. Thus the wafer continuously is caused to assume substantially any configuration assumed by the mount. It will, therefore, be apparent that the wafer W is deformed to a configuration corresponding to the configuration of the mount as the mount is caused to assume a configuration corresponding to the shape of the curved surface 42, as a vacuum is introduced into the relief 40.

In view of the foregoing, it should readily be apparent that the chuck 16 comprises a novel chuck particularly adapted to bend and then support a semiconductor wafer within the path of a beam of x-rays exiting a scatter tube and striking the wafer at the Bragg angle.

**OPERATION**

With the chuck 16 connected within the camera 10, in the manner herein before described, a vacuum is introduced into the chamber 22 via the conduit 48. This vacuum is introduced into the relief 40, via the conduit 52. The mount 44, positioned in the retainer 34, is retained in place in response to the pressure differentials existing at its opposite faces as the vacuum is introduced into the chamber 40. The apertures 46, of course, are occluded by a wafer W disposed in contiguous face-to-face engagement with the mount, in coaxial alignment with the array of apertures. Hence, the vacuum is applied to the face of the wafer W for purposes of affixing the wafer W to the mount.

The chuck 16 now is rotated for rotating the wafer, as required, about the two perpendicularly related axes, aforementioned, passing through the wafer's center until Bragg scattering occurs. The vacuum of the vacuum chamber now is increased until Rowland focusing is achieved. With the chuck 16 so positioned that a Bragg condition is established between the point source P and the curved surface of the wafer, the film F is positioned to intercept coherently scattered x-rays and the image of the wafer W is recorded to provide an economic topograph for use in examining the lattice defects of the wafer.

In view of the foregoing, it should be apparent that the method and apparatus embodying the instant invention provides a practical solution to the perplexing problem of obtaining an economic and practical x-ray examination of lattice defects introduced in semiconductor wafers during fabrication.

We claim:

1. In combination with an x-ray camera, an improved chuck for supporting a semiconductor for illumination by a beam of x-rays, including:

   A. a chuck having a concave vacuum chamber characterized by a compound curve configuration having a singular radius of curvature, and an annular support surface circumscribing the periphery of the vacuum chamber and circumscribed by an annular lip;

   B. a flexible support plate of a compound curve configuration seated on said annular surface having one face disposed in communicating relation with said vacuum chamber;

   C. means adapted to support a flexible wafer in contiguous relation with the opposite face of the support plate including an annular array of uniformly spaced apertures concentrically related to the center of the support plate establishing communication between said wafer and said vacuum chamber; and

   D. means for maintaining a vacuum within said vacuum chamber.