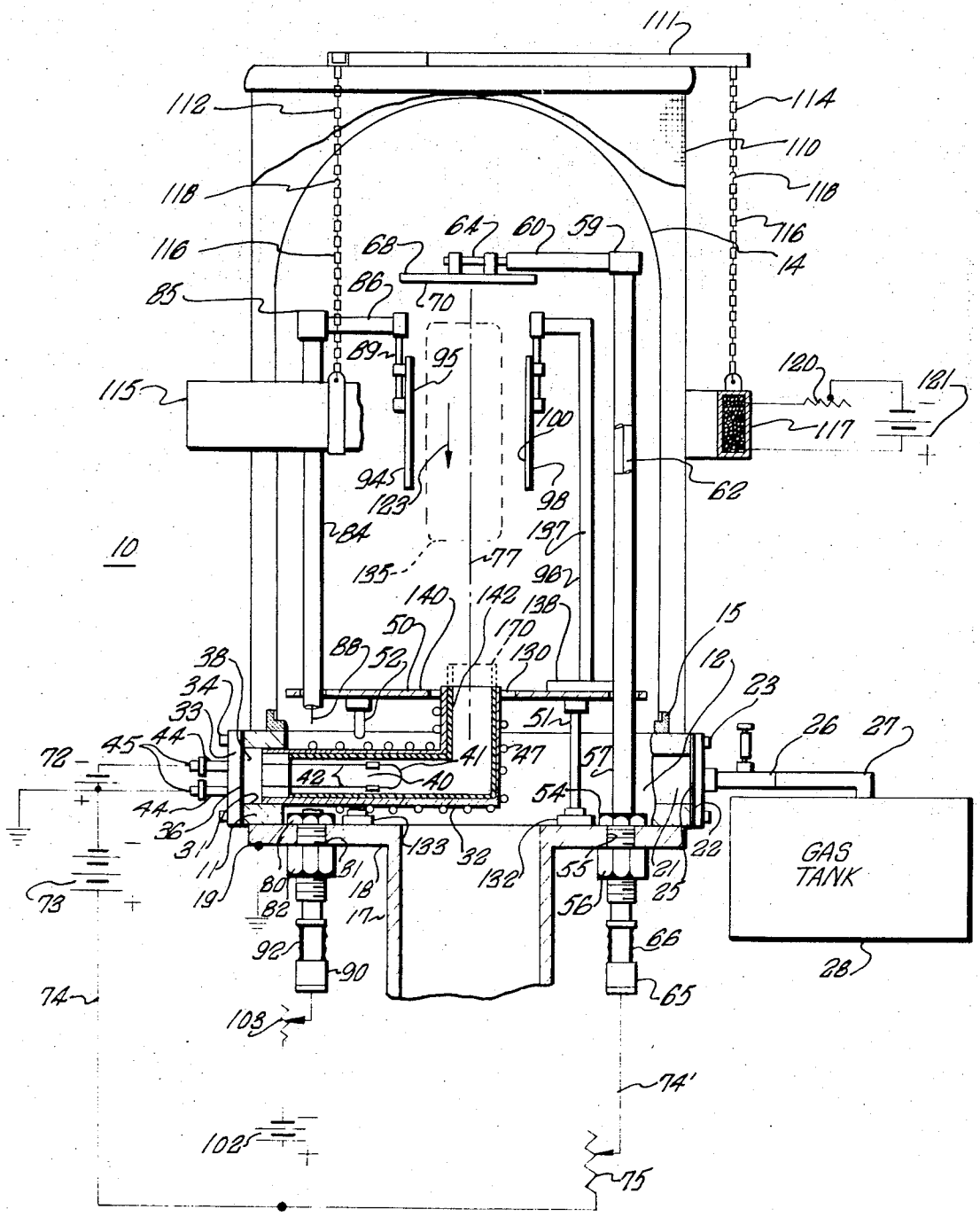
Dec. 1, 1970 R. M. MOSESON ET AL 3,544,445

FLOATING SHIELD IN A TRIODE SPUTTERING APPARATUS PROTECTING THE BASE FROM THE DISCHARGE

Filed Sept. 1, 1966 4 Sheets-Sheet 1

FIG. 1



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Filed Sept. 1, 1966 4 Sheets-Sheet 2

FIG. 2

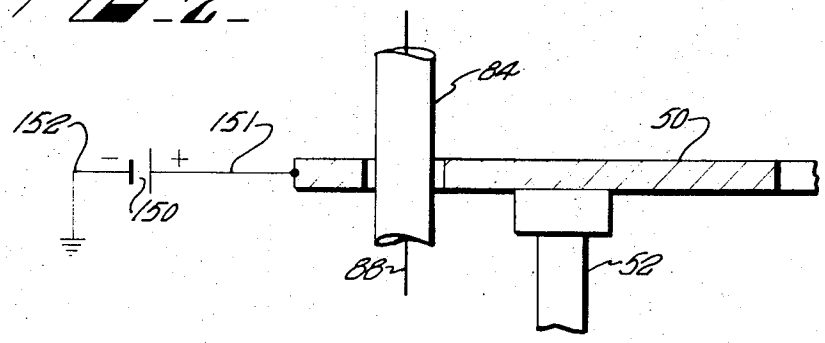
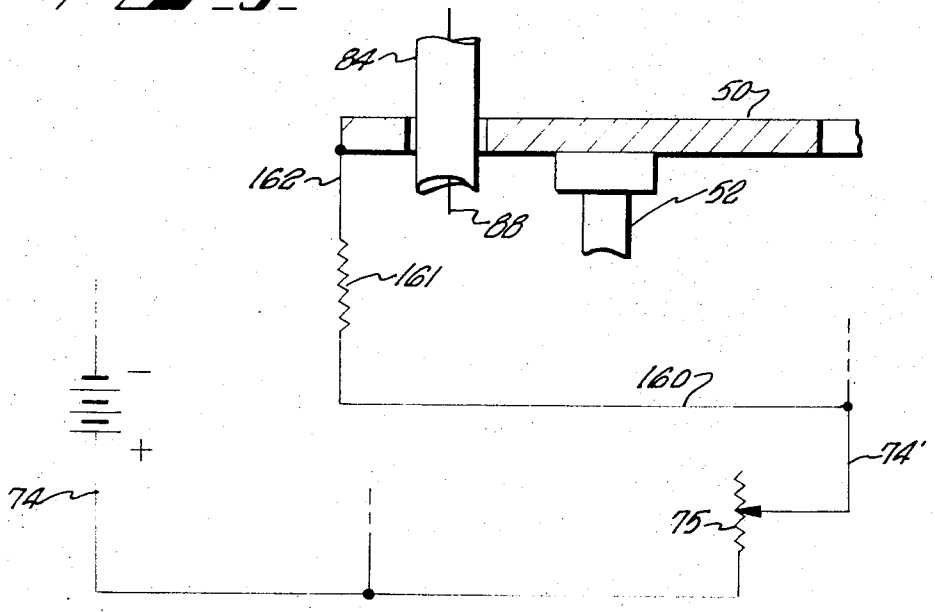


FIG. 3



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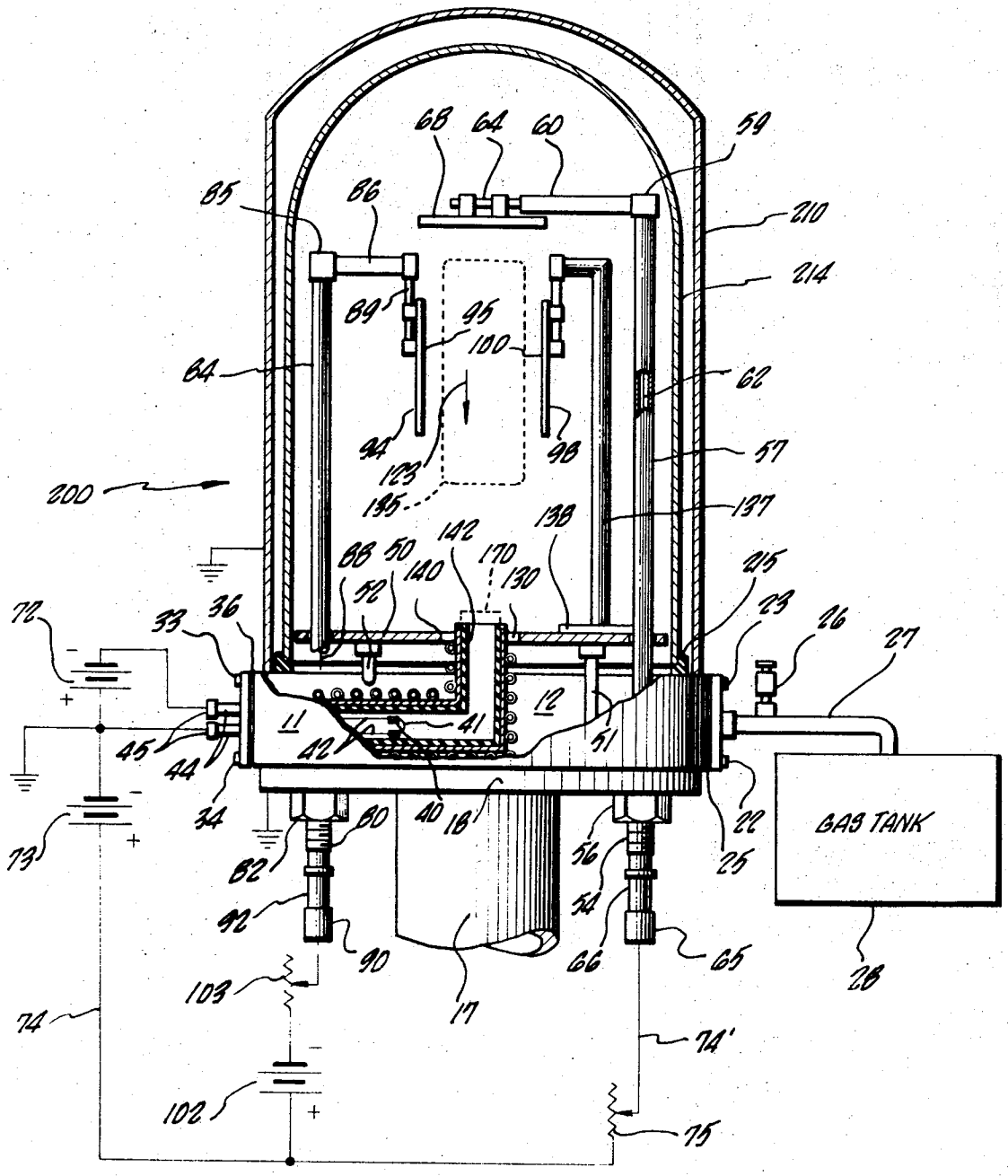
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FLOATING SHIELD IN A TRIODE SPUTTERING APPARATUS PROTECTING THE BASE FROM THE DISCHARGE

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FIG. 4



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FLOATING SHIELD IN A TRIODE SPUTTERING APPARATUS PROTECTING THE BASE FROM THE DISCHARGE

Filed Sept. 1, 1966 4 Sheets-Sheet 4

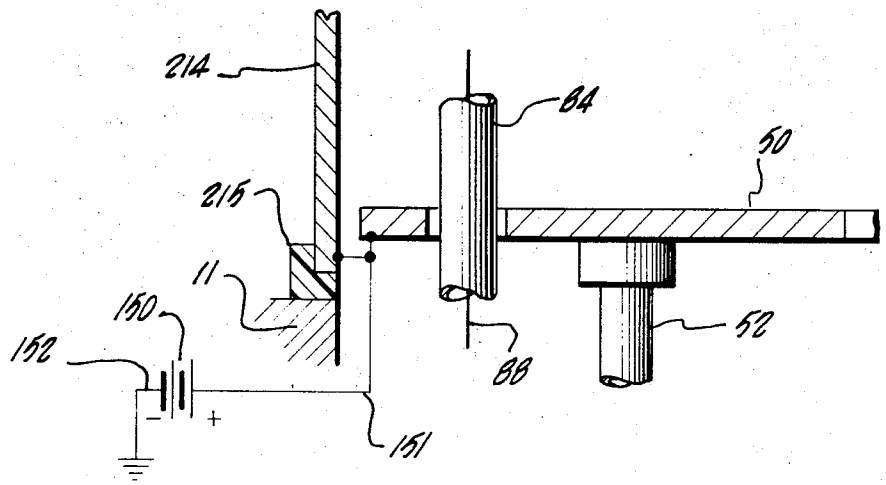


FIG. 5.

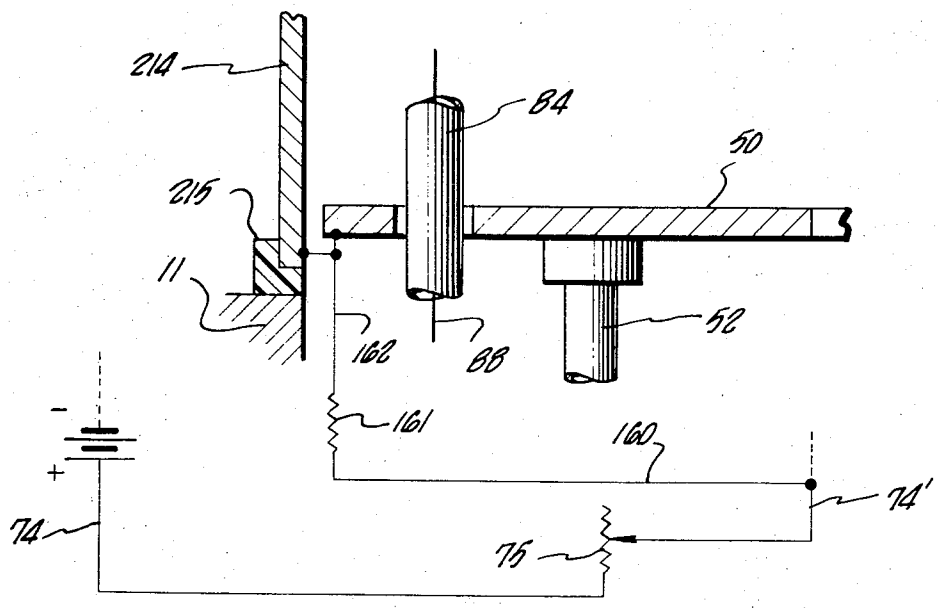


FIG. 6.

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3,544,445

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FLOATING SHIELD IN A TRIODE SPUTTERING APPARATUS PROTECTING THE BASE FROM THE DISCHARGE

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Continuation-in-part of application Ser. No. 516,472, Dec. 27, 1965. This application Sept. 1, 1966, Ser. No. 585,994

Int. Cl. C23c *15/00*

U.S. Cl. 204—298 8 Claims

This is a continuation-in-part of abandoned application Ser. No. 516,472, filed Dec. 27, 1965.

The subject invention relates to the art of sputtering, and more particularly, to apparatus for depositing thin films of material on a surface of a substrate by sputtering.

The phenomenon referred to as "sputtering" has been known for many years. Initially, this phenomenon was considered undesirable, since it caused blackening of tube walls, poisoning of cathodes and other deleterious effects in gas discharge and high vacuum apparatus and devices. More recently, sputtering has been developed to a highly sophisticated technique which permits the deposition of thin layers of material on various substrates. With the advent of miniaturization in electronics and related fields, sputtering techniques have become particularly valuable.

Advanced sputtering apparatus includes an enclosure and means for evacuating the enclosure and for establishing an ionizable atmosphere therein. The enclosure houses means for establishing an ion plasma the ions of which serve to sputter material from a suitably biased ion target. The substrate to be provided with a thin film is positioned in the enclosure so as to receive sputtered material from the ion target.

With advanced types of sputtering apparatus it has become the practice to provide means in the enclosure which are neither intended to participate directly in the generation of the ion plasma nor are supposed to sputter material onto the substrate. These means may, for example, be present in the form of a supporting structure or baseplate which is located in the enclosure to permit a proper positioning and support of the substrate. To name another example, these means may also be present in the form of a shield, between operative parts, or for an operative part, in the enclosure. To preclude fragility, many designers prefer to make these means of metal. The use of metals or possibly other electrically conducting materials is also indicated in an avoidance of an establishment of charge patterns over the surfaces of the means in question is of significance in a particular application.

The use of metal or other electrically conducting materials in the construction of the means in question has heretofore been believed to have the disadvantage of permitting these means to become a target for ions of energies sufficient to sputter material from these means. This undesirable effect has in fact been noted in existing types of sputtering apparatus in which these means have customarily been connected to ground.

In connection with attempts to overcome the above-mentioned undesirable effect, there have been suggestions to construct the means in question of the same material

as the ion target, so that the same material is sputtered from these means as from the target. While this solution appeared attractive, it was found to have severe drawbacks. In science and industry, the need for sputtering apparatus is steadily developing in the direction of apparatus which would be capable of sputtering various types of material, including abroad range of metals and even dielectric substances. Obviously each substitution of a target of one material for a target of another substance would call for a like replacement of the means in question, if the proposal just mentioned were adopted. In addition it is important in many applications that the deposition of the sputtered films be either uniform or deliberately nonuniform in a closely controlled fashion. The presence of one or more further ion targets constituted by the means in question, in addition to the principal ion target or targets, would interfere with the formation of highly uniform or deliberately non-uniform films.

The subject invention provides solutions, which do not entail these disadvantages, by providing means for establishing and maintaining a charge on the aforementioned electrically conducting means which repulses or diminishes the impingement of ions thereon. The electrical conducting means are disposed within a vacuum enclosure and could include such items as supporting structure for an ion target or anode. A baseplate located in the enclosure for supporting the support structure is another example. In any event, the electrical conducting means as used throughout this specification are those electrically conducting elements within the vacuum environment of a sputtering system which are in ion communication with the ion plasma and which have heretofore attracted ions by virtue of differences in potential between ions in the plasma and the electrically conducting means. The repulsive charge at which the electrically conducting means are maintained is positive with respect to the cathode used in the sputtering apparatus of the instant invention and preferably on the order of the potential applied to the anode which complements the cathode.

In practicing the invention, the means in question are as before made of metal or other electrically conducting material. According to one aspect of the invention, these conducting means are maintained in an electrically floating condition to diminish the impingement of ions upon and undesirable sputtering of material from these conducting means. An electrically floating condition in the present sense exists if the means in question are essentially insulated from different conducting parts or structures of the sputtering apparatus, without being connected to a source of electrical bias potential. In this electrically floating condition, the means in question are capable of accepting an electric charge without an immediate dissipation of such charge to parts or structures different from such means.

If the means in question are in an electrically floating condition, there will be a retention of the charges of ions which impinge onto these means in the operation of the apparatus. This retention can, of course, not be indefinite, inasmuch as some current conduction is present even in the best insulator. Also, if the floating means are positioned in the vicinity of a cathode, some electrons will be able to reach these means and neutralize the ion-imparted charge. On the other hand, a dissipation of the charge provided by impinging ions will be that slow, or imping-

ing ions will reduce a potential imparted by impinging electrons to such an extent that subsequently arriving ions will impinge on the means in question in a progressively decelerated fashion. After a short period of time, ions will either be incapable of reaching the means in question or will impinge with such low energies that no material which could objectionably contaminate sputtered films can be liberated from these means. Practical experiments have shown that the electrically floating means here under consideration assume during the operation of the sputtering apparatus a positive electrical potential which is in the vicinity of the positive potental of the anode of the sputtering apparatus.

An apparatus in accordance with a preferred embodiment of the invention includes the above-mentioned enclosure, means for evacuating the enclosure and for establishing an ionizable atmosphere therein, and means for establishing an ion plasma in the enclosure. The apparatus further includes an ion target of material to be sputtered located in the enclosure to receive ions from the plasma. When the ion target is not mounted on the cathode as in prior art diode systems, means are used for electrically biasing the ion target to cause the impingement of ions from the plasma onto the target and the sputtering of material from the target. The substrate on which a thin film is to be provided is located in the enclosure for the reception of material sputtered from the ion target. Electrically conducting means are located in the enclosure and present at least one surface to the plasma. As indicated above, these electrically conducting means may be present in the form of a supporting or baseplate structure or a shield between operative parts, or for an operative part, in the enclosure. According to the invention, the apparatus includes insulating means for maintaining the electrically conducting means just mentioned in an electrically floating condititon to diminish the impingement of ions upon and undesirable sputtering of material from these electrically conducting means.

From another aspect thereof, the subject invention provides also apparatus in which the above-mentioned conducting means are not maintained in an electrically floating condition, but have applied thereto an electrical potential. This expedient is particularly advantageous in, but is not limited to, apparatus in which the ion plasma is formed by a cathode and an anode and in which the electrically conducting means in question are, for instance, located in the vicinity of the cathode, such as in the form of a supporting structure or baseplate, for example, which may also serve as a baffle or shield. While such supporting structures or baseplates have heretofore customarily been connected to ground, the present aspect of the subject invention provides for the application of an electrical potential thereto which is on the order of the positive potential of the anode and thus positive with respect to the cathode. This reduces the energy of the impinging positive ions from the plasma onto the means in question and practically eliminates the objectionable sputtering of material from these means.

Another embodiment of the subject invention is directed to sputtering apparatus using metal or other electrically conductive bell jars or enclosures. A metal bell jar, just as other electrically conductive structures exposed to an ion plasma, can be sputtered. Because of its exposed state, a metal bell jar must be maintained electrically neutral in order to avoid hazardous working conditions for operating personnel. To avoid supttering of the metal bell jar while maintaining it electrically neutral, an electrically conductive shield is interposed between the ion plasma and the bell jar. The shield is electrically insulated from the base used in the sputtering apparatus. This shield is maintained either in an electrically floating condition or electrically biased such that ions from the ion plasma are repulsed resulting in a substantial reduction or elimination of its sputtering.

The subject invention and its various aspects will become more readily apparent from the following detailed description of a preferred embodiment and modifications thereof, illustrated by way of example in the accompanying drawing, in which:

FIG. 1 is an elevation, partially in section, of an apparatus according to the invention, with associated circuitry;

FIG. 2 shows a fraction of part of the apparatus of FIG. 1 and illustrates a modification in accordance with a further embodiment of the invention;

FIG. 3 shows a fraction of part of the apparatus of FIG. 1 and illustrates a modification in accordance with yet a further embodiment of the invention;

FIG. 4 is an elevation, partially in section, of another embodiment of the invention;

FIG. 5 shows a fraction of part of the apparatus of FIG. 4 and illustrates a modification; and

FIG. 6 shows a fraction of part of the apparatus of FIG. 4 and illustrates further embodiment of the invention.

The sputtering and film-depositing apparatus **10** shown in FIG. 1 comprises a base **11** having a central opening **12**, and a removable bell jar **14** located on base **11** and sealed thereto at annular structure **15**. A vacuum conduit **17** is connected to base **11** by a flange **18** and gasket **19**. The space in base **11** and bell jar **14** is evacuated by means of a conventional high vacuum pump (not shown) which is connected to vacuum conduit **17** which is thus part of a means for evacuating the enclosure formed by the base **11** and bell jar **14**.

The base **11** has a first lateral aperture **21** which communicates with the opening **12**. A flange **22** is mounted to the base **11** at aperture **21** by a number of bolts **23**. A sealing ring **25** seals the flange **22** to the base **11**. A manually adjustable needle valve **26** is connected to flange **22** so that one of its ports communicates with the aperture **21**. The other port of needle valve **26** is connected to a pipe **27** which leads to a gas tank **28**. The gas tank, which may be a gas bottle, contains an ionizable gas, such as argon, which has the effect of facilitating the ionization process in the bell jar **14**, when admitted to the base **11** and jar **14** by the needle valve **26** in small quantities. It would also be possible to provide the necessary ionizing environment in bell jar **14** by adjusting the operation of the vacuum pump so as to permit a sufficient number of gas molecules to remain in the bell jar **14** during the evacuation process. However, the use of a separate gas tank and needle valve permits a more convenient and precise adjustment of the ionizing environment.

The base **11** has a second lateral aperture **31** which communicates with the space in bell jar **14** through substantially tubular filament shield **32**. A flange is fastened to the base **11** at aperture **31** by a number of bolts **34**. A sealing ring **36** seals the flange **33** to the base **11**. Flange **33** has an extension **38** which forms the base of a cathode member **40**. The cathode member further includes a filament **41** which is supported and supplied with electric current by a pair of leads **42** that extend through the flange **33** and are insulated therefrom by a pair of insulating sleeves **44**. A pair of terminals **45** is mounted on sleeves **44** and connected to leads **42**. In the illustrated embodiment the filament shield **32** carries a coil of tubing **47** which is connected to a supply of coolant liquid in a conventional manner not shown per se. The coolant liquid is caused to circulate through tubing or coil **47** so as to cool the filament shield. In this manner, overheating of the filament shield is avoided. A baffle plate or baseplate **50** encompasses the upper end of filament shield **32** and is supported by studs **51** and **52**.

The baseplate **50** has a central aperture **130** at which it is spaced and thus mechanically isolated and electrically insulated from the filament shield **32**. The region of the base **11** at lateral aperture **31** serves as a means for main-

taining the cathode shield in spaced relation from the baseplate **50**. The studs **51** and **52** rest on and are supported by a pair of insulators **132** and **133**. In this manner, the baseplate **50** is maintained in an electrically floating condition in that it will, at least for some time, retain an electric charge occurring thereon. If desired, the studs **51** and **52** may be made of insulating material, whereupon the insulators **132** and **133** can be dispensed with. If the insulators **132** and **133** are present and the studs **51** and **52** are of metal, the plate **50** is, of course, still in an electrically floating condition. The plate **50** and studs **51** and **52** are then jointly considered as an electrically conducting means which is insulated from any different part or structure of the apparatus. The operational significance of this electrically floating condition with respect to the illustrated embodiment will become apparent at this description proceeds.

The apparatus further includes a bushing **54** which extends through a bore **55** in flange **18** and is held therein by a nut **56**. A tube **57** extends through and is sealed to the bushing **54**. Tube **57** carries at its upper end an elbow member **59**. A further tube **60** is connected to elbow member **59** to extend substantially perpendicularly to tube **57**. An insulating wire **62** extends through tubes **57** and **60** and is connected to an anode support rod **64** which is supported by, but insulated from, the tube **60**. The wire **62** is also connected to a terminal **65** which is mounted on the lower end of tube **57** by an insulator **66**. An anode **68** is suspended from and electrically connected to support **64**. Anode **68** has a substantially horizontal anode surface **70** which faces in the direction of filament shield **32**.

After the base **11** and bell jar **14** have been evacuated, the filament **41** is supplied with a heating current from a battery **72** which is connected to the terminals **45**. The anode **68** is positively biased with respect to the filament **41** by a battery **73**. The negative terminal of battery **73** is connected to one of the filament terminals **45**, and may be grounded or connected to the apparatus **10**. The positive terminal of the battery **73** is connected to the anode terminal **65** through a conductor **74**, a variable resistor **75**, and a conductor **74'**.

The heated filament **41** will release electrons to the anode surface **70**. These electrons will collide with gas molecules present in bell jar **14**. The gas molecules will thus be ionized and an ion plasma will form in the space between the anode and the plate **50**. The ion plasma, which is schematically symbolized by a dotted outline **135**, will extend substantially along an axis indicated by phantom line **77**. The needle valve **26** may be adjusted from time to time to admit a desired number of gas molecules from the tank **28** to the ion plasma. Since the cathode is in the form of the heated filament **41**, a large number of electrons will be released into the bell jar **14** and a vigorous formation of the ion plasma will take place.

A further bushing **80** extend through an aperture **81** in flange **18** and is held therein by a nut **82**. A tube **84** extends through and is sealed to bushing **80**. Tube **84** carries at its upper end an elbow member **85**. A further tube **86** is connected to elbow member **85** to extend substantially perpendicularly to tube **84**. An insulated wire **88** extends through tubes **84** and **86** and is connected to a target support **89** located adjacent and insulated from tube **86**. The lower end of wire **88** is electrically connected to a terminal **90** which is insulated from tube **84** by an insulator **92**.

An ion target in the form of a plate **94** is mounted on target support **89**. The plate **94** is of the material to be sputtered and has a surface **95** disposed laterally of the ion plasma axis **77**. In the illustrated embodiment, the surface **95** is not only spaced from axis **77** but also extends substantially parallel thereto. A substrate support **96** is mounted on and extends from the plate **50**. The support **96** may at least in part be of an insulating material. For instance, a glass rod could be used as the stem **137** or an insulating plate as the foot **138** of the support. If the support **96** is of metal, the plate **50**, this support **96** and, if the studs **51** and **52** are also of metal, these studs are jointly considered as electrically floating conducting means. Use of insulating material in the construction of the support **96** is, however, indicated if it should be found, in an apparatus built according to the subject invention, that the presence of an elongated conductor in the form of the support **96** would cause an excessive dissipation of electric charges from the plate **50** if electrically connected to the plate **50**.

A substrate **98** is mounted on and suspend from the support **96**. The substrate **98** has a surface **100** on which a thin film of material sputtered from target surface **95** is to be deposited. The surface **100** is disposed laterally of the plasma axis **77** so that it is spaced from axis **77** and faces the target surface **95** to receive material sputtered therefrom. In the illustrated embodiment, the substrate surface **100** extends substantially parallel to the target surface **95** and the anode surface **70** is spaced from and extends substantially at right angles to the surfaces **95** and **100**.

The negative terminal of a battery **102** is connected to the target terminal **90** through a variable resistor **103**. The positive terminal of battery **102** is connected to the lead **74** which extends from the positive terminal of battery **73**. The target **94** and surface **95** are thus electrically biased so that ions from the ion plasma are caused to impinge on target surface **95**. These impinging ions will sputter material from the target surface **95**, which material will deposit itself on the substrate surface **100** and form a thin film thereon. During operation of the illustrated apparatus, the anode current can be adjusted by means of resistor **75** and the target current by means of resistor **103**.

The apparatus further includes a substantially cylindrical cover **110** which rests on base **11** and is removable therefrom. The lateral wall of cover **110** may be of nonmagnetic wire mesh. A three-leg support **111** is placed on the top of cover **110**. Three chains, two of which are apparent in the drawing at **112** and **114**, are suspended from the support **111**. A magnet structure **115** which houses an electromagnetic coil **17** is suspended from the latter chains by a number of further chains **116** which are connected to the former chains by hooks **118**.

The coil **117** is energized by a battery **121** through a variable resistor **120**, which permits adjustment of the current through coil **117** and thus of the magnetic field produced by this coil. The coil is of annular configuration and the magnetic field, which is diagrammatically indicated in the drawing by an arrow **123**, extends in part along the axis **77**. The chains **112**, **114** and **116** and the hooks **118** permit the magnet coil to be raised, lowered and tilted with respect to the target **94** and substrate **98** to cause the formation of highly uniform or deliberately nonuniform films on the substrate surface **100**.

In the illustrated embodiment, the plate **50** presents a surface **140** to the ion plasma symbolized by the dotted outline **135**. During operation of the apparatus, ions will move from the plasma in the direction of the surface **140** and will impinge on this surface. These ions will tend to sputter material from the plate **50** that could contaminate the film forming on the substrate surface **100**. Since the plate **50** is in accordance with the subject invention maintained in an electrically floating condition, impinging ions will build up a charge which will lessen and decelate further ion impingement to the point that no noticeable amount of material is anymore sputtered from the plate **50**. An objectionable dissipation of material from the plate **50** to the substrate surface **100** is even avoided if electrons from the filament **41** should tend to charge the plate negatively. In that case, positive ions from the plasma will diminish such negative charge on the floating plate **50** and, as experiments have shown, will impart on the plate **50** a positive potential which will be in the vicinity

of the potential at the anode **68**. In operating apparatus of the type illustrated in FIG. 1, it has been found that the positive potential assumed by the floating plate **50** will only be from about 10 to 20 volts less than the potential difference to produce objectionable sputtering of material from the plate **50**. Even is some material should still be able to leave the plate, its energy will be that low that it cannot reach the substrate surface **100** to an objectionable extent. At the same time, the conductive nature of the plate **50** precludes the building up of any objectionable charges on localized surface areas of the plate.

In the illustrated embodiment, the plate **50** also serves as a baffle or shield with respect to the electrically conducting base structure, including base **11** and flange **18**, of the apparatus. Owing to the arrangement of the plate **50** and the electrical charge assumed thereby, this base structure and also the filament shield **32** are guarded against ion impact.

In the illustrated embodiment, the filament shield **32** has an inner lining **142** of an insulating material, such as a ceramic. If desired, this lining may be provided by suitably tailored conventional high-temperature insulating tubes. The lining **142** reduces the impact of ions on the inside of the metallic portion of filament shield **32** and diminishes the emanation of contaminants from other causes from such inside. The functions of the lining **142** and of the electrically floating plate **50** thus jointly contribute to the formation of superior films on substrate surfaces.

FIG. 2 schematically illustrates fractions of the base plate **50**, the stud **52**, the tube **84** and the lead **88**, all of which have been described above in connection with their associated parts. The plate **50** is again maintained in an electrically insulated condition in the manner already described. The plate is, however, now positively biased by an electric source **150**, here shown as a battery, which has its positive terminal connected to the plate **50** by a lead **151** and its negative terminal connected to ground by a lead **152**.

While the conductor **151** has been shown in a simple fashion, it will be understood that it may be led through a bushing (not shown) which extends through the flange **18** and is similar to the bushing arrangements **54** and **80** previously described.

The value of the positive potential imparted on the plate **50** by the source **150** is made to be in the vicinity of the positive potential of the anode **68**. In practical experiments, it has been determined that the plate **50** may be from about 10 to 20 volts negative to zero volts with respect to the potential at the anode **68**, without objecionable sputtering occurring from the plate **50**. The filament liner **142** and the other previously described parts and structures may again be employed under this modification.

FIG. 3 shows a further modification in which the desired positive potential on the electrically insulated plate **50** is obtained by connecting this plate **50** to the previously mentioned conductor **74'**. As illustrated, this connection takes place through a conductor **160**, a resistor **161**, which may be variable if desired, and a conductor **162**. The conductor **162** may again be led through a bushing arrangement similar to the bushings **54** and **80** described and illustrated in connection with FIG. 1. It will be recalled in this connection that the conductor **74'** is the conductor which is connected to the anode terminal **65** on the one hand and, through the conductor **74** and resistor **75**, to the positive terminal of the anode battery **73** shown in FIG. 1.

The value of the resistor **161** shown in FIG. 3 is such that the plate **50** receives a positive potential that is similar to the positive potential of the anode. By way of example, the plate **50** may be up to about 10 to 20 volts lower than the positive potential existing at the anode **68** of the sputtering apparatus, without objectionable sputtering occurring from the plate **50**. The filament liner **142** and the other parts and structures previously described in connection with FIG. 1 may again be employed under the modification illustrated in FIG. 3.

Another embodiment of the instant invention is shown in FIG. 4. Reference numeral **200** denotes the sputtering and film depositing apparatus of this embodiment. Metal bell jar **210** is disposed on base **11** either through a gasket (not shown) or directly. This bell jar is grounded in order to avoid electric hazard to operating personnel. Electrically conducting shield **214** is disposed within bell jar **210** to insulate the latter from impinging ions from ion plasma **135**. Shield **214** is electrically insulated from base **11** through an annular insulating collar or standoff **215**. As in the previously described embodiment, base **11** is grounded. In other respects the embodiment shown in FIG. 4 is identical with embodiment shown in FIG. 1 and hence will not be described in detail. The identical elements are referred to by identical reference numerals. The requirement for the inner shield **214** is dictated betated because it is undesirable to have an electrically charged structure exposed to operating personnel. The shield is maintained in the electrically floating state previously defined. The electrically floating state is achieved by the impingement of ions on shield **214** which creates a positive charge and the electrical insulation provided by the standoff **215** which prevents dissipation of the charge. This positive charge will eventually reach a steady state value approaching the potential of anode **68**.

FIG. 5 illustrates an embodiment of the invention which is similar to FIG. 3 in that electrically conducting structure in ion communication with plasma **135** is biased to inhibit or avoid impingement by positive ions. Thus base plate **50** is connected through lead **151** to the positive terminal of bias source **150**. Shield **214** is connected through lead **216** to lead **151** and thus is biased positively with respect to the cathode in the same manner as base plate **50**.

FIG. 6 is similar to FIG. 3 in that the electrically conductive structure facing ion plasma **135** is maintained at a positive potential with respect to the cathode through conductor **74'**. Thus base plate **50** and shield **214** are connected to conductor **74'** through conductor **162**, resistor **161** and conductor **160**. For this purpose conductor **217** connects shield **214** to conductor **162**. As before, resistor **161** is valued such that plate **50**, and as a consequence shield **214**, are maintained at a positive potential similar to the potential of anode **68**.

In all of the illustrated embodiments, the insulating liner **142** may be extended upwardly as shown in FIG. 1 by dotted lines at **170**, so as to augment the direction given to electrons traveling to the ion plasma in the vicinity of the ion target **94**.

While specific examples have been described and illustrated, various modifications within the scope of the invention will be apparent or suggest themselves to those skilled in the art.

What is claimed is:

1. An apparatus for depositing thin films by sputtering material from an ion target onto a substrate, which comprises:

an enclosure having a base;

means for evacuating said enclosure and for establishing an ionizable atmosphere therein;

a base plate having a central aperture, said base plate located above and electrically isolated from the base of said enclosure and defining a sputtering zone above and isolated from the base and isolated from the base of said enclosure;

means for establishing an ion plasma in said zone, said means incluindg an anode, a cathode, and a tubular cathode shield encompassing said cathode, with said shield extending through the central aperture and electrical isolated from said base plate;

means for positioning the ion target inside said zone;

means for applying an electrical bias to the ion target

to attract ions to the target and sputter material therefrom; and

means for positioning the substrate inside said zone for the reception of material sputtered from the ion target.

2. An apparatus as recited in claim 1 including a lining of insulating material in the tubular cathode shield and on the end thereof for diminishing undesired release of materials from the cathode shield.

3. An apparatus as recited in claim 1 including means for positively biasing said base plate.

4. An apparatus as recited in claim 2 including means for positively biasing said base plate.

5. An apparatus as recited in claim 1 including a second enclosure located within said first enclosure, said second enclosure electrically isolated from said first enclosure.

6. An apparatus as recited in claim 2 including a second enclosure located within said first enclosure, said second enclosure electrically isolated from said first enclosure.

7. An apparatus as recited in claim 3 including a second enclosure located within said first enclosure, said second enclosure electrically isolated from said first enclosure.

8. An apparatus as recited in claim 4 including a second enclosure located within said first enclosure, said second enclosure electrically isolated from said first enclosure.

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