One of the problems with existing IBSM technologies is caused by the geometry of the sputtering. A significant amount of sputtered materials is usually deposited on the walls and other parts of the vacuum chamber rather than on the sample. This has the potential to lead to waste of sputtering materials and lower yield.

Embodiments of the present invention seek to address at least some of the aforementioned disadvantages. Embodiments of the present invention seek to at least provide the public with a useful choice.

SUMMARY

In accordance with an aspect of the invention, there is provided an ion beam sputtering apparatus including an ion source configured to generate a hollow ion beam along a beam axis that is located in a hollow part of the beam; and a sputtering target having a target body that defines at least one target surface, the target body comprising sputterable particles, the target body being located relative to the ion source so that the ion beam hits the at least one target surface to sputter particles from the target body towards a surface of an object to be modified. The target body is shaped so that the particles sputtered towards a surface to be modified are generally sputtered from the sputtering target in radially extending sputter directions relative to the beam axis, the sputter directions; wherein the target body has a target passage that extends through the target body, the target passage having an ion beam inlet for the ion beam and a particle outlet for sputtered particles to exit the target passage towards a surface to be modified; wherein a cross sectional area of the particle outlet, in a plane perpendicular to the beam axis, is substantially smaller than a cross sectional area of a hollow portion of the ion beam.

The term ‘comprising’ as used in this specification means ‘consisting at least in part of’. When interpreting each statement in this specification that includes the term ‘comprising’, features other than that or those prefaced by the term may also be present. Related terms such as ‘comprise’ and ‘comprises’ are to be interpreted in the same manner.

In an embodiment the target body has a target passage that extends through the target body, the target passage having an ion beam inlet for the ion beam and a particle outlet for sputtered particles to exit the target passage towards a surface to be modified, and the at least one target surface is in the form of at least surface of the target body that at least partly defines the passage.

In an embodiment a cross sectional area of the ion beam inlet, in a plane perpendicular to the beam axis, is substantially larger than a cross sectional area circumscribed by an external periphery of the ion beam so that the beam can pass through the inlet.

In an embodiment, the sputter directions are directions extending towards the beam axis.

In an embodiment, the target passage is shaped to inhibit the ion beam exiting the target passage through the particle outlet towards (or reaching) a surface to be modified outside the passage without hitting the target surface.

In an embodiment, a cross sectional area of the particle outlet, in a plane perpendicular to the beam axis, is substantially smaller than a cross sectional area of a hollow portion of the ion beam.

In an embodiment, the beam axis intersects the ion beam inlet, the target passage and the particle outlet. In an embodiment, the beam axis is a central beam axis, and the target passage has a central passage axis that is substantially coaxial with the beam axis. In an embodiment, the target passage is generally symmetrical about the central passage axis and/or the beam axis. In an embodiment, the target body is also generally symmetrical about the central passage axis and/or the beam axis.

In an embodiment, at least part of the target passage intermediate the ion beam inlet and the particle outlet tapers towards the particle outlet.

In an embodiment, the target passage tapers from at or near the ion beam inlet to at or near the particle outlet. In an embodiment, the passage tapers at a substantially constant rate. In an embodiment, the target passage has a substantially frustoconical (or truncated-cone) shape.

In an embodiment, a cross sectional shape of the ion beam inlet (in a plane perpendicular to the beam axis) is substantially a circle. Alternatively, a cross sectional shape of the ion beam inlet may be other shapes, for example, substantially an oval, or a rectangle having rounded corners. In an embodiment, a cross sectional shape of the particle outlet (in a plane perpendicular to the beam axis) is substantially a circle. Alternatively, a cross sectional shape of the particle outlet may be other shapes, for example, substantially an oval, or a rectangle having rounded corners.

In an embodiment, the ion beam inlet is a circle substantially centred on the passage axis and/or the beam axis. In an embodiment, the particle outlet is a circle substantially centred on the passage axis and/or the beam axis. In an embodiment, the ion beam inlet and the particle outlet are substantially centred on the passage axis and/or the beam axis.

In an embodiment, the ion beam sputtering apparatus comprises a stencil at or near the particle outlet that defines a pattern for depositing the sputtered particles on to a surface to be modified according to the pattern. In an embodiment, the stencil is located adjacent, and at least partly extends across, the particle outlet.

In an embodiment, the sputtering target comprises one or more vacuum vents or openings that each extends through the target body. In an embodiment, the or each vent extends through the target body from a first end or part of the target body at or near the ion beam inlet to a second end or part of the target body at near the particle outlet.

In an embodiment, the sputtering apparatus comprises or is associated with a support for at least partly supporting an object having a surface to be modified adjacent the particle outlet of the sputtering target, outside the passage.

In an embodiment, the ion source and the sputtering target are moveable relative to an object having a surface to be modified, that is located adjacent the particle outlet, outside the passage, in a direction that is substantially perpendicular to the beam axis.

In accordance with a further aspect of the invention, there is provided a method of sputtering particles onto a surface , the method includes locating the surface adjacent the particle outlet of the above sputtering apparatus, outside the target passage; creating at least a partial vacuum within a vacuum chamber that is at least partly defined by a housing that is associated with and/or part of the sputtering apparatus; generating (or providing) a hollow ion beam with the ion source; and directing the ion beam into the target passage via the ion beam inlet to sputter particles onto the surface.

In an embodiment, the surface is a planar surface, for example, a planar surface of a substrate.

In an embodiment, the method comprises moving (or advancing) the surface to be modified relative to the particle outlet.

In an embodiment, the method comprises moving the surface to be modified relative to the particle outlet in a direction that is substantially perpendicular to the beam axis.

Disclosed herein is a target body that defines a sputtering chamber for modifying a surface of an object to be modified that is located within the sputtering chamber with the sputtered particles, the target body has an ion beam inlet (or opening or mouth) for the ion beam, the ion beam inlet opening into the sputtering chamber, and the at least one target surface is in the form of (or provided by) at least one chamber (or inner) surface of the target body that at least partly defines the chamber.

In an embodiment, a cross sectional area of the ion beam inlet (in a plane perpendicular to the beam axis) is substantially larger than a cross sectional area circumscribed by an external periphery of the ion beam so that the beam can pass through the inlet.

In an embodiment, the sputtering chamber is shaped so that the particles sputtered towards an object having a surface to be modified are generally sputtered towards a central region within the sputtering chamber.

In an embodiment, the sputtering target comprises one or more shields (or guards), the or each shield being arranged to inhibit the ion beam hitting (or reaching) an object having a surface to be modified within the sputtering chamber. In an embodiment, the one or more shields comprises one or more radially and circumferentially extending (with reference to the beam axis) shields. The or each shield, in use, would be located upstream (with reference to the ion beam) of an object at least partly located within sputtering chamber.

In an embodiment, the beam axis intersects the ion beam inlet and the sputtering chamber. In an embodiment, the beam axis is a central beam axis, and the sputtering chamber has a central chamber axis that is substantially coaxial with the beam axis. In an embodiment, the sputtering chamber is generally symmetrical about the central chamber axis and/or the beam axis. In an embodiment, the target body is generally symmetrical about the central chamber axis and/or the beam axis.

In an embodiment, at least part of the sputtering chamber intermediate the ion beam inlet and an end part (or base) of the sputtering chamber that is downstream (with reference to the ion beam) of the ion beam inlet tapers in a direction towards the end part. In an embodiment, the sputtering chamber tapers from at or near the ion beam

inlet to at or near the end part. In an embodiment, the passage tapers at a substantially constant rate. In an embodiment, the sputtering chamber has a substantially conical shape, and/or a substantially frustoconical shape intermediate the ion beam inlet and the end part.

In an embodiment, a cross sectional shape of the ion beam inlet (in a plane perpendicular to the beam axis) is substantially a circle (or ring). Alternatively, a cross sectional shape of the ion beam inlet may be other shapes, for example, substantially an oval, or a rectangle having rounded corners.

In an embodiment, the sputtering apparatus comprises or is associated with a support feature for at least partly supporting (or holding or suspending) an object having a surface to be modified within the sputtering chamber. For example, an object may extend through apertures (or openings) in the target body so that the object at least partly extends across and within the sputtering chamber.

In an embodiment, the ion source and the sputtering chamber are moveable relative to an object having a surface to be modified in a direction that is substantially perpendicular to the beam axis. For example, the object may be fed through the sputtering chamber in a direction that is perpendicular to the beam axis.

In an embodiment, the ion source and the sputtering target are rotatable relative to a surface to be modified within the sputtering chamber about an axis that is perpendicular to the beam axis. For example, an object comprising the surface may be rotated.

In accordance with a further aspect of the invention, there is provided a method of sputtering particles onto a surface, the method includes locating the surface within the sputtering chamber of the above sputtering apparatus so that the surface at least partly extends across the sputtering chamber; creating at least a partial vacuum within a vacuum chamber that is at least partly defined by a housing that is associated with and/or part of the sputtering apparatus; generating (or providing) a hollow ion beam with the ion source; and directing the hollow ion beam into the sputtering chamber via the ion beam inlet to sputter particles onto the surface.

In an embodiment, the surface is an arcuate surface. In an embodiment, the surface is the outer surface of a conduit, for example, a pipe or tube. Alternatively, the surface may be a planar surface.

In an embodiment, the method comprises moving (or advancing) the surface to be modified relative to the ion beam and/or the sputtering chamber.

In an embodiment, the method comprises moving the surface to be modified relative to the ion beam and/or the sputtering chamber in a direction that is substantially perpendicular to the beam axis.

In an embodiment, the method comprises rotating the surface to be modified relative to the sputtering chamber.

In an embodiment, the sputter directions are directions extending away from the beam axis.

In an embodiment, the target body has at least one outer, peripheral surface that defines the at least one target surface.

In an embodiment, a cross sectional area of at least part of the target body increases in a direction away from the ion source so that the hollow ion beam strikes the at least one target surface.

In an embodiment, a cross sectional area circumscribed by an external periphery of at least part the target body (in a plane perpendicular to the beam axis) increases in a direction of the beam axis in a direction away from the ion source.

In an embodiment, the cross sectional area of at least part of the target body increases in a direction away from the ion source from a first cross sectional area that is substantially smaller than a cross sectional area of a hollow portion of the hollow ion beam to a second cross sectional area that is substantially larger than a cross sectional area of an external periphery of the hollow ion beam.

In an embodiment, the cross sectional area circumscribed by an external periphery of the target body increases from at or near a first end of the target body proximal to the ion source to at or near a second end of the target body distal the ion source, and downstream of the first end with reference to the ion beam.

In an embodiment, the cross sectional area of the external periphery of the target body increases at a substantially constant rate in the direction of the hollow ion beam.

In an embodiment, at least part of the periphery of the target body intermediate the first end and the second end has a substantially conical shape, or a substantially frustoconical shape.

In an embodiment, the sputtering apparatus is configured to at least partly extend within a hollow object (such as a conduit, or a tube or pipe), such that the beam axis is generally aligned with (parallel to or coaxial with) a central (or longitudinal) axis of the conduit.

In an embodiment, the sputtering target is moveable relative to an object having a surface to be modified in a direction that is substantially parallel to the beam axis.

In an embodiment, at least the sputtering target is moveable within a hollow object having an inner surface to be modified in a direction that is substantially parallel to the beam axis.

Disclosed herein is a method of sputtering particles onto an inner surface of a conduit, the method includes locating a sputtering apparatus so that sputtering target is at least partly located within the conduit; creating at least a partial vacuum within a vacuum chamber that is at least partly defined by a housing that is associated with and/or part of the sputtering apparatus; generating (or providing) a hollow ion beam with the ion source; and directing the hollow ion beam onto the target surface of the sputtering target to sputter particles onto the inner surface.

In an embodiment, the surface is an arcuate surface. In an embodiment, the conduit is a pipe or tube.

In an embodiment, the method comprises moving (or advancing) the surface to be modified relative to the sputtering target. In an embodiment, the method comprises moving the surface to be modified relative to the sputtering target in a direction that is substantially parallel to the beam axis.

In an embodiment, a cross sectional shape of the ion beam, in a plane perpendicular to the beam axis, is substantially a hollow circle or ring. The cross-section circumscribed by the external periphery of the ion beam is a circle. Alternatively, a cross sectional shape of the ion beam may be other shapes, for example, substantially a hollow oval, or a hollow rectangle having rounded corners.

In an embodiment, the ion beam has a potential or accelerating energy greater than or equal to 500 V. In an embodiment, the ion beam has a potential or accelerating energy in the range of about 1 kV to about 30 kV. In an embodiment, the ion beam has a potential or accelerating energy in the range of about 15 kV to about 25 kV.

In an embodiment, an angle (or angles) of incidence of the ion beam is greater than or equal to about 45 degrees. That is, the glancing angle of the ion beam (being the angle between the ion beam and the surface of the sputtering target at the point of incidence) is less than or equal to about 45 degrees. In an embodiment, the angle of incidence is in the range of about 50 to about 80 degrees (glancing angle of the ion beam is in the range of about 10 to about 40 degrees). In an embodiment, the angle of incidence is in the range of about 60 to about 75 degrees. In an embodiment, the angle of incidence is in the range of about 65 to about 75 degrees. In an embodiment, the angle of incidence is about 70 degrees

In an embodiment, the sputtering apparatus comprises, or is associated with, a housing that at least partly defines a vacuum chamber for the ion source and the sputtering target.

In an embodiment, the sputtering target is a unitary part. Alternatively, the sputtering target may be formed by two or more parts coupled and/or arranged together.

In an embodiment, the ion source is coupled to a heat sink to cool the ion source. In an embodiment, the heat sink comprises or is one or more copper parts or bodies.

In an embodiment, the target passage is shaped to inhibit the ion beam exiting the target passage through the particle outlet towards a surface to be modified outside the passage without hitting the target surface.

In an embodiment, the beam axis intersects the ion beam inlet, the target passage and the particle outlet.

In an embodiment, the beam axis is a central beam axis, and the target passage has a central passage axis that is substantially coaxial with the beam axis.

In an embodiment, the target passage is generally symmetrical about the central passage axis and/or the beam axis.

In an embodiment, the target body is also generally symmetrical about the central passage axis and/or the beam axis.

In an embodiment, the ion beam inlet and the particle outlet are substantially centred on the passage axis and/or the beam axis.

In an embodiment, a cross sectional shape of the ion beam inlet, in a plane perpendicular to the beam axis, is selected from a group comprising substantially circular, oval, and rectangular having rounded corners.

In an embodiment, a cross sectional shape of the particle outlet, in a plane perpendicular to the beam axis, is selected from a group comprising substantially circular, oval, and rectangular having rounded corners.

In an embodiment, the apparatus further comprises a stencil at or near the particle outlet that defines a pattern for depositing the sputtered particles on to a surface to be modified according to the pattern.

In an embodiment, the stencil is located adjacent, and at least partly extends across, the particle outlet.

In an embodiment, the sputtering target comprises one or more vacuum vents or openings that each extends through the target body.

In an embodiment, the or each vent extends through the target body from a first end or part of the target body at or near the ion beam inlet to a second end or part of the target body at near the particle outlet.

In an embodiment, the apparatus comprises or is associated with a support for at least partly supporting an object having a surface to be modified adjacent the particle outlet of the sputtering target, outside the passage.

In an embodiment, the ion source and the sputtering target are moveable relative to an object having a surface to be modified, that is located adjacent the particle outlet, outside the passage, in a direction that is substantially perpendicular to the beam axis.

In an embodiment, the hollow ion beam has a width W and an inner radius R at the ion source and exhibits an increase in beam width as the hollow ion beam travels toward to sputtering target, the increase in beam width comprising:

an increase of the beam width of A away from the beam axis; and

an increase of the beam width of B toward the beam axis.

In an embodiment, the sputtering target has a height d defined by $d = (A + W + B)\tan\delta$, wherein δ represents a slope of the sputtering target with respect to the hollow ion beam.

In an embodiment, the sputtering target has a maximum inner radius r equal to an inner radius $R - B$ of the hollow ion beam as it hits the sputtering target, the maximum inner radius defined by $a \leq r \leq R - B$.

In an embodiment, the sputtering target has a minimum height h defined by $h \geq d$.

In an embodiment, the sputtering target has a minimum width w defined by $w \geq A + W + B$.

In an embodiment, the sputtering target comprises a single material so that the at least one target surface provides the sputterable particles.

In an embodiment, the sputtering target comprises at least a first material and a second material, the first material different to the second material.

In an embodiment, the first material and the second material are positioned at substantially the same angle of incidence with respect to the hollow ion beam.

In an embodiment, the first material is positioned at a first angle of incidence with respect to the hollow ion beam and the second material is positioned at a second angle of incidence with respect to the hollow ion beam, the first angle of incidence different to the second angle of incidence.

In accordance with a further aspect of the invention, there is provided a method of sputtering particles onto a surface to be modified, the method includes locating a sputtering target adjacent a particle outlet of a sputtering apparatus, the sputtering target having a target body defining at least one target surface; creating at least a partial vacuum within a vacuum chamber that is at least partly defined by a housing that

is associated with and/or part of the sputtering apparatus; generating a hollow ion beam with the ion source of the sputtering apparatus; and directing the hollow ion beam into the target passage via the ion beam inlet so that the hollow ion beam hits the at least one target surface to sputter particles onto the surface to be modified. The target body is shaped so that the particles sputtered towards a surface to be modified are generally sputtered from the sputtering target in radially extending sputter directions relative to the beam axis; wherein a cross sectional area of the particle outlet, in a plane perpendicular to the beam axis, is substantially smaller than a cross sectional area of a hollow portion of the ion beam.

In an embodiment, the ion beam is inhibited from exiting the target passage through the particle outlet towards the surface to be modified.

In an embodiment, the sputtering target comprises a single material so that the at least one target surface provides the sputterable particles.

In an embodiment, the sputtering target comprises at least a first material and a second material, the first material different to the second material.

In an embodiment, the method further comprises locating a stencil at or near the particle outlet that defines a pattern for depositing the sputtered particles on to a surface to be modified according to the pattern.

The invention in one aspect comprises several steps. The relation of one or more of such steps with respect to each of the others, the apparatus embodying features of construction, and combinations of elements and arrangement of parts that are adapted to affect such steps, are all exemplified in the following detailed disclosure.

To those skilled in the art to which the invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the scope of the invention as defined in the appended claims. The disclosures and the descriptions herein are purely illustrative and are not intended to be in any sense limiting. Where specific integers

CLAIMS

1. Ion beam sputtering apparatus comprising:

an ion source configured to generate a hollow ion beam along a beam axis that is located in a hollow part of the beam; and

a sputtering target having a target body that defines at least one target surface, the target body comprising sputterable particles, the target body being located relative to the ion source so that the ion beam hits the at least one target surface to sputter particles from the target body towards a surface of an object to be modified;

wherein the target body is shaped so that the particles sputtered towards a surface to be modified are generally sputtered from the sputtering target in radially extending sputter directions relative to the beam axis, the sputter directions extending towards the beam axis;

wherein the target body has a target passage that extends through the target body, the target passage having an ion beam inlet for the ion beam and a particle outlet for sputtered particles to exit the target passage towards a surface to be modified;

wherein a cross sectional area of the particle outlet, in a plane perpendicular to the beam axis, is substantially smaller than a cross sectional area of a hollow portion of the ion beam.

2. The apparatus of claim 1 wherein the at least one target surface is in the form of at least surface of the target body that at least partly defines the passage.

3. The apparatus of claim 2 wherein a cross sectional area of the ion beam inlet, in a plane perpendicular to the beam axis, is substantially larger than a cross sectional area circumscribed by an external periphery of the ion beam so that the beam can pass through the inlet.

4. The apparatus of claim 1 wherein at least part of the target passage intermediate the ion beam inlet and the particle outlet tapers towards the particle outlet.

5. The apparatus of claim 4 wherein the target passage tapers from at or near the ion beam inlet to at or near the particle outlet.

6. The apparatus of claim 5 wherein the passage tapers at a substantially constant rate.

7. The apparatus of any one of the preceding claims wherein the target passage is shaped to inhibit the ion beam exiting the target passage through the particle outlet towards a surface to be modified outside the passage without hitting the target surface.

8. The apparatus of any one of claims 2 to 7 wherein the beam axis intersects the ion beam inlet, the target passage and the particle outlet.

9. The apparatus of claim 8 wherein the beam axis is a central beam axis, and the target passage has a central passage axis that is substantially coaxial with the beam axis.

10. The apparatus of claim 9 wherein the target passage is generally symmetrical about the central passage axis and/or the beam axis.

11. The apparatus of claim 10 wherein the target body is also generally symmetrical about the central passage axis and/or the beam axis.

12. The apparatus of any one of claims 2 to 11 wherein the ion beam inlet and the particle outlet are substantially centred on the passage axis and/or the beam axis.

13. The apparatus of any one of the preceding claims wherein a cross sectional shape of the ion beam inlet, in a plane perpendicular to the beam axis, is selected from a group comprising substantially circular, oval, and rectangular having rounded corners.

14. The apparatus of any one of the preceding claims wherein a cross sectional shape of the particle outlet, in a plane perpendicular to the beam axis, is selected from a group comprising substantially circular, oval, and rectangular having rounded corners.

15. The apparatus of any one of the preceding claims further comprising a stencil at or near the particle outlet that defines a pattern for depositing the sputtered particles on to a surface to be modified according to the pattern.

16. The apparatus of claim 15 wherein the stencil is located adjacent, and at least partly extends across, the particle outlet.

17. The apparatus of any one of the preceding claims wherein the sputtering target comprises one or more vacuum vents or openings that each extends through the target body.

18. The apparatus of claim 17 wherein the or each vent extends through the target body from a first end or part of the target body at or near the ion beam inlet to a second end or part of the target body at near the particle outlet.

19. The apparatus of any one of the preceding claims, the apparatus comprising or associated with a support for at least partly supporting an object having a surface to be modified adjacent the particle outlet of the sputtering target, outside the passage.

20. The apparatus of any one of the preceding claims wherein the ion source and the sputtering target are moveable relative to an object having a surface to be modified, that is located adjacent the particle outlet, outside the passage, in a direction that is substantially perpendicular to the beam axis.

21. The apparatus of any one of claims 1 to 20 wherein the object having a surface to be modified is moveable relative to the ion source and the sputtering target.

22. The apparatus of claim 21 wherein the object having a surface to be modified is moveable from atmospheric pressure into a vacuum chamber within which exists at least a partial vacuum, the vacuum chamber at least partly defined by a housing.

23. The apparatus of any one of the preceding claims wherein the hollow ion beam has a width W and an inner radius R at the ion source and exhibits an increase in beam width as the hollow ion beam travels toward to sputtering target, the increase in beam width comprising:

an increase of the beam width of A away from the beam axis; and

an increase of the beam width of B toward the beam axis.

24. The apparatus of claim 23 wherein the sputtering target has a height d defined by $d = (A + W + B)\tan\delta$, wherein δ represents a slope of the sputtering target with respect to the hollow ion beam.

25. The apparatus of claim 24 wherein the sputtering target has a maximum inner radius r equal to an inner radius $R - B$ of the hollow ion beam as it hits the sputtering target, the maximum inner radius defined by $a \leq r \leq R - B$.

26. The apparatus of claim 24 or claim 25 wherein the sputtering target has a minimum height h defined by $h \geq d$.

27. The apparatus of any one of claims 23 to 26 wherein the sputtering target has a minimum width w defined by $w \geq A + W + B$.

28. The apparatus of any one of the preceding claims wherein the sputtering target comprises a single material so that the at least one target surface provides the sputterable particles.

29. The apparatus of any one of claims 1 to 27 wherein the sputtering target comprises at least a first material and a second material, the first material different to the second material.

30. The apparatus of claim 29 wherein the first material and the second material are positioned at substantially the same angle of incidence with respect to the hollow ion beam.

31. The apparatus of claim 29 wherein the first material is positioned at a first angle of incidence with respect to the hollow ion beam and the second material is positioned at a second angle of incidence with respect to the hollow ion beam, the first angle of incidence different to the second angle of incidence.

32. A method of sputtering particles onto a surface comprising:

locating the surface adjacent the particle outlet of the sputtering apparatus of claim 1 or claim 2, outside the target passage;

creating at least a partial vacuum within a vacuum chamber that is at least partly defined by a housing that is associated with and/or part of the sputtering apparatus;

generating a hollow ion beam with the ion source of the sputtering apparatus; and

directing the hollow ion beam into the target passage via the ion beam inlet to sputter particles onto the surface.

33. The method of claim 32 further comprising sliding the surface under or in front of the sputtering apparatus.

34. The method of claim 33 further comprising sliding the surface from atmospheric pressure into the vacuum chamber.

35. A method of sputtering particles onto an outer surface of an arcuate surface, the method comprising:

locating the surface within the sputtering chamber of the sputtering apparatus of any one of claims 4 to 6 so that the surface at least partly extends across the sputtering chamber;

creating at least a partial vacuum within a vacuum chamber that is at least partly defined by a housing that is associated with and/or part of the sputtering apparatus;

generating a hollow ion beam with the ion source; and

directing the hollow ion beam into the sputtering chamber via the ion beam inlet to sputter particles onto the surface.

36. A method of sputtering particles onto a surface to be modified, the method comprising:

locating a sputtering target adjacent a particle outlet of a sputtering apparatus, the sputtering target having a target body defining at least one target surface;

creating at least a partial vacuum within a vacuum chamber that is at least partly defined by a housing that is associated with and/or part of the sputtering apparatus;

generating a hollow ion beam with the ion source of the sputtering apparatus; and

directing the hollow ion beam into the target passage via the ion beam inlet so that the hollow ion beam hits the at least one target surface to sputter particles onto the surface to be modified;

wherein the target body is shaped so that the particles sputtered towards a surface to be modified are generally sputtered from the sputtering target in radially extending sputter directions relative to the beam axis, the sputter directions extending towards the beam axis;

wherein a cross sectional area of the particle outlet, in a plane perpendicular to the beam axis, is substantially smaller than a cross sectional area of a hollow portion of the ion beam.

37. The method of claim 36 wherein the ion beam is inhibited from exiting the target passage through the particle outlet towards the surface to be modified.

38. The method of claim 36 or claim 37 further comprising sliding the surface to be modified under or in front of the ion source and the sputtering target.

39. The method of claim 38 further comprising sliding the surface to be modified from atmospheric pressure into the vacuum chamber.

40. The method of any one of claims 32 to39 wherein the sputtering target comprises a single material so that the at least one target surface provides the sputterable particles.

41. The method of any one of claims 32 to 39 wherein the sputtering target comprises at least a first material and a second material, the first material different to the second material.

42. The method of any one of claims 32 to 39 further comprising locating a stencil at or near the particle outlet that defines a pattern for depositing the sputtered particles on to a surface to be modified according to the pattern.