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MULTIPLE CATHODE SPUTTERING FIXTURE

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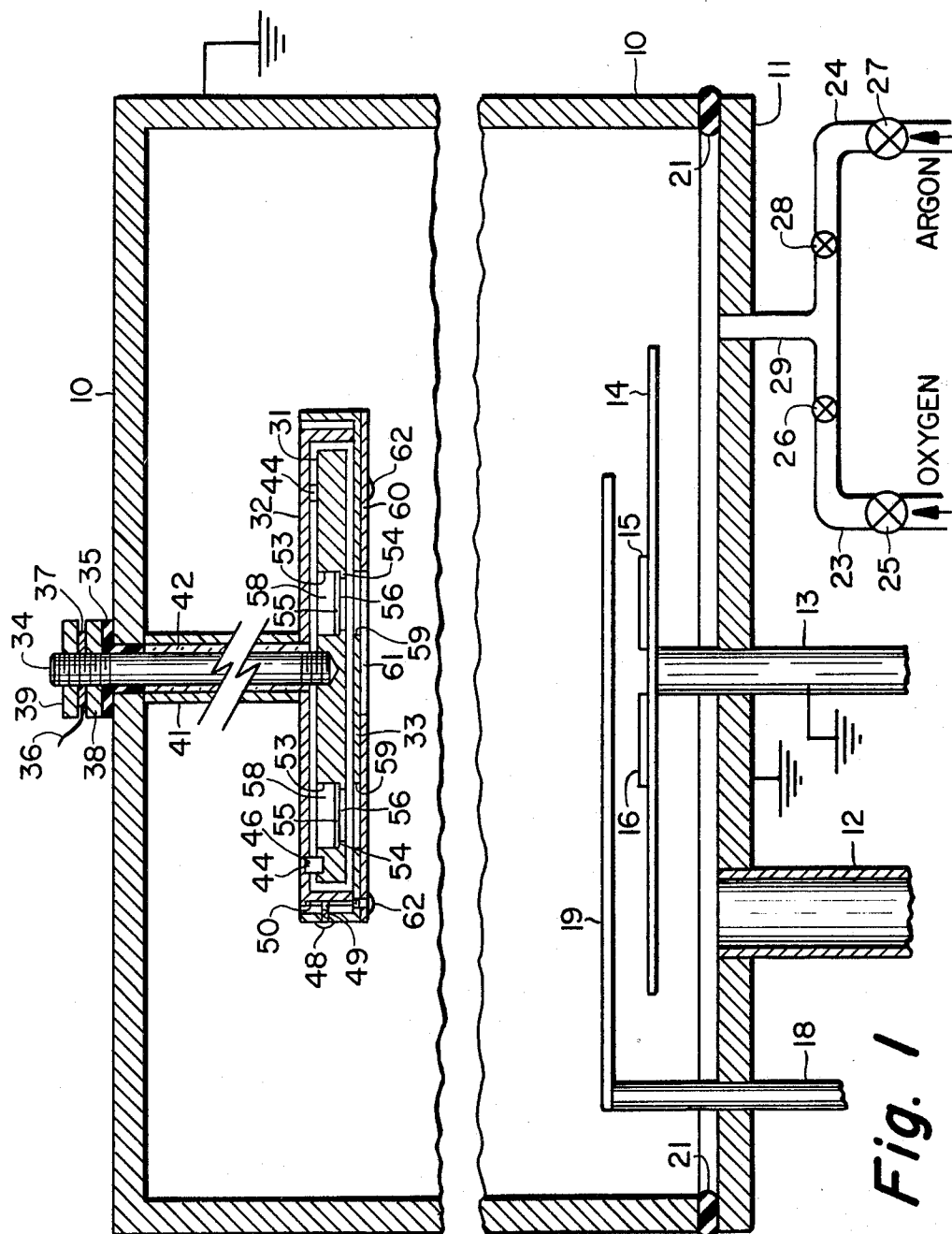


Fig. 1

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MULTIPLE CATHODE SPUTTERING FIXTURE
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ABSTRACT OF THE DISCLOSURE

A multiple cathode sputtering fixture is described which permits the simultaneous sputtering of a plurality of cathodes. Because of the simple cathode shapes accommodated by this fixture, even hard brittle materials are easily supported for sputtering. When differing cathode materials are used, thin film mixtures or alloys may be deposited.

Sputtering refers to the removal of material from a surface due to particle bombardment and is an occurrence commonly observed at the cathode in a D.C. gas discharge. A gas, which is admitted into an evacuated chamber containing anode and cathode electrodes, ionizes upon application of a voltage to the electrodes. The positive ions are attracted to and bombard the negatively charged cathode resulting in a liberation of the cathode material. This phenomenon is termed cathode sputtering. The disintegrated material leaves the cathode surface either as free atoms or in chemical combination with the residual gas molecules. Some of the liberated atoms are deposited on surfaces surrounding the cathode. This effect has been utilized to produce homogeneous thin films of elements, alloys or compounds on substrates suitably positioned within the evacuated chamber.

In a cathode sputtering apparatus the cathode may be suspended from the top of the evacuated chamber and must be connected to a source of high negative potential. Cathode materials which are mechanically strong and easily machinable can be formed into the desired shape and supported in the deposition chamber with little difficulty. For example, a piece of cathode material may be formed into a disc or a cylinder and bored and tapped on the top side thereof so that a high voltage conductive rod may be screwed therein to support the material while supplying a high voltage thereto.

However, some materials such as silicon are not compatible with the usual drill and tap or welding operations which are required to support the cathode material in the deposition chamber. Furthermore, conventional cathode support devices may lack means to provide adequate electrical contact to a semiconducting cathode material. In addition, most cathode holders can support only one piece of cathode material.

It is, therefore, an object of this invention to provide a support for a brittle cathode sputtering material.

Another object of this invention is to provide a cathode holder for a cathode sputtering apparatus which permits the simultaneous sputtering of a plurality of cathodes of identical or different materials.

A further object of this invention is to provide a multiple cathode sputtering fixture which permits the use of materials such as silicon and germanium which are not compatible with the usual drill and tap or welding operations necessary for cathode support.

Another object of this invention is to provide a support for a cathode for use in a sputtering apparatus, the cathode material being such that it is not easily formed into the usual cathode shapes.

Briefly, the cathode support according to this invention comprises a flat conductive holder having at least one hole therethrough, each hole having an inwardly projecting

flange at the bottom portion thereof. The flange defines an aperture through which cathode sputtering occurs. A conductive means is connected to the cathode holder for supporting it and for connection of a voltage thereto. Conductive shield means surrounding the cathode holder prevent sputtering from any point thereon except through the aperture at the bottom of each of the holes. A means is provided for insulating the shield from the cathode holder.

Other objects and advantages of the invention will become apparent from the following detailed description, taken in connection with the accompanying drawings, in which:

FIG. 1 is a simplified schematic elevational view, partly in section, of an apparatus for use in thin film deposition by reactive sputtering, and

FIG. 2 is an exploded view, partly in section, of the multiple cathode sputtering fixture of this invention.

The basic apparatus required for the deposition of thin films by reactive sputtering is shown in FIG. 1. The apparatus includes a suitable vacuum chamber including a conductive cylinder 10 which is disposed upon a conductive base plate 11 having a vacuum conduit 12 connected thereto. A shaft 13 which protrudes through the base member 11 rotatably supports a rotatable substrate pedestal 14 on which the substrates 15 and 16 are situated to be coated. A rotatable shaft 18 supports a shutter 19 which may extend over a major portion of the substrate pedestal 14. Suitable sealing means (not shown) surround the shafts 13 and 18 to insure a retention of a vacuum within the chamber. The cylinder 10 may be sealed to the base member 11 by an annular rubber gasket 21.

Provision is made for evacuating the vacuum chamber via the vacuum conduit 12 which is controlled by a suitable valve (not shown). Furthermore, there are represented gas feeding pipes 23 and 24 which supply gas to a feeder pipe 29 which exhausts in the vacuum chamber. The flow of gas in these pipes is regulated by the valves 25 and 27 while the valves 26 and 28 may be used as on-off valves. In addition to an inert gas such as argon, which ionizes and bombards the cathode, a reactive gas such as oxygen may be introduced into the chamber if it is desirable to deposit an oxide of the cathode material on the substrate.

The cathode support, which is suspended from the top of the cylinder 10 in FIG. 1, is also shown in an exploded view in FIG. 2. The cathode support comprises three major parts, the cathode holder 31, the upper shield 32, and the lower shield 33. These three parts may be made of a conductive material such as aluminum, which does not readily sputter. The cathode holder is suspended from the top of the cylinder 10 by a steel rod 34 which is insulated from the cylinder by a rubber bushing 35. The terminal portion 37 of a high voltage line 36 is secured to the steel rod 34 by two nuts 38 and 39 which also suspend the rod 34 from the top of the cylinder 10. An aluminum tube 41, which is insulated from the steel rod by a quartz tube 42, makes an electrical connection between the upper shield 32 and the top of the cylinder 10. Since the entire cylinder is maintained at ground potential, the shields are grounded by the aluminum tube. The cathode holder 31 is maintained at a high negative potential, since it is connected to the steel rod 34. Insulation between the holder and the shields is accomplished by maintaining the separation at all points therebetween to less than the cathode dark space for the conditions under which sputtering takes place (approximately 3 mm.). A plurality of quartz spacers 44 which are situated in holes 45 and 46 in the cathode holder 31 and the top shield 32, respectively, maintain the proper spacing between these two elements. A plurality of setscrews 48, which are screwed into holes 49 in the flanged portion of the bottom shield 33, engage a longitudinal slot 50 in the flanged portion of the top shield 32. The vertical

displacement of the bottom shield with respect to the top shield can be adjusted by varying the vertical position of the setscrew 48 in the slot 50 so that the proper spacing exists between the cathode holder 31 and the bottom shield 33.

A plurality of holes 53 located in the cathode holder 31 have inwardly projecting flanged portions 54 at the bottom thereof to retain discs of cathode material 55 which are supported therein. The annular flange 54 defines a hole 56 through which the cathode material is sputtered. A plurality of cylindrical conductive weights 58 may be inserted into the holes 53 after the cathode material 55 has been inserted therein to insure that a good ohmic contact is made to the sputtering material. Furthermore, the height of the cylinders 58 is chosen so that the tops thereof are within the cathode dark space distance from the upper shield 32 after they are inserted over the cathode material 55, so that sputtering does not take place in the upper regions of the holes 53. A plurality of holes 59 in the bottom shield 33 are aligned with the holes 56 to permit sputtering of the cathode material 55 therethrough. The setscrews 48 and the quartz spacers 44 assure orientation of the lower shield to the cathode holder so that the holes in the lower side of these two parts are properly aligned to limit sputtering to the cathode target area. When less than the total number of cathodes are used, a plate 60 may be fastened to the bottom shield by a plurality of screws 62. An aperture 61 in the plate 60 exposes less than the total number of holes in the bottom shield 33. In the disclosed embodiment, the three most centrally located holes in the shield 33 are exposed by the aperture 61.

A specific example of the use of the apparatus of FIG. 1 to deposit a thin film of silicon dioxide is as follows. The vacuum system within the cylinder 10 is maintained at a pressure of approximately 25 microns of mercury. Ambient pressure is controlled by throttling the vacuum port rather than adjusting the valves 25 and 27. Thus, the gas input remains quite constant. The cathode discs are held at about -3500 volts, resulting in a discharge condition. The gas composition is controlled to be approximately equal parts of oxygen and an inert gas such as argon. As the voltage is applied, the inert gas ionizes upon collision with the electrons accelerated by the field, and the heavy positive ions bombard the negatively charged cathodes, thereby resulting in the liberation of target material. The removed material is oxidized by the oxygen and deposits on the substrates.

Each deposition begins with a closed shutter over the carefully cleaned substrates 15 and 16. A high vacuum, i.e., 10^{-7} mm. of mercury is initially obtained followed by a pure argon backfill to a pressure of approximately 25 microns of mercury. Sputtering for a brief period in argon or other inert gas serves to prepare the initial cathode surface for each run. Next, a several minute sputtering cycle is run with oxygen added to the argon flow to provide initial stability to the deposition conditions and a reproducible history for the cathode prior to predeposition. The shutter 19 is then opened and oxidized cathode material is deposited on the silicon substrates 15 and 16.

A cathode holder constructed in accordance with this invention permits the simultaneous sputtering of up to 12 cathodes of identical or differing materials. In one specific embodiment the holes 53 are $1\frac{1}{4}$ inch in diameter and the flanged portion 54 forms a $\frac{15}{16}$ inch diameter hole. The distance from the top of the hole 53 to the flange 54 is $\frac{1}{2}$ inch. In order to sputter a material in this fixture, the material samples must be less than $\frac{1}{2}$ inch thick, preferably but not necessarily having flat parallel top and bottom sides. The sample must also be able to drop into the $1\frac{1}{4}$ inch diameter hole 53 but completely cover the concentric $\frac{15}{16}$ inch diameter hole 56.

Almost any solid can be easily shaped to meet these requirements. If the material is substantially less than $\frac{1}{2}$ inch thick, the weight-spacer 58 is placed over the sample to facilitate electrical contact between the cathode material and the holder and to maintain close spacing between the cathode and the top shield.

The above described fixture has been used successfully for the deposition of thin films of silicon and silicon dioxide. The rotating substrate pedestal 14 assures uniformity of film thickness. With planetary substrate movement and cathodes of dissimilar materials, mixtures of uniform composition could be deposited.

What is claimed is:

1. In a cathode sputting apparatus, including a chamber, a support for holding at least one piece of cathode material within said chamber, said support comprising a conductive cathode holder having at least one hole therethrough, an inwardly projecting flange extending from said holder at one end of each hole, each said flange retaining one piece of cathode material within its associated hole, said flange defining an aperture through which cathode sputtering occurs; means to support a sputtering discharge within said chamber; conductive means connected to said cathode holder for applying a negative potential thereto; conductive shield means surrounding said cathode holder; means for insulating said shield means from said cathode holder; and means for making said shield means positive relative to said cathode holder for inhibiting sputtering from any point on said holder except through said apertures.

2. An apparatus as described in claim 1 wherein said holder has a plurality of holes therein, said support further comprising a conductive plate having an aperture therein, said aperture being aligned with and being co-extensive with less than all of said holes the remainder of said holes being obscured by the solid portion of said plate, said plate being secured to said shield means.

3. An apparatus as described in claim 1 which further includes a plurality of conductive weights disposed within said holes adjacent said cathode material, the height of said spacers being such that the thickness of said cathode material plus the height of said weight causes the top of said weight to be less than the cathode dark space distance from said shield means.

4. An apparatus as described in claim 1 which further includes a conductive cylinder surrounding said conductive support means and being insulated therefrom, said cylinder being connected to said shield means.

5. An apparatus described in claim 1 wherein said shield means comprises first and second flat conductive portions having flanged edges at the periphery thereof which overlap each other, said second shield portion having holes therein which are aligned with said apertures in said cathode holder.

6. An apparatus as described in claim 5 which further includes a plurality of insulating spacers situated between said cathode holder and said first shield portion.

7. An apparatus as described in claim 1 which further includes means for adjusting the spacing between said shield means and said cathode holder.

8. An apparatus as described in claim 5 which further includes means to align said holes in said second shield portion with said apertures in said cathode holder.

9. An apparatus as described in claim 8 wherein said means to align comprises a first plurality of alignment holes in said cathode holder and a second plurality of alignment holes in said first shield portion which are properly aligned with said first mentioned holes, and a plurality of insulating spacers disposed in and extending between said first and second plurality of alignment holes.

10. An apparatus described in claim 9 wherein said means to align further comprises a plurality of slots in the flanged portion of said first shield portion and a plurality of setscrews located in the flanged portion of said

second shield portion, said setscrews being aligned with
said slots.

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