

## Claims

1. A vacuum chuck apparatus, comprising: a chuck body having a substantially flat chucking surface; three or more collapsible bellows each collapsible by at least five hundred micrometers in a direction orthogonal to the flat chucking surface of the chuck body, wherein each collapsible bellows has a compliant shape configured to conform to a non-planar backside surface of a substrate; three or more lift structures, each lift structure coupled to one of the three or more collapsible bellows; and one or more actuators configured to move the three or more lift structures and the three or more collapsible bellows in a direction orthogonal to the flat chucking surface of the chuck body and into contact with the substrate to form a vacuum clamped connection between the three or more collapsible bellows and the substrate, the one or more actuators further configured to move the three or more lift structures, the three or more collapsible bellows, and the substrate toward the flat chucking surface of the chuck body.
2. The vacuum chuck apparatus of claim 1, wherein the chuck body is mounted to a motion stage subsystem such that the chuck body is movable with respect to the motion stage subsystem in the direction orthogonal to the flat chucking surface of the chuck body, and wherein the three or more lift structures are movable with respect to the motion stage subsystem in the direction orthogonal to the flat chucking surface of the chuck body.
3. The vacuum chuck apparatus of claim 2, wherein the three or more lift structures are moveable with respect to the chuck body by a combination of movements of the chuck body and the three or more lift structures with respect to the motion stage subsystem such that the three or more collapsible bellows extend at least 10 millimeters above the flat chucking surface of the chuck body.
4. The vacuum chuck apparatus of claim 1, further comprising: one or more recessed annular channels in the chuck body, wherein each

of the one or more recessed annular channels includes an extensible sealing element coupled to a bottom surface of the one or more recessed annular channels, wherein each extensible sealing element is configured to extend at least 5 millimeters above the flat chucking surface of the chuck body.

5. The vacuum chuck apparatus of claim 4, wherein the one or more recessed annular channels are coupled to one or more vacuum bleed orifices to regulate an amount of vacuum maintained in the one or more recessed annular channel when the substrate is vacuum clamped to the flat chucking surface of the chuck body.

6. The vacuum chuck apparatus of claim 1, further comprising: one or more vacuum channels distributed across the flat chucking surface of the chuck body, wherein each of the one or more vacuum channels are coupled to a vacuum source such that a vacuum is drawn through the one or more vacuum channels to vacuum clamp the substrate to the flat chucking surface of the chuck body.

7. The vacuum chuck apparatus of claim 6, wherein the one or more vacuum channels include one or more horizontal channels formed in the flat chucking surface of the chuck body between raised areas of the flat chucking surface of the chuck body.

8. The vacuum chuck apparatus of claim 1, further comprising: one or more vacuum channels disposed in the flat chucking surface of the chuck body surrounding each opening in the chuck body associated with each of the three or more collapsible bellows.

9. The vacuum chuck apparatus of claim 1, further comprising: one or more vacuum channels disposed in the flat chucking surface of the chuck body along one or both sides of each of the one or more recessed annular channels.

10. A vacuum chuck apparatus, comprising: a chuck body having a substantially flat chucking surface; one or more recessed annular

channels disposed in the substantially flat chucking surface of the chuck body, wherein each of the one or more recessed annular channels includes an extensible sealing element coupled to a bottom surface of the one or more recessed annular channels, wherein each extensible sealing element is configured to extend at least 5 millimeters above the flat chucking surface of the chuck body; three or more lift structures each coupled to one of three or more collapsible bellows, wherein each collapsible bellows has a compliant shape configured to conform to a non-planar backside surface of a substrate; and one or more actuators configured to move the three or more lift structures and the three or more collapsible bellows in a direction orthogonal to the flat chucking surface of the chuck body and into contact with the substrate to form a vacuum clamped connection between the three or more collapsible bellows and the substrate, the one or more actuators further configured to move the three or more lift structures, the three or more collapsible bellows, and the substrate toward the extensible sealing elements coupled to the chuck body.

11. The vacuum chuck apparatus of claim 10, wherein the chuck body is mounted to a motion stage subsystem such that the chuck body is movable with respect to the motion stage subsystem in the direction orthogonal to the flat chucking surface of the chuck body, and wherein the three or more lift structures are movable with respect to the motion stage subsystem in the direction orthogonal to the flat chucking surface of the chuck body.

12. The vacuum chuck apparatus of claim 11, wherein the three or more lift structures are moveable with respect to the chuck body by a combination of movements of the chuck body and the three or more lift structures with respect to the motion stage subsystem such that the three or more collapsible bellows extend at least 10 millimeters above the flat chucking surface of the chuck body.

13. The vacuum chuck apparatus of claim 10, wherein the one or more recessed annular channels are coupled to one or more vacuum bleed orifices to regulate an amount of vacuum maintained in the one or more recessed annular channel when the substrate is vacuum clamped to the flat chucking surface of the chuck body.

14. The vacuum chuck apparatus of claim 10, further comprising: one or more vacuum channels disposed in the flat chucking surface of the chuck body, wherein the one or more vacuum channels surround each opening in the chuck body associated with each of the collapsible bellows.

15. The vacuum chuck apparatus of claim 10, further comprising: one or more vacuum channels disposed in the flat chucking surface of the chuck body along one or both sides of each of the one or more recessed annular channels.