CLAIMS

1. An apparatus comprising:

a first end effector blade having a proximal end and a distal end;

a second end effector blade having a proximal end and a distal end, the distal ends of the first and second end effectors each having a distal cleat mounted thereto;

an actuator mechanism having a portion thereof positioned between the first end effector blade and the second end effector blade, wherein the actuator mechanism comprises a first portion and a second portion, wherein the second portion of the actuator mechanism comprises a proximal cleat mounted thereto and includes the portion of the actuator mechanism that is positioned between the first end effector blade and the second end effector blade, and wherein the second portion of the actuator mechanism is movable relative to the first portion such that a distance between the distal cleats and the proximal cleat is adjustable by the actuator mechanism;

an end effector wrist unit, the end effector wrist unit including:

a wrist unit housing;

an end effector mount assembly having a first end effector mount and a second end effector mount; and

one or more rotational interfaces, wherein:

the first end effector mount is configured to mechanically connect with the first end effector blade, the first end effector blade having a major surface defining a first plane,

the second end effector mount is configured to mechanically connect with the second end effector blade, the second end effector blade having a major surface positioned on the first plane,

the proximal ends of the first and second end effector blades are fixedly mounted to the end effector mount assembly,

the end effector mount assembly is connected with the wrist unit housing via the one or more rotational interfaces such that the end effector mount assembly is rotatable through a first angular range of motion relative to the wrist unit housing and about a first axis,

the first axis is substantially parallel to the first plane when the first end effector blade is mounted to the first end effector mount, and

the first portion of the actuator mechanism is fixed with respect to the end effector mount assembly.

2. The apparatus of claim 1, wherein the first end effector mount has a first planar end effector mounting surface that is configured to mate against the first end effector blade when the first end effector mount is mated to the first end effector blade and the first planar end effector mounting surface is parallel to the first axis.

3. The apparatus of claim 2, wherein the first and second end effector blades are configured to be non-parallel to a wafer at initiation of a pick up operation.

4. The apparatus of claim 1, wherein the first end effector blade is made of a ceramic material.

5. The apparatus of claim 1, wherein the first end effector blade is made of silicon carbide.

6. The apparatus of claim 1, further comprising a first positive stop and a second positive stop, the first positive stop positioned so as to contact a portion of the end effector mount assembly when the end effector mount assembly is at a first rotational limit of the first angular range of motion and the second positive stop positioned so as to contact a portion of the end effector mount assembly when the end effector mount assembly is at a second rotational limit of the first angular range of motion.

7. The apparatus of claim 6, wherein one or both of the first positive stop and the second positive stop are adjustable.

8. The apparatus of claim 1, wherein the first angular range of motion is less than 10 degrees.

9. The apparatus of claim 1, further comprising a damper mechanism that is configured to damp rotational movement of the end effector mount assembly relative to the wrist unit housing.

10. The apparatus of claim 9, further comprising a draw link and a rocker arm, wherein:

the draw link has a first end rotatably coupled to a first end of the rocker arm so as to be rotatable about a second axis relative to the rocker arm and a second end rotatably coupled to the end effector mount assembly so as to be rotatable about a third axis relative to the end effector mount assembly, and

the rocker arm has a second end rotatably coupled with a first end of the damper mechanism so as to be rotatable about a fourth axis relative to the damper mechanism and is mounted so as to be rotatable about a fifth axis that is fixed with respect to the wrist unit housing.

11. The apparatus of claim 10, wherein a first distance between the fifth axis and the fourth axis is greater than a second distance between the fifth axis and the second axis.

12. The apparatus of claim 11, wherein the first distance is at least 1.5 times the second distance.

13. The apparatus of claim 1, wherein the second end effector blade is fixed with respect to the end effector mount assembly.

14. The apparatus of claim 13, wherein:

each distal cleat has a riser portion extending away from the corresponding end effector blade and a catch surface extending outward from the riser portion thereof, and

each catch surface is spaced apart from the corresponding end effector blade by at least a first gap distance.

15. The apparatus of claim 14, wherein each catch surface slopes away from the corresponding end effector blade with increasing distance from the riser portion from which that catch surface extends.

16. The apparatus of claim 15, wherein:

the second portion of the actuator mechanism is configured to be movable between a first configuration and a second configuration relative to the first portion of the actuator mechanism,

the proximal cleat of the actuator mechanism and has a catch surface that faces in substantially the same direction as the catch surfaces of the distal cleats,

the catch surface of the proximal cleat and the catch surfaces of the distal cleats, in the first configuration, do not overlap a first reference circle when the second portion of the actuator mechanism is in the first configuration,

the catch surface of the proximal cleat and the catch surfaces of the distal cleats, in the second configuration, all overlap a second reference circle when the second portion of the actuator mechanism is in the second configuration, and

the first reference circle and the second reference circle have the same diameter.

17. The apparatus of claim 16, wherein the first reference circle has a diameter selected from the group consisting of 200 mm, 300 mm, and 450 mm.

18. The apparatus of claim 1, wherein the end effector wrist unit is configured such that:

when the end effector wrist unit is positioned in a first orientation with the first axis horizontal and the first plane substantially horizontal, the end effector mount assembly moves to a first rotational limit of the first angular range of motion due solely to gravitational loading and a side of the first end effector blade that carries the distal cleat thereof faces in a first direction, and

when the end effector wrist unit is positioned in a second orientation, the end effector mount assembly also moves to a second rotational limit of the first angular range of motion due solely to gravitational loading and the side of the first end effector blade that carries the distal cleat thereof faces in a second direction that is substantially opposite the first direction.

19. The apparatus of claim 1, further comprising a base, one or more robot arm links, and a wrist drive unit, wherein:

the one or more robot arm links include a first robot arm link that is configured to be rotatable relative to the base and about a base axis,

the wrist drive unit is supported by the one or more robot arm links and includes a wrist mount that is rotatable about an axis that is perpendicular to an axis that is parallel to the base axis, and

the end effector wrist unit is mounted to the wrist mount.

20. The apparatus of claim 1, further comprising a base, one or more robot arm links, and a wrist drive unit, wherein:

the one or more robot arm links include a first robot arm link that is configured to be rotatable relative to the base,

the wrist drive unit is supported by the one or more robot arm links and includes a wrist mount that is rotatable about an axis that is perpendicular to an axis that is parallel to the first axis, and

the end effector wrist unit is mounted to the wrist mount.

21. A method comprising:

a) moving an end effector wrist unit to a first position relative to a wafer resting on a pedestal, the end effector wrist unit supporting one or more end effector blades that are rotationally mounted with respect to the end effector wrist unit by way of one or more rotational interfaces, wherein:

the one or more end effector blades are rotatable about a first axis relative to the end effector wrist unit, and

the one or more end effector blades have distal cleats mounted to a distal end or ends thereof;

b) lowering the end effector wrist unit from the first position to a second position in which the distal cleats first contact the pedestal, wherein the one or more end effector blades are positioned in a non-parallel orientation relative to the wafer in each of the first position and the second position; and

c) further lowering the end effector wrist unit from the second position to a third position, thereby causing the one or more end effector blades to rotate about the first axis relative to the end effector wrist unit and thereby position the one or more end effector blades in a nominally parallel orientation relative to the wafer.

22. The method of claim 21, wherein, in the third position, a proximal cleat that is supported by the end effector wrist unit is positioned with a catch surface thereof positioned such that at least part of the catch surface is at a lower elevation than an edge of the wafer with respect to a normal vector of the wafer.

23. The method of claim 22, further comprising moving at least one cleat of the distal cleats and the proximal cleat radially inward with respect to the wafer such that the catch surface of the proximal cleat and catch surfaces of the distal cleats all overlap the wafer when viewed along an axis perpendicular to the wafer.

24. The method of claim 23, further comprising raising the end effector wrist unit by a fourth distance after moving the at least one cleat of the distal cleats and the proximal cleat radially inward with respect to the wafer, thereby lifting the wafer off of the pedestal.

25. The method of claim 24, further comprising rotating the end effector wrist unit by 180° about a second axis perpendicular to the first axis and substantially parallel to the wafer after raising the end effector wrist unit by the fourth distance.