

A COATING APPARATUS

Technical Field

This invention relates to an arc deposition
5 apparatus for applying a coating to a substrate.

Background

Physical vapor deposition (PVD) is a technique typically employed in coating applications. PVD finds
10 utility in industries including but not limited to, semiconductors, hard tooling, mold deposition and hard coating. Known PVD processes include evaporation, sputtering and arc deposition.

In recent years, arc deposition has gained
15 importance in the realm of PVD. During arc deposition, an electric arc is generated and maintained between the coating source (usually biased as the cathode) and an anode surface. The cathode, upon being struck with a high electric current (typically in excess of 100 amperes
20 (A)), releases a high velocity jet of vaporized cathode material, known as the plasma beam. The plasma beam contains high energy particles including ions and electrons. The plasma particles travel along a plasma beam path and subsequently impinge onto a substrate
25 surface which is to be coated with the plasma particles. This form of arc deposition technique has found to be particularly suitable for numerous commercial applications, particularly in the deposition of wear-coat surfaces of cutting tools, drill bits, gears, molds, etc.

30 In one known arc deposition apparatus, the substrate to be coated is mounted on a substrate holder which is vertically arranged to be substantially perpendicular to the direction of the plasma beam. One problem associated with having a vertically arranged substrate holder is

that there exists a need to secure the substrate(s) on the holder during the deposition process. This problem becomes especially pronounced when it comes to large and heavy substrates, for example silicon wafers or molds.

5 Silicon wafers are costly substrates and highly brittle in nature. Presently, silicon wafer deposition typically utilizes magnetron sputtering and chemical vapor deposition processes. It is desired, however, to employ arc deposition on silicon wafers for its high energy and

10 high density deposition. A problem arises because there is need for the wafer to be tilted to accommodate conventional arc apparatuses, which is complicated and not economical

In the semiconductor industry, the loading of wafers

15 is typically performed through robotic arm loading on a chuck. The chuck typically also performs the function of cooling, rotation and insulation (for electrical biasing purposes). As such, the design of the chuck can be complicated, in particular, when it comes to providing

20 cooling in vacuum. There is usually a need to provide a medium between the chuck and the wafer to ensure good thermal conduction. Typically, helium gas will be used. Helium will be purged in between the chuck and the wafer but due to gravity, helium is only present in the grooves

25 between the wafer and the chuck. During conventional arc deposition however, the wafer needs to be tilted to the vertical position. Hence, the following technical problems arise:

1. An additional mechanism may be required to tilt the
- 30 holder from a horizontal to a vertical position which cannot be accomplished with ease in vacuum due to the need for precision control and the weight of the chuck;

2. There is also a need to ensure that the wafer can be held firmly on the chuck. Complicated jigging may need to be designed as a result. However, in modern wafer fabrication, jigging is generally undesirable and usually avoided.

3. The reliability of thermal and electrical conductivity is adversely affected due to the lack of gravitational force acting on the wafer. This in turns affects the final yield of the wafer.

The technical difficulty in employing arc deposition on heavy molds, such as for example, plastic injection molds, lies in the process of mounting the relatively bulky and heavy molds on a vertical substrate holder and thereafter securing the molds in position during the deposition process. Of course, this problem plagues various forms of large substrates, a mold is merely exemplary in demonstrating this problem.

Additionally, it can require an operator an inordinate amount of time to affix the substrates onto the vertically disposed holder. The operator may expend undue time attempting to affix the substrates onto the holder and will also be required to provide additional securing means to anchor the substrates onto the holder to prevent displacement during deposition. Herein lies the subsidiary problem of contamination. Preferably, physical handling of the substrates should be minimized prior to the coating process. This is because physical handling of the substrates tends to introduce impurities onto the coating surface of the substrate. Understandably, this can have an adverse impact on the uniformity and density of the resultant coating, which in turn reduces the mechanical strength of the coating. Vertically arranged substrate holders unfortunately exacerbate the problem of contamination. Due to the

practical difficulties in affixing and fastening the substrates onto the vertically arranged holders, the operator inevitably introduces minute particles and impurities onto the substrate surface through excessive
5 handling.

Another problem associated with known deposition apparatus designs is that there is often an uneven depletion of the cathode surface. The motion of the electric arc is random and is initiated when the surface
10 of the cathode experiences a high intensity current, resulting in the formation of a high emittance zone called the "cathode spot". The cathode spot is capable of relocating to an adjacent spot, resulting in the apparent motion of the electric "arc". Sometimes however, a
15 cathode spot may stay at an evaporative spot for longer than usual, resulting in excessive vaporization and the subsequent emission of a large quantity of cathode material. This phenomenon causes the formation of macroparticles in the produced plasma beam.
20 Macroparticles (which are essentially a large cluster of plasma particles exceeding 50 nm in size) are undesirable as they are detrimental towards coating uniformity and density.

Furthermore, as a result of macro-particle
25 formation, small craters may be formed on the target (cathode) surface. Such craters, which are the result of uneven depletion of the target surface, lower the subsequent deposition rate as compared to a relatively smooth target surface experiencing uniform erosion. To
30 ameliorate this problem, one solution adopted by existing arc deposition users is to cut and expose a fresh, un-cratered surface of the cathode. However, this approach causes hassle and disruption to the coating process. Moreover, such an approach also leads to significant

wastage of the cathode material, which can be costly to purchase.

Accordingly, there is a need to provide a coating apparatus that can solve or ameliorate the technical problems described above. There is a need to provide a coating apparatus that is capable of processing substrates that may be too cumbersome to mount on a conventional substrate holder. There is also a need to provide a coating apparatus that can minimize impurities and deposit dense, uniform coatings. There is also a need to provide a target source that can be uniformly depleted to minimize wastage of the cathode material and optimize deposition rates. Last but not the least, there is a need to provide a deposition apparatus that is compact and suited for retrofitting.

Summary

In a first aspect, there is provided a coating apparatus for coating a substrate comprising: a chamber; a cathodic arc source for generating and projecting a plasma beam along a plasma beam path within said chamber, said projected plasma crossing a horizontal plane within the chamber; a moveable holder having a planar mounting surface that is generally parallel to said horizontal plane, said moveable holder being configured to move the planar mounting surface relative to the horizontal plane within said chamber and into the path of the plasma beam to form a plasma coating on said substrate.

The cathodic arc source may be selected from metals, metal alloys, ceramics, carbon and mixtures thereof, which are capable of electrical conduction.

In one embodiment, the present coating apparatus is suited for depositing a layer of coating on a substrate,

wherein the substrate has a length dimension greater than its thickness dimension. Exemplary substrates include, but are not limited to, silicon wafers, drill bits and molds.

5 The plasma beam path may describe a generally curved trajectory as it passes from the plasma beam duct into the deposition chamber. In one embodiment, the plasma beam path may be generally tangential with respect to the horizontal plane.

10 The coating apparatus may further comprise filtering means, adapted to separate or remove macroparticles from the plasma beam path. The filtering means may include any one of, or a combination of the following, such as physical baffles, plasma ducts having continuous bends or
15 discrete bends and electromagnetic fields. In one embodiment, the filtering means comprises an electromagnetic field applied across a plasma duct having an angular bend. Advantageously, the filtering means serves to separate or deviate large clusters of the
20 plasma particles (i.e. macroparticles) from the main plasma beam path. As a result, the deposited coating is free from irregularities and is capable of having a densely packed arrangement. Advantageously, the high density of the coated layer correlates strongly with its
25 good mechanical strength.

 The moveable holder may comprise a planar mounting surface that is generally parallel to the horizontal plane. Advantageously, this configuration overcomes the difficulty of mounting large substrates and securing them
30 onto a substrate holder. Substrates are simply allowed to rest upon the mounting surface under the force of gravity. Even more advantageously, this embodiment may allow for large and unwieldy substrates to be simply placed on top of the holder without having to install

additional means for securing the substrate. Also advantageously, having a mounting surface disposed in a generally horizontal plane makes it easier for an operator to retrofit optional structural features to the holder. Exemplary optional features may include an integrated cooling system and a power source.

A cooling system may be useful in deposition processes whereby there is a constant need to cool down the substrate/substrate holder, particularly when the particles impinging the substrate are superheated particles, for example, in sputtering processes. Other optional features may include, but are not limited to, an integrated power supply, an external actuator or motor for moving the substrate holder along or out of the horizontal plane.

Also advantageously, the generally horizontal configuration of the moveable holder results in minimal handling and positioning of substrates by the operator, thereby minimizing the risk of introducing impurities onto the substrate surface.

The moveable holder may be movable relative to a horizontal plane within the deposition chamber. In one embodiment, the holder is capable of being moved such that the planar mounting surface moves laterally relative to the horizontal plane. In another embodiment, the moveable holder may be moved in a way such that the planar mounting surface rotates about a vertical axis that is substantially normal to the horizontal plane. Advantageously, the moveable holder allows the operator to fine-tune the deposition process and allows for a greater degree of control over the coating thickness and coating area. Also advantageously, the rotary motion of the planar mounting surface during the deposition process ensures a more uniform distribution of the plasma

particles, resulting in the deposition of an evenly coated layer.

The coating apparatus of the first aspect may further comprise a magnetic diffuser disposed along the plasma beam path, preferably at the entrance into the deposition chamber. The diffuser may comprise of any suitable means capable of generating a magnetic field. In one embodiment, the diffuser is a current carrying electric coil capable of generating a magnetic field for directing the plasma beam path. The magnetic field may be configured to either converge the plasma beam or to cause the plasma beam to spread out in a divergent manner. Methods for manipulating the magnetic field to achieve the convergence and/or divergence of the plasma beam are well-known to the skilled person in the art and will not be further elaborated upon herein. In one embodiment, the magnetic diffuser is configured to cause divergence in the plasma beam at the entrance to the deposition chamber. Advantageously, the divergence of the plasma beam may be coupled with the rotary motion of the substrate holder to achieve a surprisingly uniform coating. Alternatively, the magnetic diffuser may be employed to converge the plasma beam onto an area of substrate where a thicker coat is desired, for example, in the coating of tool tips or where the size of the substrate is smaller.

In a second aspect, there is provided a cathode assembly for generating and projecting a plasma beam in an arc deposition apparatus, said assembly comprising: a target positioned for generating a plasma beam along an adjacent plasma duct when an electric current strikes an ignition surface of said target; an electrode disposed within a plasma duct and being configured to emit an electric pulse intermittently on said ignition surface of

said target; a magnetic source capable of emitting a magnetic flux to direct the plasma beam within said duct towards a deposition chamber and to induce a preferential arc motion towards said target; and means for moving the target relative to said electrode to enable different ignitions surfaces to be struck during generation of said plasma.

The cathode assembly of the second aspect may be releasably coupled to a deposition chamber. In one embodiment, the cathode assembly may be a modular unit capable of being retrofitted onto an existing deposition chamber for generating a plasma beam.

The means for moving the target may be mechanically coupled to the target. In one embodiment, the moving means may be provided adjacent to, or within, the cathode assembly, such as a motor or an actuator. In one embodiment, the target is coupled to a motor configured to rotate the target about an axis. The axis may extend from a substantially central position of the target. In one embodiment, the target may be rotated about the axis whilst electric arcs are being intermittently triggered on its surface to enable different ignition surfaces to be struck during the generation of plasma.

Advantageously, the rotary motion results in more uniform erosion of the target material and minimizes the formation of large craters on the target surface. Crater formation is undesirable as it reduces the rate of plasma deposition and further promotes the ejection of macroparticles from the target.

The electrode configured to emit electric pulses on the target may be biased as an anode. In one embodiment, an electric arc is generated from the anode by intermittently contacting the target. A mechanical "striker" coupled to the anode may be used for

the contacting or "striking" of the target to form a close circuit configuration, thereby triggering an electric current through the target.

5 The time interval between the intermittent striking may range from about 30 seconds to about 60 seconds. Typically, the electric arc describes a random and independent arc path; a new arc generated by a subsequent "strike" from the anode travels independently of the path undertaken by the previous arc. The inventors have
10 surprisingly discovered that by initiating arc formation on the target at intervals of about 30 to 60 seconds, cathode spot formation is more evenly distributed across the surface of the target. As a result, a more uniform erosion of the target is achieved and this effect
15 advantageously synergizes with the rotary motion of the target assembly.

The cathode assembly may further comprise filtering means as disclosed in the first aspect. The filtering means may comprise an electric coil for inducing a
20 magnetic field. Without being bound by theory, the inventors have surprisingly discovered that the fluxing of the magnetic field lines (induced by the electric coil) with the target may influence the arc movement on the target surface. In particular, it has been observed
25 that the flux between the magnetic field and the target causes the electric arc to preferentially "migrate" towards the centre of the target. Advantageously, the rotary motion of the target, the intermittent contact between the striker and the target and the provision of a
30 magnetic flux cutting through the target surface, each alone and in combination, results in a surprisingly uniform erosion profile of the target source. Hence, the present cathode assembly advantageously overcomes the technical problem of crater formation. The present

cathode assembly further negates the need to constantly expose a fresh target surface for plasma beam generation, thereby preventing wastage of the target material whilst at the same time, maintaining an optimal deposition rate.

5

Definitions

The term "plasma" as used in this context, refers to an amalgamation of vaporized ions ejected from the target source and may also contain free electrons.

The term "target" as used in this context, refers to any metal, ceramic, metal alloy, carbon and its composites, and mixtures thereof which are capable of electrical conduction and to which an electric arc is applied to cause vaporization and thereby emits or ejects a plasma beam.

The term "electric arc" as used in this context, refers to the apparent motion of an electric current on a target material caused by the migration of the cathode spot on the target surface.

The term "macro-particles" as used in this context, refers to relatively large clusters of ejected target material having an aggregate diameter of larger than 50 nm.

The word "substantially" does not exclude "completely" e.g. a composition which is "substantially free" from Y may be completely free from Y. Where necessary, the word "substantially" may be omitted from the definition of the invention.

Unless specified otherwise, the terms "comprising" and "comprise", and grammatical variants thereof, are intended to represent "open" or "inclusive" language such

that they include recited elements but also permit inclusion of additional, unrecited elements.

As used herein, the term "about", in the context of concentrations of components of the formulations, typically means +/- 5% of the stated value, more typically +/- 4% of the stated value, more typically +/- 3% of the stated value, more typically, +/- 2% of the stated value, even more typically +/- 1% of the stated value, and even more typically +/- 0.5% of the stated value.

Throughout this disclosure, certain embodiments may be disclosed in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

Disclosure of Optional Embodiments

The filtering means according to the first aspect of this invention can comprise any suitable means adapted to remove or separate macroparticles from the main plasma trajectory beam. Exemplary filtering means may include a torrous duct having a curvature of about 0° to 90° offset from the plasma beam path. The torrous duct may have a single continuous bend or discrete angular bends. The

filtering means may also comprise a magnetic field generator coupled to the plasma duct for providing a magnetic field within the duct. The magnetic field is capable of affecting the trajectory movement of the plasma beam. In one embodiment, the filtering means is a duct comprising an angular bend with a curvature of about 30° (relative to the plasma beam path) coupled with a magnetic field generator, which may be an electric coil surrounding the plasma duct.

Other possible variations of the filtering means may include the installation of mechanical baffles along the plasma duct for trapping macroparticles. In one embodiment, it may be possible to filter the plasma beam with the use of baffles alone without the use of a torrous duct and/or magnetic fields, depending on the quality of coating desired.

Certain deposition processes may require the height of the substrates (and substrate holder) to be adjusted relative to the plasma beam. Accordingly, it should be appreciated that the height of the horizontal plane relative to the plasma beam path can be readily adjusted by suitable mechanical means common to the designs of deposition apparatus. Whilst the present application expresses a preference to install minimal mechanical structures within the deposition chamber, the present invention does not preclude suitable and routine modifications to the height of the substrate holder.

The cathode assembly of the second aspect may further comprise moving means coupled to the target. The moving means may be suitably configured to move the target in a rotational motion about an axial axis extending from the cross sectional surface of the target. The axial axis may extend from a substantially central point on the target surface. In one embodiment, the

moving means is an electric motor. Preferably, the electric motor can be powered by an integrated power source coupled to the cathode assembly.

5 The cathode assembly of the second aspect may further comprise cooling means. The cooling means may comprise a plurality of parallel conduits disposed within the cathode assembly. When in use, a coolant fluid may be provided within the plurality of conduits for heat exchange to thereby reduce the overall temperature of the
10 cathode assembly. In one embodiment, the coolant fluid is water.

Brief Description Of Drawings

Fig. 1 is a schematic diagram of a coating apparatus
15 according to a disclosed embodiment.

Fig. 2 is an expanded view of the cathode arc source of Fig. 1.

Fig. 3A is a top view of the cathode showing the erosion patterns of the cathode spot(s). Fig. 3B is a
20 side view of the cathode with the cathode spot and magnetic flux lines. Fig. 3C is a simplified version of the cathode of Fig. 3B.

Fig. 4A and Fig. 4B are cross-sectional views of the plasma beam duct. Fig. 4A further includes a filter
25 bend.

Fig. 5A and Fig. 5B are schematic diagrams showing the relationship between the magnetic coil current and the magnitude of plasma beam divergence.

30

Detailed Description of Drawings

Referring to Fig. 1, there is provided a coating apparatus 100. The coating apparatus 100 comprises a cathode arc source 4, a plasma beam duct 9, magnetic
35 coils 26 (acting as the magnetic source) and a deposition

chamber 2. In use, a substrate 8 is placed on a substrate holder 6 within the deposition chamber 2 such that the substrate 8 and substrate holder 6 lie along a substantially horizontal plane (or along the x-axis). The cathode arc source 4 generates and projects a plasma beam 11 that travels within the plasma beam duct 9 along a plasma beam path (not shown). The direction of the plasma beam path is controlled by the magnetic flux generated by the magnetic coils 26 that are suitably positioned along the plasma beam duct 9. As shown in Fig. 1, the plasma beam duct 9 is a torrous duct and comprises an angular bend prior to contacting with the deposition chamber 2. Due to the magnetic coils present at the bend, the plasma beam 11 curves downwards under the influence of the magnetic field.

As such, the plasma beam 11 enters the deposition chamber 2 at an angle that is shown in Fig. 1 as $(90-\theta)^\circ$ and deposits a coating on the substrate 8, facilitated by a negative bias which is being applied to the substrate holder 6. By introducing the plasma beam 11 into the deposition chamber 2 at an angle, this ensures that macroparticles within the plasma beam duct 9 fall downwards under the force of gravity (as a result of their significant mass) onto an empty area adjacent the substrate holder instead of onto the substrate 8 or the substrate holder 6. The movement of the macroparticles within the plasma beam duct 9 will be explained in detail further below.

A magnetic diffuser in the form of magnetic coil 10 is positioned at the entrance of the deposition chamber 2 to diverge or broaden the plasma beam 11 entering the deposition chamber 2. Due to the effect of the magnetic flux, the plasma beam 11 becomes diffused and spreads out such that the width of the coating deposited on the

substrate 8 increases. Hence, the magnetic coil 10 aids to direct the plasma beam 11 onto the substrate 8, increases the coating width on the substrate 8 and improves the coating uniformity on the substrate 8. This enables bigger substrates to be coated efficiently and with less time. The divergence of the plasma beam 11 also serves to confer an operator improved control over the deposition rates. A less divergent plasma beam 11 will possess faster deposition rates at the expense of coating a smaller area. A more divergent plasma beam 11 will conversely have lower deposition rates, albeit being able to coat a larger surface area.

The substrate holder 6 can be moveable such that the substrate 8 or plurality of substrates 8 placed thereon can be displaced to a desired coating location. In this case, the substrate holder 6 can rotate about a substantially central axis 7 that extends normally from the substrate 8. As the substrate holder 6 rotates, the substrate 8 can be evenly coated by the plasma beam 11 that enters the chamber via a fixed point. In another embodiment, the substrate holder 6 can be moved laterally along the horizontal plane such that the plasma beam 11 can continuously coat a number of substrates 8 without having to move the plasma beam 11. Such mobility is envisioned to be particularly useful in a continuous coating configuration whereby a plurality of substrates are to be coated sequentially as they move along the horizontal plane, for example, on a conveyor belt system. In a further embodiment, the substrate holder 6 can be moved vertically (or along the y-axis) relative to the horizontal plane such that the sides of the substrate 8 can be coated as desired. The motion of the substrate holder 6 is controlled by a mechanical motor (not shown).

The cathode arc source 4 together with the plasma beam duct 9 can be releasably coupled to the deposition chamber 2.

Fig. 2 is an expanded view of the cathode arc source 4 and part of the magnetic coils 26 of Fig. 1, as shown in Fig. 1 by the dotted box 12. The cathode arc source comprises a cathode 14, an anode 22 and a trigger 24. The cathode 14 is rotatable about an axial axis that extends from a substantially central position of the cathode 14. A moving means such as a motor (not shown) is used to rotate the cathode 14. A cooling conduit 16 connects a coolant source (not shown) to and extends within the cathode 14. The cooling conduit 16 allows a cooling means such as a coolant to flow through the cooling conduit 16 and into the cathode 14 so as to prevent over-heating of the cathode 14. The coolant can be a refrigerant or water.

A power source 18 provides a low voltage, high current supply to the cathode 14. As the trigger 24 strikes the cathode 14, the electrical circuit between the cathode 14 and anode 22 is closed such that an electric arc is produced on the cathode 14 surface. The trigger 24 strikes the cathode 14 at regular intervals to ensure uniform erosion of the cathode 14. Part of the magnetic coil from Fig. 1 is shown in Fig. 2 as magnetic coil 26'. The magnetic flux 28 generated from the magnetic coil 26' fluxes with the cathode 14 and extends within the plasma beam duct 9'. The presence of the magnetic flux 28, the rotational motion of the cathode 14, coupled with the ignition of an electric arc at regular intervals, allow for a more uniform erosion of cathode 14. The inventors have found that without the rotational motion, the cathode 14 tends to erode in an uneven manner. An insulator 20 surrounds the cathode 14

in order to prevent the risk of short circuitry and also to protect the user from electrical shocks.

Fig. 3A is a top view of the cathode 14 of Fig. 2 that is represented here as cathode 14'. As mentioned above, the trigger 24 hits the cathode at regular intervals to produce a cathode spot. Such cathode spots are shown in Fig. 3A as cathode spot 30 and retrigger cathode spot 32. The first cathode spot 30 is generated when the trigger strikes the cathode surface. After a fixed time interval, typically about 30 seconds, a second strike occurs and retriggers the formation of a second cathode spot 32. Upon the second strike, the first cathode spot 30 is terminated as the arc current always chooses a path of least resistance. Preferably, the trigger 24 will strike the cathode 14 closer to the edge of the cathode 14 surface to allow the arc spot to preferentially migrate towards the centre of the target. The rotary motion of the cathode 14 further allows the cathode spots to be ignited at distinct locations, resulting in an even distribution of cathode spot formation. As mentioned, the cathode spot 30 and retrigger cathode spot 32 tend to erode along an erosion pattern 34 and migrate preferentially towards the center of the cathode 14'. The same erosion and migration pattern can be seen in Fig. 3B and Fig. 3C, which are side views of the cathode 14'. In Fig. 3B, the arc spot 30 is shown to be positioned along the top of the cathode 14' and along a magnetic flux 28'. This cathode spot 30 is shown to be moving towards the center of the cathode 14' as shown in Fig. 3C as shown by arrow 36. As mentioned, it is believed that the cathode spot 30 tends to migrate to the centre of the cathode 14' as a result of the intersection between the magnetic flux 28' with the cathode 14' surface. Particularly, it has been

observed that arc spots have the highest tendency to move towards the direction where the magnetic flux intersects the cathode surface at incident angles of less than 90° . Accordingly, the provision of the magnetic flux
5 advantageously helps to promote a generally central migration pattern as shown in Fig. 3A, resulting in a more uniform erosion profile of the cathode surface.

Fig. 4A and Fig. 4B are cross-sectional views of the plasma beam duct 9". Here, like reference numerals are
10 used but depicted with a double prime (") symbol. In Fig. 4A, the plasma beam duct 9" further includes an angular bend 38 that is positioned proximate to the point of entry into the deposition chamber (not shown). Baffles 40 are provided within the plasma beam duct 9" to
15 trap any macroparticles that are present in the plasma beam 11". The macroparticles may bounce off the baffles 40 and travel along a zig-zag path 42 and separate from the plasma beam 11" along the bend 38 and fall downwards under the force of gravity. Plasma particles that are
20 present in the plasma beam 11" will proceed to be deposited on the substrate within the deposition chamber. Fig. 4B depicts an alternative embodiment of a plasma beam duct 9" without the bend 38. A plurality of baffles 40 are positioned within the plasma beam duct 9" to trap
25 the macroparticles and hence, remove the macroparticles from the plasma beam 11".

Fig. 5A and Fig. 5B are schematic diagrams showing the relationship between the magnetic coil current and the type of magnetic flux produced. Here, like reference
30 numerals are used but depicted with a triple prime (') symbol. In Fig. 5A, the smaller coil current provided to the magnetic diffuser 10'" causes the plasma beam 11'" to experience a reduced magnitude of divergence. Consequently, the width of the coated substrate 8'" is

relatively smaller. In this manner, a smaller substrate 8'" can be effectively coated with a higher deposition rate. In Fig. 5B, due to the bigger coil current provided to the magnetic diffuser 10'", the plasma beam 5 11'" experiences a greater magnitude of divergence. Hence, a relatively larger substrate 8'" can be uniformly coated, however, at a lower deposition rate.

Applications

The coating apparatus of the present invention may be suitable for use in deposition processes for large or bulky substrates, for instance, silicon wafers, tool tips and moulds. The substrate holder is advantageously adapted for holding and securing the substrates in such a way such that the length dimension of the substrate is disposed relative to the horizontal plane of the deposition chamber. In this manner, the substrate is mounted onto the substrate holder with ease and may be further held in place by its own weight, reducing the risk of substrates disengaging the substrate holder during the deposition process.

The coating apparatus of the present invention may be used for producing coatings that contain minimal impurities and possess high density and uniformity. The ease of mounting the substrates reduces the need for physical handling and lowers the amount of impurities that may be introduced as a result. Furthermore, the moveable substrate holder and the magnetic diffuser of the coating apparatus serve to ensure a uniform coating deposited on the substrate. The cathode assembly of the present invention further ensures an even erosion of the cathode target and prevents the formation of macroparticles in the plasma beam. As a result, the coating deposited on the substrate is capable of being densely packed and has uniform thickness. This result is particularly useful for coatings that are expected to resist severe wear and tear.

Furthermore, the cathode assembly of the present invention preferably comprises an integrated power and cooling source and is releasably detachable from a deposition chamber. As a result, it is highly compact and

foresees utility as a modular unit suitable for retrofitting onto other deposition apparatus.

Claims

1. A coating apparatus for coating a substrate comprising:
 - 5 a chamber;
 - a cathodic arc source for generating and projecting a plasma beam along a plasma beam path within said chamber, said projected plasma crossing a horizontal plane within the chamber;
 - 10 a moveable holder having a planar mounting surface that is generally parallel to said horizontal plane, said moveable holder being configured to move the planar mounting surface relative to the horizontal plane within said chamber and into the
 - 15 path of the plasma beam to form a plasma coating on said substrate.
2. A coating as claimed in claim 1, wherein the substrate has a length dimension greater than its
20 thickness dimension.
3. A coating as claimed in claim 1, wherein the plasma beam path that crosses the horizontal plane is generally tangential with respect to said
25 horizontal plane.
4. The coating apparatus of claim 1, wherein said cathodic arc source is capable of electrical conduction and is selected from the group
30 comprising of metals, metal alloys, ceramics, carbon and mixtures thereof.
5. The coating apparatus of claim 1, further comprising a filtering means.

- 5 6. The coating apparatus of claim 3, wherein said filtering means is selected from the group consisting of: baffles, plasma ducts with continuous bends or discrete angular bends, electromagnetic fields and any combination of the above.
- 10 7. The coating apparatus of claim 4, wherein said filtering means is coupled to a magnetic source, said magnetic source configured to project said plasma beam along said plasma beam path to contact with the substrate.
- 15 8. The coating apparatus of claim 7, wherein said filtering means is capable of segregating macroparticles from said plasma beam using gravitational force.
- 20 9. The coating apparatus of claim 1, wherein the moveable holder moves such that the planar mounting is lateral movement relative to said horizontal plane.
- 25 10. The coating apparatus of claim 1, wherein the moveable holder moves such that the planar mounting rotates about a vertical axis that is substantially normal to said horizontal plane.
- 30 11. The coating apparatus of claim 1, wherein movement of said moveable holder is driven by a mechanical motor.

12. The apparatus of claim 1, wherein said apparatus further comprises a magnetic diffuser disposed along said plasma beam path.

5 13. The apparatus of claim 11, wherein said magnetic diffuser comprises a magnetic source, and wherein said magnetic source is configured to diverge said plasma beam projected from said cathodic arc source.

10

14. The apparatus of claim 11, wherein said magnetic diffuser comprises a magnetic coil.

15

15. A cathode assembly for generating and projecting a plasma beam in an arc deposition apparatus, said assembly comprising:

20

a target positioned for generating a plasma beam along an adjacent plasma duct when an electric current strikes an ignition surface of said target;

25

an electrode disposed within a plasma duct and being configured to emit an electric pulse intermittently on said ignition surface of said target;

30

a magnetic source capable of emitting a magnetic flux to direct the plasma beam within said duct towards a deposition chamber and to induce a preferential arc motion towards said target; and

means for moving the target relative to said electrode to enable different ignitions surfaces to be struck during generation of said plasma.

16. The cathode assembly of claim 14, wherein the
electrode is configured to pulse at regular time
intervals.
17. The cathode assembly of claim 14, wherein said
assembly is releasably coupled to said deposition
chamber.
18. The cathode assembly of claim 14, wherein said
means for moving said target rotates the target
about an axis.
19. The cathode assembly of claim 17, wherein said
axis extends from a substantially central position
of said target.
20. The cathode assembly of claim 14, further
comprising a cooling means for cooling the target.
21. The cathode assembly of claim 19, wherein said
cooling means comprises a body coupled to the
target, the body having a plurality of conduits
extending therethrough for allowing cooling fluid
to be transmitted therein.
22. The cathode assembly of claim 20, wherein said
coolant is a refrigerant.
23. The cathode assembly of claim 20, wherein said
coolant is water.

24. The cathode assembly of claim 14, wherein said electrode is biased as an anode.

5 25. The cathode assembly of claim 23, wherein said anode comprises a mechanical striker configured to intermittently contact the cathode to thereby generate an electric current on said cathode.