May 9, 1972 H. R. KOENIG 3,661,761
RF SPUTTERING APPARATUS FOR PROMOTING RESPUTTERING OF FILM DURING DEPOSITION
Filed June 2, 1969 2 Sheets-Sheet 1

FIG. 1

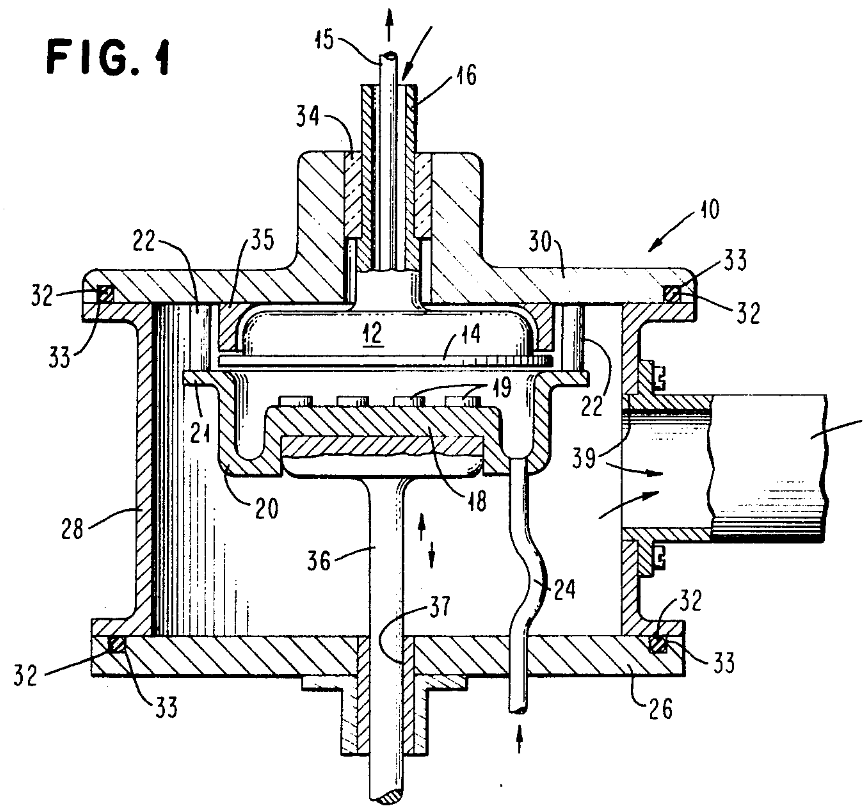


FIG. 2A

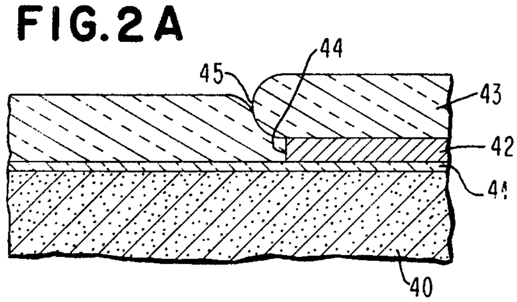


FIG. 2B

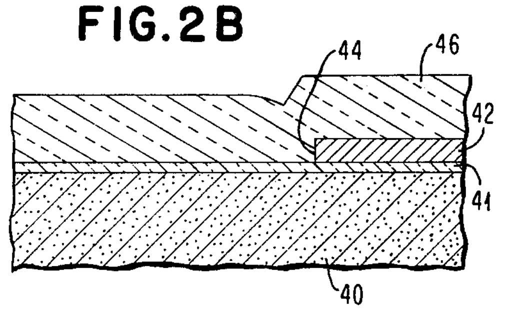
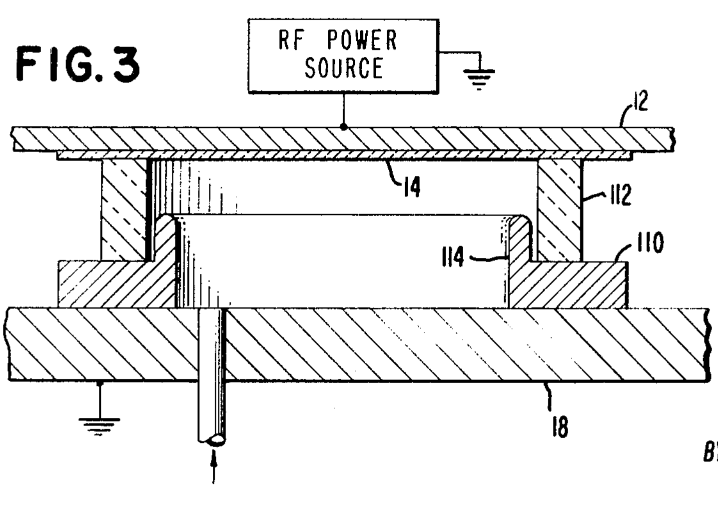


FIG. 3



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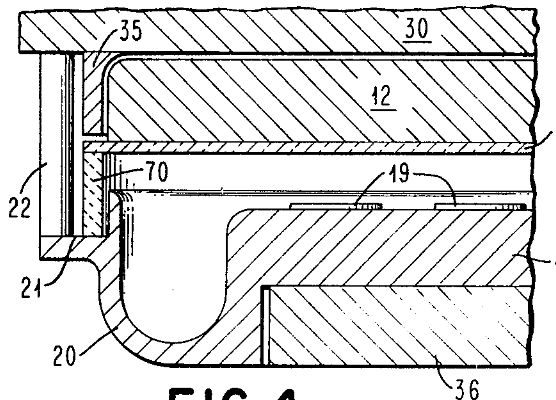


FIG. 4

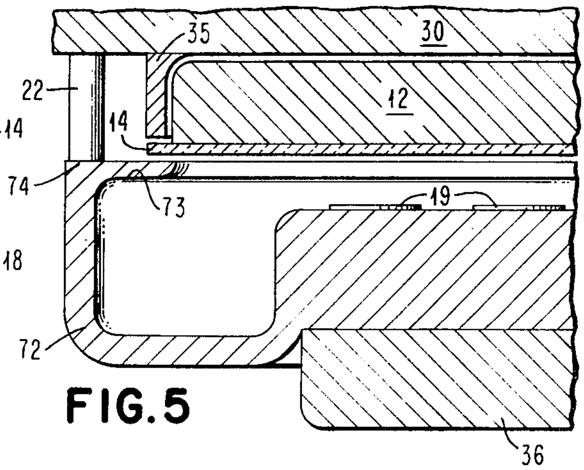


FIG. 5

FIG. 6

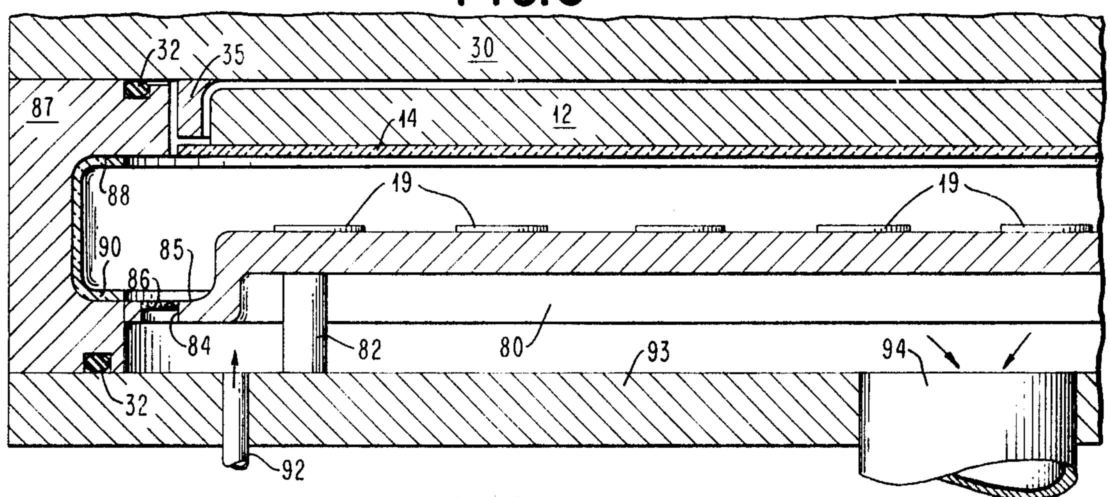
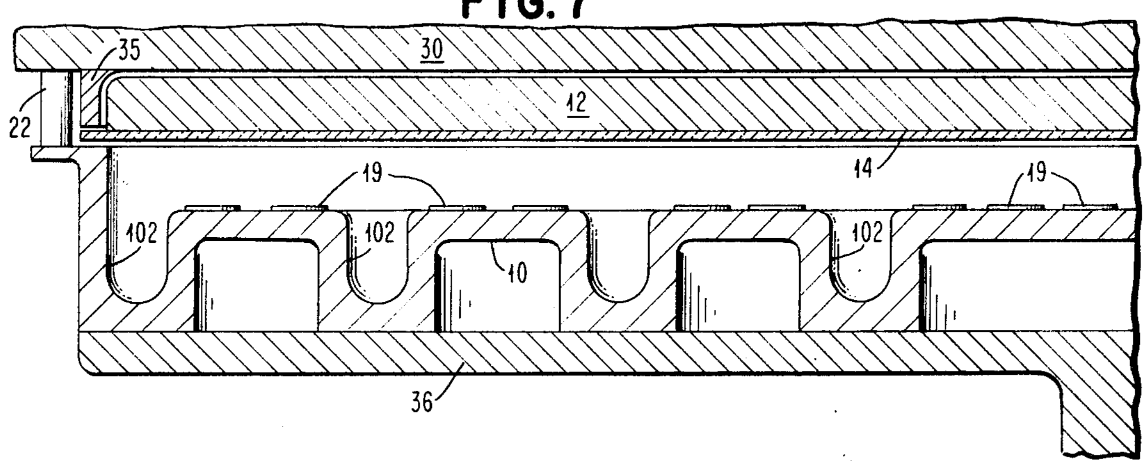


FIG. 7



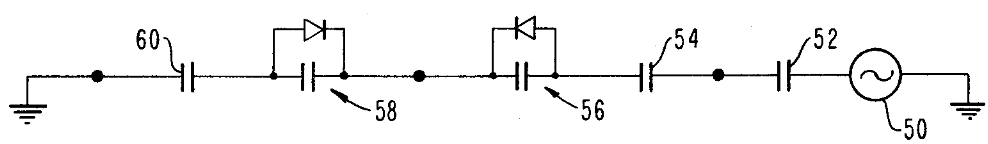


FIG. 8

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RF SPUTTERING APPARATUS FOR PROMOTING RESPUTTERING OF FILM DURING DEPOSITION

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Int. Cl. C23c *15/00*
U.S. Cl. 204—298 9 Claims

ABSTRACT OF THE DISCLOSURE

An RF sputtering method and apparatus wherein the area ratio of the substrate holder electrode to the target holder electrode is less than 2.5 and the region of the glow discharge is confined to promote resputtering, which improves the over-all quality of the resultant sputtered film.

DISCUSSION OF THE PRIOR ART

The deposition of films by sputtering is well-known in the art. In general there are two types of sputtering. Namely direct current commonly designated as DC, and radio frequency commonly designated as RF. DC sputtering is usually restricted to the deposition of conductive films. However, RF sputtering can be used to deposit either conductive or dielectric or insulating materials. Sputter depositing of films both conductive and insulating, is finding new applications, particularly in the fabrication of semiconductor devices. As the semiconductor devices becomes more sophisticated and more miniaturized the requirements for films used in the fabrication become more demanding. For example, a defect in a conductive or dielectric film in a very small device is much more likely to have an impact on its operability than if the device were much larger.

In sputtered films, both dielectric and conductive, used in the fabrication of semiconductor devices, a number of factors profoundly affect the quality of the films. As for example in metallic films it is important to obtain high conductivity. It is well-known that contaminants such as CO_2, O_2, and H_2O reduce the conductivity. Further H_2O when present in the films may present serious corrosion problems. In dielectric films contamination, such as CO_2 and H_2O affects etch rates and dielectric qualities. As for example contamination can produce pin holes and other defects which reduce the breakdown strength, and H_2O which may produce corrosion problems in the underlying metal stripe structure.

In integrated circuit devices, the circuit metallurgy consists of conductive metal stripes etched to the desired configuration from a single layer of metal or a laminated layer of metal. This circuit metallurgy is normally deposited on the top surface of a silicon dioxide layer bonded to the surface of the device body. The circuit metallurgy thus presents an irregular surface which can be advantageously protected by a thin layer of glass, silicon dioxide, silicon nitride, or combinations of suitable passivating layers. Frequently the circuit metallurgy consists of a plurality of alternate dielectric layers and metallurgy layers connected through via holes to collectively form a complete complex circuit. Each of the respective metallurgy layers must be effectively insulated from the associated layers by a suitable dielectric layer of the type referred to previously. Such layers are normally relatively thin and in general have thicknesses only slightly larger than the thickness of the metallurgy. Effective passivation requires dielectric films of good quality. A further important requirement is that the etched surfaces of the metallurgy be covered to thus provide effective edge protection. Film deposited by known RF deposition techniques have on occasion failed to provide effective edge protection.

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It is well-known that film quality is improved in DC sputtered deposition of metal films by positive ions bombardment of the film during deposition, commonly referred to as resputtering. The quality of silicon dioxide films deposited by RF sputter deposition is also improved by resputtering.

SUMMARY OF THE INVENTION

An object of this invention is to provide an improved RF sputtering apparatus for promoting resputtering during deposition of the film.

Another object of this invention is to provide an improved RF sputtering apparatus capable of depositing a high quality impervious layer over a substrate surface.

Still another object of this invention is to provide an improved RF sputtering apparatus which in operation will provide improved edge protection, improved film adhesion, and reduce contamination in the film.

In accordance with the aforementioned objects, the sputtering apparatus of the invention has a target electrode, a target of material to be sputter mounted over the target electrode, a substrate holder electrode spaced from the target electrode with an area ratio, of the substrate holder electrode to the target electrode holder less than 2.5, and an RF power source for applying an RF potential between the target electrode and the substrate holder electrode.

DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention as illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is an elevational view in cross-section of a preferred specific embodiment of the sputtering apparatus of the invention.

FIG. 2A is a fragmentary elevational view in cross-section in greatly enlarged scale illustrating the nature of a sputtered dielectric layer over a metallurgy stripe of semiconductor material deposited by sputtering techniques and apparatus known to the prior art.

FIG. 2B is a fragmentary elevational view in cross-section in greatly enlarged scale illustrating the sputtered dielectric layer produced by the apparatus and method of the subject invention.

FIG. 3 is an elevational view in cross-section showing a sputtering apparatus used to establish the resputtering theory and area relationship of the invention.

FIG. 4 is an elevational broken view in cross-section illustrating electrode structure of a preferred specific embodiment of the invention.

FIGS. 5, 6 and 7 are partial elevational views in cross-section of electrode structure illustrating various further embodiments of the sputtering apparatus of the invention.

FIG. 8 is a schematic diagram depicting the potential drop of current within the sputtering apparatus during operation thereof.

DESCRIPTION OF PREFERRED EMBODIMENTS

RF sputtering systems take advantage of the characteristic differences in electron and ion mobilities. The RF frequency applied is greater than the plasma ion resonance frequency of the glow space and lower than the plasma electron resonance frequency. Ion sheaths commonly referred to as dark spaces form next to the electrodes.

By way of explanation consider a glass tube having two electrodes of equal area facing one another a reasonable distance apart. With the application of sufficient DC voltage, a discharge strikes and a dark space is seen at the cathode. The voltage difference between the cathode and anode is dropped almost entirely across the dark space, leaving the glow space nearly field free. If, instead of DC, a low frequency alternating voltage is applied to this tube it is observed that the system behaves as though it had two cathodes since a dark space is seen at both electrodes. In actual fact this system is really a succession of short-lived DC discharges of alternating polarity since, at these low frequencies, there is ample time for a discharge to become fully established within each cycle.

When the frequency of the applied voltage is increased it is observed that the minimum pressure at which the discharge will operate is gradually reduced, the effect being detectable at about 50 kilohertz leveling off for frequencies in excess of a few megahertz. This indicates that there is an additional source of ionization other than the secondary electrons ejected from the electrodes. This source is electrons in the glow space that are heated as a consequence of the fact that electrons oscillating in the radio frequency field and making elastic collisions with gas atoms can pick up sufficient energy to cause ionization. The high voltage electrode which is essential in a DC glow discharge for the generation of secondary electrons is no longer needed by the RF glow in order to maintain itself.

Since the RF discharge is not dependent on secondary electrons from the electrodes, large electrode voltages are not necessary for maintaining the discharge. In addition the mechanism by which electrons absorb energy from the RF field would not apply to the heavier ions which would be expected to pick up relatively little energy from the RF field. At first glance one would not, therefore, expect an RF discharge to contain ions with sufficient energy to cause sputtering.

In practice, however, it is found that the glow space of an RF discharge develops an appreciable positive potential relative to the two electrodes, this potential difference appearing across the dark spaces. This arises because the electrons have a much higher mobility than the ions and are so very easily collected at the electrode whenever it becomes positive with respect to the glow discharge. This, in turn, causes depletion of the electrons from the dark space with a consequent rise in potential of the glow space with respect to the electrodes. The magnitude of the potential acquired by the glow space is such that through most of each RF cycle no electrons can leave it. On the other hand, positive ions will be attracted to the electrodes which they will reach after several RF cycles, once they enter a dark space. Sufficient electrons to balance this relatively small ion current will flow from the glow space to the electrodes during the small fraction of the RF cycle when the potential difference between the glow space and the electrodes is a minimum. The RF current through the dark space is thus principally electron displacement current, only a small fraction being electron or ion conduction current. Thus to a first approximation, RF coupling across the dark spaces is capacitive. However, the majority of the ions that do reach the electrodes have sufficient energy to cause sputtering.

The foregoing discussion was for electrodes of equal size. Let us now consider a configuration in which one electrode is appreciably larger than the other. The relative capacitive coupling of the glow space of the two electrodes now changes with the result that the potential of the glow space changes. However, no DC voltage differences can be maintained in the external RF circuit, so that the DC bias voltage across the dark space at the two electrodes remains equal. Hence this configuration behaves as before, that is as though the two electrodes had equal area, and the material is sputtered at the same rate per unit area from each electrode.

However, if a capacitor is inserted in the external circuit the DC potential between the glow space and the smaller electrode is no longer required to equal that of the larger electrode and the glow space. This results in an unequal rate of ion bombardment of the electrode with the larger area, and thus results in a deposition of material from the smaller electrode.

In summarizing, to a first approximation, the glow space is at a uniform potential, and potential differences between electrodes are taken across the dark spaces. Further the glow space of the discharge is capacitively coupled through the dark spaces to the electrodes and is always higher in potential than the highest potential electrode surface. A representative circuit approximating the sputtering discharge is shown in FIG. 8. The potential applied by RF power source **50** is dropped across a blocking capacitor **52**, which is described and claimed in commonly assigned U.S. patent applications Ser. Nos. 514,853 and 514,827; a target **54**, a first dark space **56** between the target electrode and the glow, a second dark space **58** between the substrate holder and the glow discharge, and film **60** on the substrate.

The two dark spaces behave like capacitors with diodes paralleling them. The dark spaces are connected through the glow space, which is of relatively low impedance. RF voltages acros sthe dark spaces are rectified resulting in a DC bias voltage across them.

The ions which sputter the target and those which resputter the film have energies roughly in proportion with the voltage across the respective dark spaces. The ratio of these ion energies, and therefore the ratio of voltages across the dark spaces, is a factor controlling film quality. The ratio of voltages across the dark spaces is determined by the ratio of capacitances of the dark spaces, which in turn is largely controlled by the ratio of electrode areas. A rough relationship between the electrode areas and ratio of voltages across the dark spaces can be derived as follows:

When it is assumed that (1) the current density of the positive ion is uniform and equal at both electrodes, (2) the positive ions come from the glow space and traverse the dark space without making inelastic collisions, and (3) the capacitance across the dark space is proportional to the electrode area and inversely proportional to the dark space thickness. Then, based on the assumptions 1 and 2, the equation for space charge limited ion current would require that

$$\frac{D_1}{D_2}=\left(\frac{V_1}{V_2}\right)^{3/4}$$

where D_1 and D_2 are thicknesses of the dark spaces and V_1 and V_2 are the DC bias voltages across them. Capacitive division of RF voltage between the dark spaces, which is in effect rectified to give DC bias, requires that V_1/V_2 equal C_2/C_1, where C_1 and C_2 are the respective capacitances across the dark spaces. Assumption 3 requires that

$$\frac{C_2}{C_1}=\frac{A_2D_1}{A_1D_2}$$

where A_1 and A_2 are the areas of the electrodes. Combining the above equations gives the result

$$\frac{V_1}{V_2}=\left(\frac{A_2}{A_1}\right)^4$$

In conventional systems, the substrate holder is maintained at the same potential as the metal walls of the vacuum chamber and the glow space fills the entire vacuum chamber. The substrate holder and the other metal surfaces in the chamber comprise an electrode of large area compared with the target, normally an area more than four times than that of the target.

Films deposited with such prior art systems have need for improvement in regard to adhesion, resistance to chemical attack, film defects, contamination, and edge protection.

The apparatus and method of this invention effectively promotes resputtering in an RF sputtering chamber, of both conductive and insulating films, to (1) reduce contamination in the resultant films, (2) improve adhesion between the deposited film and the substrates, (3) improve edge protection, particularly in insulating films, (4) reduce porosity, and (5) improve resistance to chemical attack.

Referring now to the drawings, FIG. 1 illustrates a first preferred specific embodiment of the improved sputtering apparatus **10** of the invention. The apparatus **10** has a target electrode **12** supporting a target **14** of material to be sputter deposited. Preferably target electrode **12** is provided with a suitable cooling means as for example a tube **15** mounted in a larger hollow conduit **16** wherein water or other suitable cooling fluid can be introduced and circulated within the hollow electrode. Substrate holder electrode **18** is mounted in spaced relation to electrode **12**. Substrate semiconductor wafers **19** are shown supported on electrode **18**. Electrode **18** has an annular downwardly extending portion **20** which significantly increases the surface area of the electrode **18**. The area ratio of the substrate holder **18** to the target electrode is less than 2.5, more preferably in the range of 1.4 to 2.0. This is a significant feature of the improved sputtering apparatus of the invention. The substrate holder electrode **18** is mounted with the extending flange **21** in abutment with downwardly extending pins **22** which space the electrode **18** from target **14**. The spacing is such that there is a small space between flange **21** and target **14**. It can be seen that the combination of the target **14** and the electrode **18** confines the region of the glow discharge within a larger chamber. A suitable conduit **24** is provided to introduce a gas, commonly an inert gas such as argon, into the confined region of the glow discharge. The electrodes **12** and **16** are supported in a chamber illustrated on the drawings as a bottom plate **26**, a cylindrical wall **28** and a top plate **30**. Seals **32** disposed in annular grooves **33** in plates **26** and **30** insure a vacuum tight chamber. Electrode **12** has an annular insulating member **34** disposed between an apertured extension on plate **30** and stem **16**. A shield member **35** can be provided which surrounds electrode **12** and is spaced therefrom. Electrode **18** includes a movable support element **36** extending through guide **37** in plate **26**. Support **36** is of a conductive material and is in electrical contact with electrode **18**. A suitable RF power source (not shown) is provided for applying an RF potential between the target electrode **12** and the substrate holder electrode **18**. Cylindrical wall **28** has an aperture **39** connected to a relatively large conduit **38** which is connected to a suitable vacuum source (not shown).

The apparatus **10** has a substrate holder electrode **18** with an effective surface area significantly larger than the effective surface area of the target holding electrode **12**. Providing a substrate holder electrode having an effective surface area which is less than 2.5 times the area of the target holder electrode promotes resputtering of the deposited film during the deposition.

In FIG. 2A there is depicted a typical cross-section of sputter deposited layer of inorganic insulating material produced by conventional sputtering techniques. In semiconductor device structure a wafer **40** is normally provided with an SiO_2 layer **41** and an overlying metallurgy stripe **42**. Insulating layer **43**, typically SiO_2 or glass, overlies the surface of SiO_2 layer **41** and the stripe **42**. As indicated, at the top vertical edge **44** of the stripe **42** there is a discontinuity, or channel **45**, in the dielectric film. This discontinuity is a flaw, which could cause failure of such a device. For example, if layer **43** is the top passivating layer moisture or other contaminates may reach the metallic strip **42** through openings in **45** causing corrosion and subsequent failure. Further, if additional levels of metallurgy are deposited on the device **40** metal from the overlying layer could reach through openings or cracks in the discontinuity **45** and form a short with the underlying stripe **42**.

In contrast FIG. 2B shows in cross-section insulating glass layer **46** deposited over similar device structure. Note that unlike FIG. 2A there is no channel leading from the edge **44** of stripe **42**. The dielectric film **46**, although conforming somewhat to the upper surface of the device, is continuous in the step down over stripe **42**.

A significant feature of the apparatus of the invention is that in the embodiments of FIGS. 1, 4 and 5 the sputting gas is introduced directly into the region confining the glow discharge. This permits a higher pressure within this chamber since it is bled off through relatively small openings and exhausted through the chamber. In general, increasing the gas pressure provides a higher sputter deposition rate. The electrons ejected from the target and accelerated at high energy in the dark space make more ionizing collisions before being collected by the substrate holder electrode when the gas pressure is higher. However, low pressure is desirable to prevent a discharge between the target holder electrode and the shield surrounding it.

Yet another advantage of confining the glow discharge is that it minimizes the effect of outgasing of surfaces after the chamber has been opened and subsequently closed. Each time the sputting chamber is opened the inside and the elements thereof are exposed to the atmosphere and a small amount is absorbed by the walls and element. Upon closing and drawing a vacuum in the chamber the elements which are heated outgas. In the instant apparatus only the electrodes are heated to any significant extent and thus these are the only surfaces which outgas.

Referring now to FIG. 4, there is illustrated another preferred specific embodiment of the electrode structure of the invention. Target electrode **12** supports target **14**, which is shielded by shield **35** in basically the same arrangement as illustrated in FIG. 1. Substrate holder electrode **18** is provided with an annular portion **20** which serves to increase the area of the electrode, and a flange **21** in abutment with metal pins **22**. There is provided a cylindrically shaped member **70** of a dielectric material to close the gap between the substrate electrode holder **18** and the target **14**. Element **70** can be of glass or any suitable type of insulating material.

Referring now to FIG. 6 there is illustrated yet another preferred specific embodiment of the invention. The target electrode **12**, target **14**, and shield **35** are basically the same as in the structure illustrated in FIG. 1. However, substrate holder electrode **72** is provided with an annular peripheral chamber which extends outwardly beyond the edge of target **14**. The electrode **72** is provided with an inwardly extending flange **73** which is spaced from the target **14**. This spacing is maintained by abutment pins **22** in combination with the upwardly facing surface **74**.

Referring now to FIG. 6 there is illustrated yet another preferred specific embodiment of the invention. In this embodiment the target electrode **12**, target **14**, shield **35** are also basically similar to the structure illustrated in FIG. 1. However, the substrate holder electrode **80** is supported on pins **82** and is provided with aperture **84** distributed along the protruding peripheral flange **85**. A screen **86** can be provided to cover the apertures **84**. Wall **87** is provided an annular groove which cooperates with electrode **80** to form a relatively large surface and to confine the glow discharge region of the apparatus. Covering the interior wall **88** is a thin layer **90** of glass or other suitable dielectric material. The gas inlet **92** is provided in the bottom plate **93** below electrode **80** and also the vacuum outlet **94**. Seals **32** seal the joints between top plate **30**, wall **87**, and bottom plate **93**.

Referring now to FIG. 7, there is illustrated yet another preferred specific embodiment of this invention. When the size of the electrode is increased beyond a certain point the capacitive effects at the edge become increasingly significant and generate non-uniform electric fields. In order to assure uniform film deposits on the substrates the opposing areas of the electrodes should be re-adjusted. In this embodiment the target holder electrode and its associated elements are basically the same as is illustrated in FIG. 1. In substrate holding electrode

100 there is provided a plurality of annular grooves 102 in the top surface of the electrode. These grooves provide a more uniform matching of the surface area of the substrate holding electrode and the target electrode which results in more uniform electric fields, which in turn produce more even deposit of films.

The following examples are included to clarify and present preferred specific embodiments of the invention and not to unduly limit same.

Example I

In order to establish the validity of the foregoing derived correlation between the voltage of the dark spaces and the respective areas of the electrodes the electrode area ratio was varied with an experimental sputtering apparatus shown in FIG. 3 and the voltages across the dark spaces measured. The apparatus consisted of an RF power source connected across electrodes **12** and **18**. A layer of quartz **14** served as the target. Different flange elements **110** of conductive material were supported on electrode **18** for different runs and the region between the electrodes confined with a glass cylinder **112**. In order to achieve different area ratios of the electrodes element **110** with different lengths of upstanding flange portions **114** were used during the run.

Sputtering gas was admitted to the sputtering chamber and the pressure within the chamber controlled. By substituting different elements **110**, area ratios of 1 to 2.28 were achieved. A retarding potential instrument was used to obtain energy distributions of charged particles incident on the grounded substrate holder electrode. From this data, the voltages across the dark spaces of the two electrodes was established. The results thus obtained are presented in the following table.

A_1/A_2	$(A_1)/^4(A_2)$	V_2/V_1	V_1+V_2
1	1	1	1,370
1.36	3.4	1.7	1,330
1.80	10.5	6.0	1,330
2.28	27.3	12.0	1,400

In the table A_1 is the combined area of the electrode **18** and the inner surface of flange **110**; A_2 is the area of the electrode **12** within cylinder **112**; V_1 is voltage between the glow space and electrode **18**; and V_2 is the voltage between the glow space and the target electrode **12**. As the table indicates, there is a definite correlation between the ratio of the voltages to the ratio of the areas taken to the fourth power within the limits imposed by experimental errors, measurement techniques and other conditions within the chamber which depart from the theoretical. More specifically, the extent to which the fourth power relation holds is limited largely by the extent to which the stated assumptions in the derivation are valid. In systems like those of FIG. 1 used for film deposition, corners are put in with considerable radius instead of right angles, resulting in closer agreement than shown in the above table. The calculation can be further refined by assuming the area of the glow space adjacent to the electrode, separated from it by the dark space, in place of the area of the electrode. In smaller systems, such as that used for the data of the above table, where the dark space thicknesses are a significant fraction of the dimensions of the chamber, this correction is more important. Also note that the total potential drop across the electrodes remained essentially constant.

Examples II and III

In order to evaluate the film produced by the subject invention, films were deposited by sputtering techniques known to the prior art and the apparatus of the invention, and the resultant films compared. A quartz target was used in both sputtering apparatuses. In the apparatus practicing the invention the ratio of the substrate area to the target area was 2, whereas in the apparatus practicing the art the corresponding ratio was approximately 5. Argon gas was used in both instances with the pressure in the sputtering apparatus practicing the invention being 50 microns, whereas the other apparatus practicing the prior art pressure was 5 microns. This pressure variation was made because the pressure of 50 microns in the chamber practicing the prior art would result in a film of very low quality. Thus the reduction in pressure was necessary to provide nearly optimum conditions to produce a film useful for purposes of comparison. A quartz film approximately 2 microns in thickness was deposited over a silicon substrate having a metallurgy stripe approximately 1 micron in thickness. The rate in both instances was approximately 250 A. per minute.

After the sputtering operations were complete, the films were compared. The substrate having the film sputtered in accordance with the invention showed superior edge protection with a profile similar to that depicted in FIG. 2B. In contrast the edge profile of the substrate sputtered in accordance with the prior art techniques appeared generally as depicted in FIG. 2A exhibiting hairline cracks leading from the edge of the metallurgy to the surface. Both substrates were broken. The break in the wafer sputtered in accordance with the invention broke cleanly over the stripe indicating good adhesion. In contrast the other substrate broke unevenly parting at the interface between the stripe and the film indicating relatively poorer adhesion. Both substrates were subjected to an etchant consisting of a buffered HF solution to provide a measure of resistance to chemical attack. The etch rate in the film sputtered in accordance with the invention had an etch rate appreciably lower than the etch rate of the film sputtered in accordance with the prior art teachings. Salt water was contained over the top surfaces of the wafers and a 40 volt potential applied between the water and the underlying conductive pattern. Any holes in the film produced bubble trails at the opening. It was noted that the film produced by the technique of the invention had approximately 1/10 the number of pin holes as the corresponding film sputtered in accordance with the teachings of the prior art.

While the invention has been particularly shown and described with reference to preferred specific embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail may be made without departing from the scope of the invention.

What is claimed is:

1. An RF sputtering apparatus comprising:
- a target electrode,
- a target of material to be sputtered mounted on said target electrode,
- a substrate holder electrode spaced from said target electrode,
- said substrate electrode and said target forming at least in part an enclosure for confining a glow discharge,
- an annular peripheral recessed portion on said substrate holder electrode, the area ratio of said substrate holder electrode including said recessed portion within said enclosure to the area of the target electrode being less than 2.5 and greater than 1,
- an RF power source for applying an RF potential between said target electrode and said substrate holder electrode,
- said area ratio of said electrodes promoting a significant amount of resputtering of the deposited film.

2. The apparatus of claim **1** which further includes a chamber which encloses said enclosure for confining a glow discharge.

3. The apparatus of claim **2** which further includes a conduit having an outlet in communication with the confined space between said target holder electrode and said substrate holder electrode.

4. The apparatus of claim **2** which further includes an outwardly extending radial flange on the periphery of said recessed annular portion of said substrate holder, and a plurality of projections in fixed relation around the periphery of said target holder electrode which make contact with said radial flange.

5. The apparatus of claim **2** wherein said substrate holder electrode further includes a plurality of grooves distributed over the surface thereof.

6. The apparatus of claim **5** wherein said grooves are annular in shape.

7. The apparatus of claim **2** wherein said substrate holder electrode includes on said annular recessed portion an inwardly extending radial flange, and a plurality of projections in fixed relation about said target holder electrode which contact said radial flange.

8. The apparatus of claim **1** wherein said area ratio is in the range of 1.4 to 2.0.

9. The apparatus of claim **1** which further includes:

a top plate supporting said target electrode, a bottom plate supporting said substrate holder electrode,

an annular wall disposed between said top plate and said bottom plate forming an enclosure,

said substrate holder electrode in combination with said wall and said target confining the region for the glow discharge.

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