Jan. 30, 1973 E. C. ORRIS 3,714,019

CATHODE SPUTTERING ELECTRODE ASSEMBLY

Filed Feb. 4, 1971 2 Sheets-Sheet 1

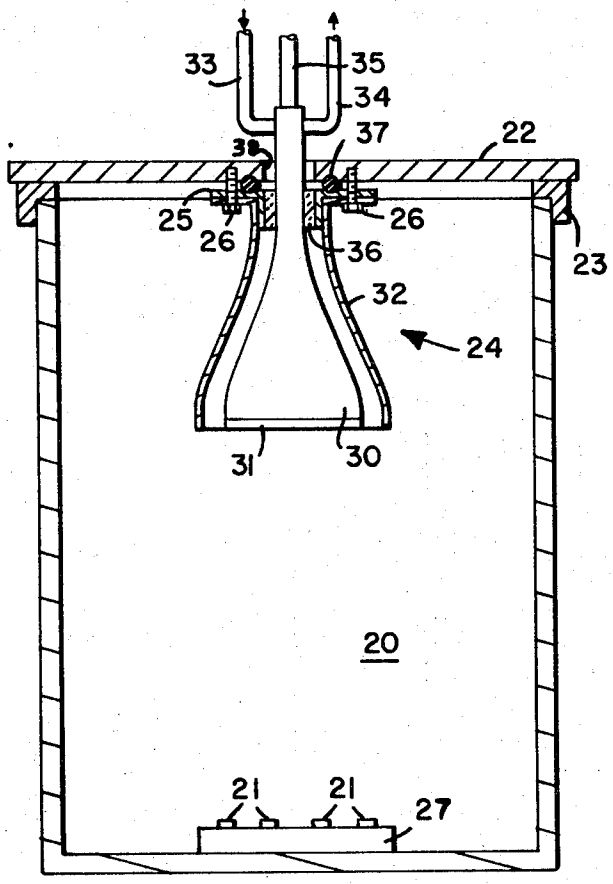


FIG. 1

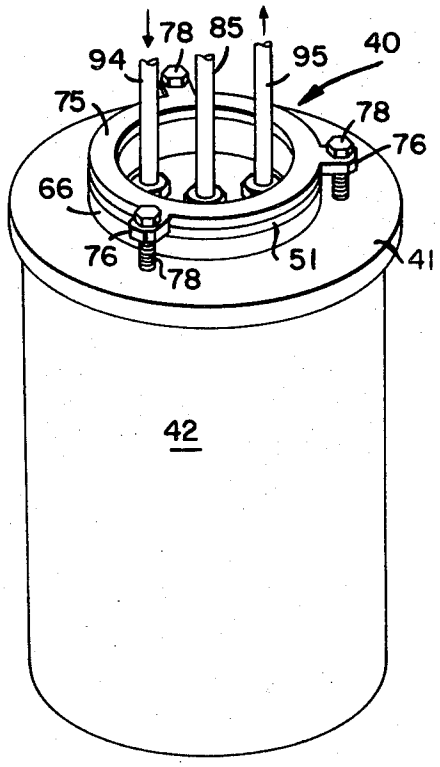


FIG. 2

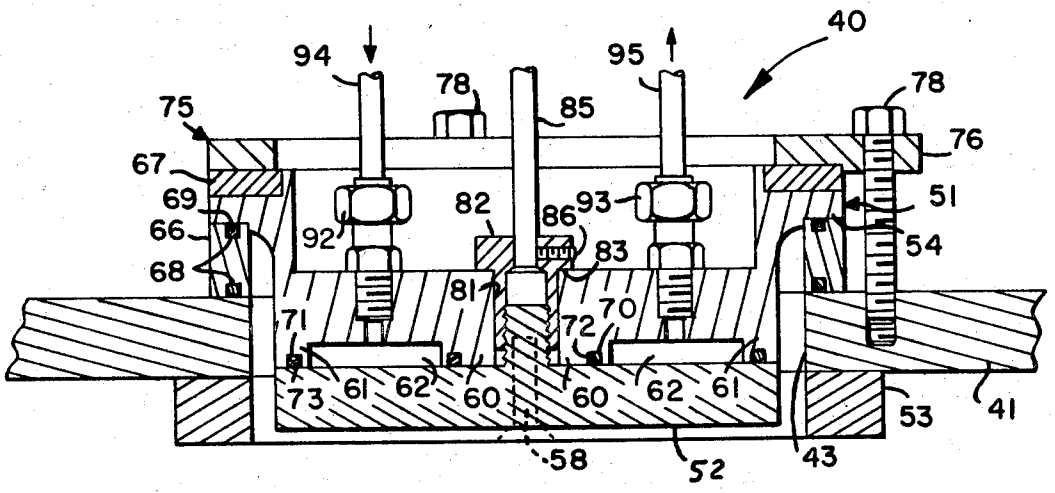


FIG. 3

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CATHODE SPUTTERING ELECTRODE ASSEMBLY

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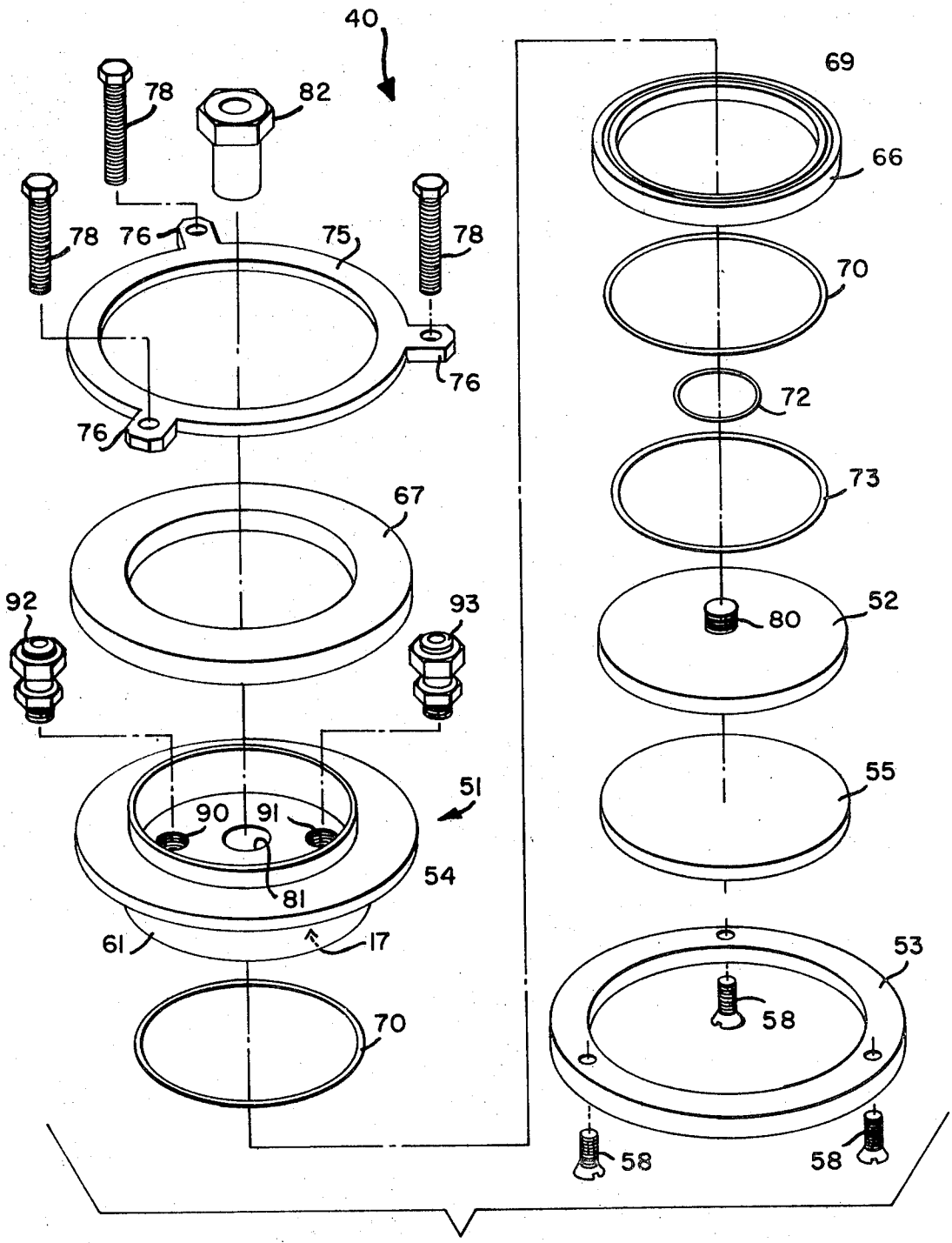


FIG. 4

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CATHODE SPUTTERING ELECTRODE ASSEMBLY

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ABSTRACT OF THE DISCLOSURE

A sputtering electrode assembly is provided for external mounting to a vacuum chamber. A back-up electrode and a layer of target material mounted thereon comprising a part of the assembly extend through a port a short distance into the chamber. The chamber wall serves as a substantial part of the dark space shield surrounding the back-up electrode thereby reducing the distributed capacitance of the assembly as a whole. The provision for external mounting and removal of the assembly from the chamber further minimizes contamination of the chamber from inadvertant release of coolant and other foreign materials into the chamber.

BACKGROUND OF THE INVENTION

The present invention relates in general to cathode sputtering apparatus and in particular to an improved sputtering electrode assembly.

Conventional sputtering apparatus comprises a vacuum chamber, a substrate holder and a sputtering electrode assembly which extends into the chamber. The electrode assembly includes a target back-up plate or electrode on which is mounted target material. Ions generated in a plasma within the chamber strike the target material ejecting particles therefrom. The particles transit the space between the target material and substrate holder for coating substrates supported on the substrate holder. To prevent sputtering of the target back-up electrode and to restrict sputtering to desired surfaces of the target material mounted thereon, there is provided a dark space shield surrounding the target back-up electrode and edges of the target material.

As is well known to those familiar with sputtering equipment and other apparatus utilizing plasmas, a space within which no ionization occurs develops immediately adjacent the negative electrode. In sputtering apparatus, this electrode is the target back-up electrode. This space is commonly known as the dark space. The thickness of the dark space is a function of the gas pressure between the negative and corresponding positive electrode and the voltage applied to the electrodes. So long as the dark space shield is within the dark space and maintained at the potential of the surrounding chamber, ions generated within the plasma will not sputter the shield or the shielded portions of the electrode assembly.

Typically, prior art electrode assemblies and their dark space shields are removably mounted on the interior surface of a wall of the vacuum chamber or on the interior surface of an electrode assembly base plate which serves as a wall of the vacuum chamber. The electrode and shield extend a considerable distance into the interior of the vacuum chamber and are found to present an undesirably large distributed capacitance to the power supply which must be compensated for by a matching circuit for maximizing power transfer to the plasma.

The internal mounting of the electrode and shield assembly is also found to make removal and disassembly of the electrode assembly for cleaning and changing target material cumbersome and difficult. Not infrequently the vacuum chamber area is contaminated by foreign material

and coolant used in cooling the back-up electrode in the process of removal and disassembly of the electrode assembly.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided for use in an otherwise conventional sputtering vacuum chamber an improved sputtering electrode assembly. The improved assembly is provided to be removably mounted on the exterior surface of a wall of the vacuum chamber or on the exterior surface of an electrode assembly base plate serving as a wall of the vacuum chamber. A target back-up electrode and target material mounted thereon forming a part of the electrode assembly is provided to be inserted in a port in the wall or base plate and to extend a relatively short distance into the interior of the vacuum chamber. The resulting reduction in the size of the components comprising the electrode assembly is reflected in a reduction of the distributed capacitance between the electrode and surrounding hardware and a simplification of any matching circuit used for maximizing power transfer to the plasma. The external mounting of the electrode assembly further serves to simplify the removal and disassembly of the electrode assembly and precludes contamination of the vacuum chamber by inadvertant release of coolant and other foreign materials into the chamber when the back-up electrode and target material is removed from the remainder of the assembly for routine maintenance and changing of target material.

These and other objects, features and advantages of the present invention will be apparent in the following detailed description and accompanying drawings.

DESCRIPTION OF DRAWINGS

FIG. 1 is a cross-sectional view of a typical prior art sputtering apparatus.

FIG. 2 is a prospective view of a sputtering apparatus using an electrode assembly made in accordance with the present invention.

FIG. 3 is a partial elevation cross-sectional view of the electrode assembly of FIG. 2.

FIG. 4 is an exploded prospective view of the components of the electrode assembly of FIG. 3.

DETAILED DESCRIPTION OF THE INVENTION

A conventional prior art sputtering apparatus as shown in FIG. 1 comprises a cylindrically shaped vacuum chamber 20 on which is fitted a sputter electrode assembly base plate 22 provided with an aperture or port 38 of typically 1 to 3 inches in diameter. A gasket 23 between the vertical walls of chamber 20 and plate 22 serves to provide a vacuum tight seal when chamber 20 is evacuated. A sputter electrode assembly 24 comprising a target back-up electrode 30 to which is mounted a layer of target material 31 and a dark space shield 32 is mounted to the interior surface of base plate 22 as by flanges 25 and bolts 26. Target back-up electrode 30 is typically 5 inches in diameter at its lower end. Shield 32 is maintained in electrical contact with base plate 22 through flanges 25 and is insulated from electrode 30 by an insulator 36, as of ceramic or the like. Extending from the upper end of electrode 30 there is provided a pair of coolant pipes 33, 34 which serve to cool electrode 30 and an electrically conductive member 35 for applying a potential to electrode 30. Coolant pipes 33, 34 and member 35 extend through port 38 for connection with an external coolant pump and power supply not shown. One or more substrates 21 are supported in the bottom of chamber 20 by a substrate holder 27.

As illustrated, electrode assembly 24 typically extends a considerable distance into the interior of chamber 20 resulting in an undesirably large distributed capacitance between shield 32 and electrode 30. As indicated, the

geometry of assembly 24 not only results in an undesirably large distributed capacitance, but the size of port 38 necessitates removal and disassembly of the electrode assembly 24 from within the area of chamber 20.

In practice, when routine maintenance or a change of target material is required, chamber 20 and base plate 22 are separated as by hydraulic jacks or other lifting apparatus not shown. Because of the proximity of chamber 20 to assembly 24 when separated, removal and disassembly of assembly 24 not infrequently results in contamination of chamber 20 by the inadvertant release of coolant or other foreign material from assembly 24.

Referring to FIG. 2, there is provided in accordance with the present invention, an improved sputtering electrode assembly 40, removably mounted to the upper surface of a conventional base plate 41 resting on the top of a conventional vacuum chamber 42. While chamber 42, base plate 41 and each of the components of electrode assembly 40 as illustrated herein are generally cylindrical in shape it is understood that other geometries are considered suitable.

Referring to FIGS. 3 and 4, generally cylindrically shaped sputtering electrode assembly 40 is provided to extend through a circular port 43 in base plate 41.

In general, assembly 40 comprises a cathode body 51 and a target back-up electrode 52 to which is permently or removably mounted a layer of target material 55. A ring shaped dark space shield 53 of rectangular cross-section is provided for mounting as by screws 58, or the like to the interior surface of base plate 41 about the periphery of port 43 and is typically provided to extend a relatively short distance below the lower surface of target material 55. An upper portion of cathode body 51 is provided with an outwardly horizontally extending flange 54. The lower portion of cathode body 51 is provided with a downwardly directed interior wall 60 and a downwardly directed exterior wall 61 which serve together with back up electrode 52 to form a coolant chamber 62 for cooling back-up electrode 52. The lower surface of walls 60, 61 is further provided with a pair of recesses 70, 71 for receiving a pair of O rings 72, 73, respectively. O rings 72, 73 serve to insure a vacuum tight seal between cathode body 51 and back-up plate 52.

For insulatingly mounting electrode assembly 40 to the exterior surface of base plate 41 there is provided a lower and an upper insulating ring 66, 67 formed to mate with the lower and upper surfaces respectively of flange 54 of cathode body 51. Lower ring 66 is further provided with a lower and an upper recess 68 for receiving a pair of O rings 69 which serve to insure a vacuum tight seal between cathode body 51 and base plate 41. A circular mounting plate 75 is provided with a plurality of outwardly extending ears 76 for receiving bolts 78 for removably mounting assembly 40 to the upper surface of base plate 41. As shown, mounting plate 75 makes mechanical contact with only the upper surface of insulating ring 67 thereby electrically insulating the remainder of assembly 40 from base plate 41 and the surrounding vacuum chamber 42.

Axially disposed within the center of back-up electrode 52 there is further provided a threaded male coupling member 80. Cathode body 51 is further provided with a bore hole 81 for receiving member 80 and an internally threaded female back-up nut 82.

Back up nut 82 is provided with an outwardly directed shoulder 83 which engages the upper surface of cathode body 51 about bore hole 81 when nut 82 is threaded on coupling member 80 for compressively securing in a vacuum tight fashion back-up electrode 52 to cathode body 51. Back up nut 82 is further provided with an axial bore hole 84 for receiving a conductive rod or member 85 for coupling back-up electrode 52 to an external power supply, not shown. A set screw 86 is provided in nut 82 to removably secure rod 85.

Cathode body 51 is further provided with a pair of threaded coolant passageways 90, 91 in fluid communication with coolant chamber 62. A pair of male fluid connectors 92, 93 are threaded into passageways 90, 91 for receiving and removably retaining a pair of coolant pipes 94, 95 which serve as input and output lines respectively for a coolant pump, not shown.

In an electrode assembly made in accordance with the present invention, the base plate 41 or vacuum chamber wall, as the case may be, serves as a substantial part of the dark space shield and that together with dark space shield 53, the dimensions of the effective dark space shield are considerably reduced from that encountered in prior art sputtering apparatus. Typically, the thickness of base plate 41 and shield 53 is a total of two inches. In certain applications it is possible to remove shield 53 entirely, raise electrode 52 to a position coextensive with the plane of the base plate 41 and reduce the distributed capacitance even further. In practice, it has been found possible to reduce the distributed capacitance to as little as 25% of its former magnitude.

Whether or not a particular application requires or permits the use of the reduced distributed capacitance obtained with the present invention or requires an extended back-up electrode and shield, it is apparent that the provisions permitting mounting of electrode assembly 40 to the external surface of base plate 41, permits easy and safe removal of assembly 40 from chamber 42 for routine maintenance and changing of the target material without the danger heretofore encountered in inadvertently releasing coolant and other foreign material into the chamber.

What is claimed is:

1. A sputtering electrode assembly adapted for removable mounting in a port in a wall of vacuum chamber comprising: a cathode body provided with a flange extending horizontally outwardly therefrom; a first insulating collar for removable mounting in a vacuum tight fasion between the undersurface of said outwardly extending flange on said cathode body and the exterior surface of said wall about said port; a horizontally extending mounting plate; a second insulating collar for removable mounting between the upper surface of said outwardly extending flange on said cathode body and the undersurface of said mounting plate; means for removably attaching said mounting plate to the exterior surface of said wall for removably mounting said cathode body within said port in a vacuum tight fashion and electrically insulated from said wall by said first and said second insulating collars; and means for coupling an electrical potential to said cathode body.

2. A sputtering electrode assembly according to claim 1 further comprising a target back-up electrode mounted to the undersurface of said cathode body.

3. A sputtering electrode assembly according to claim 2 wherein said cathode body further comprises a downwardly extending interior wall and a downwardly extending exterior wall and wherein said target back-up electrode is removably mounted in vacuum-tight fashion to the undersurface of said downwardly extending interior and exterior walls of said cathode body for forming a coolant chamber in said cathode body.

4. A sputtering electrode assembly according to claim 3 further comprising a dark space shield surrounding said target back-up electrode removably mounted to the interior surface of said wall about said port.

5. A sputtering electrode assembly according to claim 4 wherein the outside diameter of the downwardly extending exterior wall of said cathode body and the outside diameter of said target back-up electrode is less than the diameter of said port and the inside diameter of said dark space shield.

6. A sputtering electrode assembly according to claim 5 further comprising a coolant input and output passageway in fluid communication with said coolant chamber

in said cathode body for cooling said target back-up electrode.

7. A sputtering electrode assembly according to claim 6 wherein said cathode body is provided with a bore hole, and further comprising: a first coupling member fixed to the upper surface of said target back-up electrode in registration with said bore hole; and a second coupling member provided with an outwardly extending shoulder for engaging the upper surface of said cathode body about said bore hole and a downwardly directed extension for engaging said first coupling member for removably securing said target back-up electrode to the undersurface of said cathode body in a vacuum-tight fashion.

8. A sputtering electrode assembly according to claim 7 wherein said second coupling member comprises a bore hole for receiving a conductive member for applying an electrical potential to said target back-up electrode.

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