as those available for flat sheet mould fabrication. Moreover, imprint drums, or nanoimprinting roll bodies, typically have a large radius to minimize pattern feature distortion. The roll bodies are therefore expensive, heavy and difficult to handle when interchanging or replacing moulds.

Removable nanoimprinting moulds have been proposed, whereby metal bars are riveted or screwed to the nanoimprinting mould, and the bars are detachably attached to the nanoimprinting roll. To avoid the metal bars imprinting on the substrate, they are attached to the roll body at positions recessed inwardly of the circumference of the roll body (e.g. insets or recesses). Also, to ensure the pattern is accurately imprinted, the moulds are tensioned to pull flat against the circumference of a body of the nanoimprinting roll.

Methods employing removable nanoimprinting moulds create stress concentrations in the mould, at the locations of the rivets or screws, which damage or distort the moulds particularly during tensioning. Moreover, in order to pass inwardly from the circumference of the roll body, the mould must bend around a radius that is less than that of the circumference of the roll body. As a result, moulds are often bent past their plastic radius – the radius above which the mould will return to a flat condition once removed from the roll body, and below which plastic deformation of the mould begins to occur.

Summary

According to a first aspect, the present disclosure provides a nanoimprinting mould device comprising:

a nanoimprinting mould for forming a pattern in a substrate; and

a connector adhered to a surface of the nanoimprinting mould and comprising engagement means for engaging a nanoimprinting shell or roll thereby to secure the nanoimprinting mould to the shell or roll, the shell or roll being rotatable, in use, to bring the nanoimprinting

mould against the substrate to form the pattern in the substrate; wherein the nanoimprinting mould comprises a patterned surface facing, in use, outwardly of the shell or roll and an opposing rear surface facing, in use, towards the shell or roll, the connector being adhered to the opposing rear surface; wherein the connector comprises a slot for receiving the nanoimprinting mould and: opposed sides of the slot are adhered to respectively opposite ones of the patterned surface and opposing rear surface; and/or the slot is narrower than a thickness of the nanoimprinting mould so that the connector is adhered to the nanoimprinting mould at least partially by friction between the slot and nanoimprinting mould.

According to a second aspect, the present disclosure provides a nanoimprinting roll assembly comprising:

a nanoimprinting roll; and

at least one nanoimprinting mould device of the first aspect, the at least one nanoimprinting mould being secured to the nanoimprinting roll.

According to a third aspect, the present disclosure provides a nanoimprinting roll assembly comprising:

a nanoimprinting shell fittable over a nanoimprinting roll and rotatable with rotation of the nanoimprinting roll; and

at least one nanoimprinting mould device of the first aspect, the at least one nanoimprinting mould being secured to the nanoimprinting shell.

According to a fourth aspect, the present disclosure provides a nanoimprinting machine comprising:

a nanoimprinting roll assembly according to the second or the third aspect; and

a motor for rotating the nanoimprinting roll assembly.

According to a fifth aspect, the present disclosure provides a method of forming a nanoimprinting mould device, the method comprising:

providing a nanoimprinting mould and a connector;

applying adhesive to a surface of the nanoimprinting mould and/or the connector; and

bringing the nanoimprinting mould and connector together so that the adhesive forms a bond between the nanoimprinting mould and connector; wherein the nanoimprinting mould comprises a patterned surface facing, in use, outwardly of the shell or roll and an opposing rear surface facing, in use, towards the shell or roll, the connector being adhered to the opposing rear surface; wherein the connector comprises a slot for receiving the nanoimprinting mould and: opposed sides of the slot are adhered to respectively opposite ones of the patterned surface and opposing rear surface; and/or the slot is narrower than a thickness of the nanoimprinting mould so that the connector is adhered to the nanoimprinting mould at least partially by friction between the slot and nanoimprinting mould.

According to a sixth aspect, the present disclosure provides a jig for forming a nanoimprinting mould device of the first aspect, the jig comprising:

a support surface for supporting one of a nanoimprinting mould and a connector during formation of the nanoimprinting mould device;

alignment features to facilitate proper alignment of components such that the nanoimprinting mould device formed using the jig fits to a nanoimprinting roller drum;

one or more press members in use to apply a pressure to the nanoimprinting mould and connector during adhesion of the nanoimprinting mould to the connector; and

one or more pressure adjustment members for adjusting the pressure applied by the one or more press members.

The mould may be attached to the roll drum by fasteners. The fasteners may be screws or bolts the rotation of which selectively increase or decreases tension in the nanoimprinting mould.

As used herein, the terms “adhere”, “adhesion” and similar are intended to include within their scope the connection of a nanoimprinting mould to a connector using means other than those requiring penetrations to be formed in the mould, for example, bolting or riveting the mould to the connector. Forms of connection within the scope of the term “adhere” include, but are not limited to, friction-fitting, adhesive connection, magnetic attraction and vacuum suction.

Similarly, the term “continuous” when used in the context of a surface refers to the body, which comprises the surface, having no full thickness penetrations.

As used herein, the terms “plastic bending radius” or “plastic radius” refer to the radius above which a mould will return to a flat condition once removed from the roll body, and below which plastic deformation of the mould begins to occur. In other words, if a bending force is

means 62 of the shell 22. In other words, the sheet 26 is positioned between the corresponding engagement means 62.

The extensions 28 are adhered to a surface, namely rear surface 32, of the sheet 26. In particular, the extensions 28 are adhered to a strip 38 of surface 32. The strip 38 is defined by the region between broken line 40 and the respective end 42 of the sheet 26.

Adhesion may be achieved using any appropriate method, such as cold welding or using liquid or solid (e.g. pressure or temperature sensitive) adhesives. In the embodiment shown in FIG. 4, adhesion is achieved by depositing an adhesive along one or both of the strip 38 and region of the respective extension 28 that comes into contact with the strip 38. The adhesive is deposited so that it forms a substantially uniform film over the strip 38 or corresponding region of the extension 28 (i.e. the region that will be in contact with the strip 38 when formed into a mould device 24). It will be appreciated that the adhesive may alternatively be deposited at irregular intervals or using any suitable deposition method.

The region of the surface 32, namely strip 38, over which the extensions 28 adhere to the surface 32 is continuous. In other words, there are no penetrations through the sheet 26. The adhesion therefore forms a connection between the connector and mould, or sheet 26, on only one side of the mould, or sheet 26. In use, there is no part of the connector that projects outwardly of the sheet 26, away from the circumferential surface 44 of the shell 22 (see FIG. 2).

The connector must be sufficiently thin that it can fit between the sheet 26 and circumferential surface 44 of the shell 22 without deforming or bending the sheet 26 when the sheet 26 is tensioned onto the circumferential surface 44. To achieve this, while maintaining low or no ductility so as not to inhibit tensioning of the mould device 24, the extensions 28 may be thin and flexible stainless steel spring forms. Alternatively, the shell 22

Claims

1. A nanoimprinting mould device comprising:

a nanoimprinting mould for forming a pattern in a substrate; and

a connector adhered to a surface of the nanoimprinting mould and comprising engagement means for engaging a nanoimprinting shell or roll thereby to secure the nanoimprinting mould to the shell or roll, the shell or roll being rotatable, in use, to bring the nanoimprinting mould against the substrate to form the pattern in the substrate;

wherein the nanoimprinting mould comprises a patterned surface facing, in use, outwardly of the shell or roll and an opposing rear surface facing, in use, towards the shell or roll, the connector being adhered to the opposing rear surface;

wherein the connector comprises a slot for receiving the nanoimprinting mould and:

opposed sides of the slot are adhered to respectively opposite ones of the patterned surface and opposing rear surface; and/or

the slot is narrower than a thickness of the nanoimprinting mould so that the connector is adhered to the nanoimprinting mould at least partially by friction between the slot and nanoimprinting mould.

2. The nanoimprinting mould device of claim 1, wherein the connector is adhered to the nanoimprinting mould by an adhesive.

3. The nanoimprinting mould device of claim 1, wherein the connector is adhered to the nanoimprinting mould by welding.

4. The nanoimprinting mould device of any preceding claim, wherein a region of the surface over which the connector adheres to the surface is continuous.

5. The nanoimprinting mould device of claim 1, wherein the connector adheres to the nanoimprinting mould by magnetic attraction.

6. The nanoimprinting mould device of any preceding claim, wherein the connector projects from an end of the nanoimprinting mould so as to extend, in use, at least part way around a circumference of the shell or roll.

7. The nanoimprinting mould device of claim 6, wherein the connector comprises two extensions extending from respectively opposite ends of the nanoimprinting mould.

8. The nanoimprinting mould device of claim 7, wherein the engagement means comprises an engagement member formed on each extension.

9. The nanoimprinting mould device of claim 8, wherein the engagement members engage the shell or roll at positions of the shell or roll that are spaced from the respectively opposite ends of the nanoimprinting mould.

10. The nanoimprinting mould device of claim 9, wherein the engagement members engage corresponding engagement members of the shell or roll, each corresponding engagement member comprising a curved section, and wherein the extensions extend from the nanoimprinting mould around the respective curved sections.

11. The nanoimprinting mould device of claim 10, wherein the curved sections have a radius that is less than the plastic radius of the nanoimprinting mould, and the nanoimprinting mould is positioned between the curved sections.

12. The nanoimprinting mould device of any one of claims 8 to 11, wherein at least one of the engagement members of the connector, when in engagement with the shell or roll, is adjustable to apply a selected amount of tension to the nanoimprinting mould.

13. The nanoimprinting mould device of claim 12, where one engagement member of the connector comprises a first reinforcement bar and the other engagement member of the connector comprises a second reinforcement bar, one or more fastener holes and, in use, one or more fasteners project through the fastener holes to secure the nanoimprinting mould to the shell or roll.

14. The nanoimprinting mould device of claim 13, wherein the second reinforcement bar comprises two sets of fastener holes, the holes in one set extending in a substantially perpendicular direction to the holes in the other set.

15. The nanoimprinting mould device of claim 14, wherein fasteners extending through the holes in one of the sets of holes are used to apply tension to the nanoimprinting mould, in use, and fasteners extending through the other set of holes are used to anchor the second reinforcement bar in position after tension has been applied.

16. The nanoimprinting mould device of any one of claims 13 to 15, wherein the first reinforcement bar is rectangular.

17. The nanoimprinting mould device of any one of claims 13 to 16, wherein the second reinforcement bar is triangular.

18. The nanoimprinting mould device of any preceding claim, wherein the engagement means reversibly secure the nanoimprinting mould to the shell or roll.

19. A nanoimprinting roll assembly comprising:

a nanoimprinting roll; and

at least one nanoimprinting mould device of any one of claims 1 to 18, the at least one nanoimprinting mould being secured to the nanoimprinting roll.

20. A nanoimprinting roll assembly comprising:

a nanoimprinting shell fittable over a nanoimprinting roll and rotatable with rotation of the nanoimprinting roll; and

at least one nanoimprinting mould device of any one of claims 1 to 18, the at least one nanoimprinting mould being secured to the nanoimprinting shell.

21. A nanoimprinting machine comprising:

a nanoimprinting roll assembly according to claim 19 or 20; and

a motor for rotating the nanoimprinting roll assembly.

22. A method of forming a nanoimprinting mould device, the method comprising:

providing a nanoimprinting mould and a connector;

applying adhesive to a surface of the nanoimprinting mould and/or the connector; and

bringing the nanoimprinting mould and connector together so that the adhesive forms a bond between the nanoimprinting mould and connector;

wherein the nanoimprinting mould comprises a patterned surface facing, in use, outwardly of the shell or roll and an opposing rear surface facing, in use, towards the shell or roll, the connector being adhered to the opposing rear surface;

wherein the connector comprises a slot for receiving the nanoimprinting mould and:

opposed sides of the slot are adhered to respectively opposite ones of the patterned surface and opposing rear surface; and/or

the slot is narrower than a thickness of the nanoimprinting mould so that the connector is adhered to the nanoimprinting mould at least partially by friction between the slot and nanoimprinting mould.

23. A method according to claim 22, wherein the step of bringing the nanoimprinting mould and connector together comprises applying pressure to the nanoimprinting mould and connector, at or near the adhesive, so as to strengthen the bond as it is formed.

24. A method of fitting a nanoimprinting mould device according to any one of claims 12 to 18, to a nanoimprinting shell or roll, the method comprising:

engaging one of the engagement members of the connector with the shell or roll;

bringing the nanoimprinting mould into contact with a circumferential surface of the shell or roll along the entire length of the nanoimprinting mould;

engaging the other engagement member of the connector with the shell or roll; and

adjusting the one of the engagement members to apply tension to the nanoimprinting mould.

25. A jig for forming a nanoimprinting mould device according to claim 1, the jig comprising:

a support surface for supporting one of a nanoimprinting mould and a connector during formation of the nanoimprinting mould device;

alignment features to facilitate proper alignment of components such that the nanoimprinting mould device formed using the jig fits to a nanoimprinting roller drum;

one or more press members in use to apply a pressure to the nanoimprinting mould and connector during adhesion of the nanoimprinting mould to the connector; and

one or more pressure adjustment members for adjusting the pressure applied by the one or more press members.

26. The jig of claim 25, wherein the support surface is configured to support a connector, during formation of the nanoimprinting mould device, comprising two extensions in positions to extend from ends of the mould during formation of the mould device.