CLAIMS

1. ——A linear electrical machine comprising:

a frame with a level reference plane;

an array of electromagnets, connected to the frame to form a drive plane at a predetermined height relative to the level reference plane, the array of electromagnets being arranged so that a series of electromagnets of the array of electromagnets define at least one drive line within the drive plane, and each of the electromagnets being coupled to an alternating current power source energizing each electromagnet;

at least one reaction platen of paramagnetic, diamagnetic, or non-magnetic conductive material disposed to cooperate with the electromagnets of the array of electromagnets so that excitation of the electromagnets with alternating current generates levitation and propulsion forces against the reaction platen that controllably levitate and propel the reaction platen along the at least one drive line, in a controlled attitude relative to the drive plane; and

a controller operably coupled to the array of electromagnets and the alternating current power source and configured so as to sequentially excite the electromagnets with multiphase alternating current so that each reaction platen is levitated and propelled with up to six degrees of freedom including at least one of attitude control and yaw control with a common set of the electromagnets, each of which generates, from excitation with common multiphase alternating current having a single common frequency per phase, both the levitation and the propulsion forces against the reaction platen so as to control the reaction platen

with up to six degrees of freedom including at least one of reaction platen attitude and reaction platen yaw at least with the reaction platen levitated.

2. ——The linear electrical machine of claim 1, wherein the controller controls the up to six degrees of freedom, generated by the array of electromagnets, including at least the reaction platen attitude with the reaction platen levitated and propelled so as to move relative to the array of electromagnets along the at least one drive line from a first predetermined position with respect to the frame to a second different predetermined position with respect to the frame.

3. ——The linear electrical machine of claim 1, wherein the controller controls the up to six degrees of freedom, generated by the array of electromagnets, including at least the reaction platen attitude and the reaction platen yaw with the reaction platen levitated and stationary relative to the array of electromagnets in a predetermined position along the at least one drive line with respect to the frame.

4. ——The linear electrical machine of claim 1, wherein the controller controls the propulsion forces, generated by the array of electromagnets, across the reaction platen so as to impart a controlled yaw moment on the reaction platen, yawing the reaction platen about a yaw axis, substantially normal to the drive plane, from a first predetermined orientation relative to the frame, to a second different predetermined orientation relative to the frame.

5. ——The linear electrical machine of claim 1, wherein the controller controls the propulsion forces, generated by the array of electromagnets, so as to impart a moment couple on the reaction

platen effecting controlled yaw of the reaction platen so as to effect at least one of positioning and centering of a wafer payload on the reaction platen relative to a predetermined wafer holding location of the frame.

6. ——The linear electrical machine of claim 1, wherein the controller controls the levitation forces, generated by the array of electromagnets, so as to impart differential levitation forces across the reaction platen that effect a controlled inclination of the reaction platen, relative to the drive plane, that controls a predetermined reaction platen attitude in at least one of reaction platen pitch and reaction platen roll.

7. ——The linear electrical machine of claim 1, wherein the controller controls the levitation forces, generated by the array of electromagnets, so as to effect a predetermined bias attitude of the reaction platen, relative to the drive plane, that imparts a bias reaction force, from a reaction platen payload seating surface on a payload supported by the reaction platen seating surface, in a direction countering payload inertial force arising from acceleration of the reaction platen along the drive plane.

8. ——The linear electrical machine of claim 7, further comprising position feedback sensors distributed on the frame configured for sensing position of the reaction platen along the drive plane and communicably coupled to the controller so the controller registers the sensed position of the reaction platen, wherein the controller is configured to sequentially excite the electromagnets of the array of electromagnets corresponding to the sensed position.

9. ——The linear electrical machine of claim 8, wherein the controller is configured to determine acceleration of the reaction platen along the drive plane at least from changes in the sensed

position, and in response to the acceleration determined, control a bias attitude of the reaction platen to provide the predetermined bias attitude countering the payload inertial force arising from the acceleration of the reaction platen.

10. —The linear electrical machine of claim 1, wherein the controller controls excitation of the electromagnets of the array of electromagnets so as to set the reaction platen attitude to bias the reaction platen against inertial forces tending to displace a payload, seated against the reaction platen, relative to the reaction platen along a seat between the payload and the reaction platen.

11. —An electromagnetic conveyor substrate transport apparatus comprising:

a chamber configured to hold a sealed atmosphere therein, and having a level reference plane and at least one substrate pass through opening for transferring a substrate in and out of the chamber through the opening;

an array of electromagnets, connected to the chamber to form a drive plane at a predetermined height relative to the level reference plane, the array of electromagnets being arranged so that a series of electromagnets of the array of electromagnets define at least one drive line within the drive plane, electromagnets in the series of electromagnets being grouped into at least one multiphase actuator unit, and each of the at least one multiphase actuator unit being coupled to a multiphase alternating current power source;

at least one reaction platen of paramagnetic, diamagnetic, or non-magnetic conductive material disposed to cooperate with the electromagnets of the at least one multiphase actuator unit so

that excitation of the electromagnets with alternating current generates levitation and propulsion forces against the reaction platen that controllably levitate and propel the reaction platen along the at least one drive line, in a controlled attitude relative to the drive plane; and

a controller operably coupled to the array of electromagnets and alternating current power source and configured so as to sequentially excite the electromagnets with multiphase alternating current so that a reaction platen is levitated and propelled, wherein each alternating current phase, of the multiphase alternating current, is dynamically allocated between respective electromagnets so that the alternating current phase of each respective electromagnet, of the electromagnet group of the at least one multiphase actuator unit, changes from a first alternating current phase to a second different alternating current phase so in effect the electromagnet group moves virtually and the at least one multiphase actuator unit formed by the electromagnet group moves virtually via dynamic phase allocation along the drive line.

12. —The electromagnetic conveyor substrate transport apparatus of claim 11, wherein the reaction platen is levitated and propelled with up to six degrees of freedom including at least one of attitude and yaw control with the virtually moving at least one multiphase actuator unit.

13. —The electromagnetic conveyor substrate transport apparatus of claim 12, wherein the controller controls the up to six degrees of freedom, generated by the array of electromagnets, including at least the reaction platen attitude with the reaction platen levitated and propelled so as to move relative to the array of electromagnets along the at least one drive line from a first

predetermined position with respect to the chamber to a second different predetermined position with respect to the chamber.

14. —The electromagnetic conveyor substrate transport apparatus of claim 12, wherein the controller controls the up to six degrees of freedom, generated by the array of electromagnets, including at least the reaction platen attitude and the reaction platen yaw with the reaction platen levitated and stationary relative to the array of electromagnets in a predetermined position along the at least one drive line with respect to the chamber.

15. —The electromagnetic conveyor substrate transport apparatus of claim 11, wherein the dynamic phase allocation is controlled so that the virtually moving at least one multiphase actuator unit moves virtually along the drive line substantially coincident with reaction platen movement along the drive line from propulsion by the virtually moving at least one multiphase actuator unit.

16. —The electromagnetic conveyor substrate transport apparatus of claim 11, wherein the controller controls the propulsion forces, generated by the array of electromagnets, across the reaction platen so as to impart a controlled yaw moment on the reaction platen, yawing the reaction platen about a yaw axis, substantially normal to the drive plane, from a first predetermined orientation relative to the chamber, to a second different predetermined orientation relative to the chamber.

17. —The electromagnetic conveyor substrate transport apparatus of claim 11, wherein the controller controls the propulsion forces, generated by the array of electromagnets, so as to impart a moment couple on the reaction platen effecting controlled yaw of the reaction platen so as to effect at least one of positioning and

centering of a wafer payload on the reaction platen relative to a predetermined wafer holding location of the chamber.

18. —The electromagnetic conveyor substrate transport apparatus of claim 11, wherein the controller controls the levitation forces, generated by the array of electromagnets, so as to impart differential levitation forces across the reaction platen that effect a controlled inclination of the reaction platen, relative to the drive plane, that controls a predetermined reaction platen attitude in at least one of reaction platen pitch and reaction platen roll.

19. —The electromagnetic conveyor substrate transport apparatus of claim 11, wherein the controller controls the levitation forces, generated by the array of electromagnets, so as to effect a predetermined bias attitude of the reaction platen, relative to the drive plane, that imparts a bias reaction force, from a reaction platen payload seating surface on a payload supported by the reaction platen seating surface, in a direction countering payload inertial force arising from acceleration of the reaction platen along the drive plane.

20. —The electromagnetic conveyor substrate transport apparatus of claim 19, further comprising position feedback sensors distributed on the chamber configured for sensing position of the reaction platen along the drive plane and communicably coupled to the controller so the controller registers the sensed position of the reaction platen, wherein the controller is configured to sequentially excite the electromagnets of the array of electromagnets corresponding to the sensed position.

21. —The electromagnetic conveyor substrate transport apparatus of claim 20, wherein the controller is configured to determine

acceleration of the reaction platen along the drive plane at least from changes in the sensed position, and in response to the acceleration determined, control a bias attitude of the reaction platen to provide the predetermined bias attitude countering the payload inertial force arising from the acceleration of the reaction platen.

22. —The electromagnetic conveyor substrate transport apparatus of claim 11, wherein the controller controls excitation of the electromagnets of the array of electromagnets so as to set the reaction platen attitude to bias the reaction platen against inertial forces tending to displace a payload, seated against the reaction platen, relative to the reaction platen along a seat between the payload and the reaction platen.

23.—_The electromagnetic conveyor substrate transport apparatus of claim 11, wherein the dynamic phase allocation is controlled so that the respective electromagnets energized by the multiphase alternating current present, with respect to the reaction platen, a substantially steady state multiphase distribution across respective electromagnets of the virtually moving at least one multiphase actuator unit.

24. —A method for a linear electrical machine, the method comprising:

providing the linear electrical machine with a frame, the frame having a level reference plane;

forming a drive plane with an array of electromagnets connected to the frame, the drive plane is located at a predetermined height relative to the level reference plane, the array of electromagnets being arranged so that a series of electromagnets of the array of electromagnets define at least one drive line within the drive

plane, and each of the electromagnets being coupled to an alternating current power source energizing each electromagnet;

providing at least one reaction platen of paramagnetic, diamagnetic, or non-magnetic conductive material disposed to cooperate with the electromagnets of the array of electromagnets; and

exciting the electromagnets with alternating current to generate levitation and propulsion forces against the reaction platen that controllably levitate and propel the reaction platen along the at least one drive line, in a controlled attitude relative to the drive plane;

wherein the electromagnets are sequentially excited, with a controller operably coupled to the array of electromagnets and the alternating current power source, with multiphase alternating current so that each reaction platen is levitated and propelled with up to six degrees of freedom including at least one of attitude control and yaw control with a common set of the electromagnets, each of which generates, from excitation with common multiphase alternating current having a single common frequency per phase, both the levitation and the propulsion forces against the reaction platen so as to control the reaction platen with up to six degrees of freedom including at least one of reaction platen attitude and reaction platen yaw at least with the reaction platen levitated.

~~25. The method of claim 24, wherein the controller controls the up to six degrees of freedom, generated by the array of electromagnets, including at least the reaction platen attitude with the reaction platen levitated and propelled so as to move relative to the array of electromagnets along the at least one~~

drive line from a first predetermined position with respect to the frame to a second different predetermined position with respect to the frame.

26. The method of claim 24, wherein the controller controls the up to six degrees of freedom, generated by the array of electromagnets, including at least the reaction platen attitude and the reaction platen yaw with the reaction platen levitated and stationary relative to the array of electromagnets in a predetermined position along the at least one drive line with respect to the frame.

27. The method of claim 24, wherein the controller controls the propulsion forces, generated by the array of electromagnets, across the reaction platen so as to impart a controlled yaw moment on the reaction platen, yawing the reaction platen about a yaw axis, substantially normal to the drive plane, from a first predetermined orientation relative to the frame, to a second different predetermined orientation relative to the frame.

28. The method of claim 24, wherein the controller controls the propulsion forces, generated by the array of electromagnets, so as to impart a moment couple on the reaction platen effecting controlled yaw of the reaction platen so as to effect at least one of positioning and centering of a wafer payload on the reaction platen relative to a predetermined wafer holding location of the frame.

29. The method of claim 24, wherein the controller controls the levitation forces, generated by the array of electromagnets, so as to impart differential levitation forces across the reaction platen that effect a controlled inclination of the reaction platen, relative to the drive plane, that controls a predetermined reaction

platen attitude in at least one of reaction platen pitch and reaction platen roll.

30. The method of claim 24, wherein the controller controls the levitation forces, generated by the array of electromagnets, so as to effect a predetermined bias attitude of the reaction platen, relative to the drive plane, that imparts a bias reaction force, from a reaction platen payload seating surface on a payload supported by the reaction platen seating surface, in a direction countering payload inertial force arising from acceleration of the reaction platen along the drive plane.

31. The method of claim 30, further comprising sensing, with position feedback sensors distributed on the frame, position of the reaction platen along the drive plane and communicably coupled to the controller so the controller registers the sensed position of the reaction platen, wherein the controller sequentially excites the electromagnets of the array of electromagnets corresponding to the sensed position.

32. The method of claim 31, wherein the controller determines acceleration of the reaction platen along the drive plane at least from changes in the sensed position, and in response to the acceleration determined, control a bias attitude of the reaction platen to provide the predetermined bias attitude countering the payload inertial force arising from the acceleration of the reaction platen.

33. The method of claim 24, wherein the controller controls excitation of the electromagnets of the array of electromagnets so as to set the reaction platen attitude to bias the reaction platen against inertial forces tending to displace a payload, seated

against the reaction platen, relative to the reaction platen along a seat between the payload and the reaction platen.

34. A method for an electromagnetic conveyor substrate transport apparatus, the method comprising:

providing the electromagnetic conveyor substrate transport apparatus with a chamber configured to hold a sealed atmosphere therein, and having a level reference plane and at least one substrate pass through opening for transferring a substrate in and out of the chamber through the opening;

forming a drive plane with an array of electromagnets connected to the chamber, the drive plane is located at a predetermined height relative to the level reference plane, the array of electromagnets being arranged so that a series of electromagnets of the array of electromagnets define at least one drive line within the drive plane, electromagnets in the series of electromagnets being grouped into at least one multiphase actuator unit, and each of the at least one multiphase actuator unit being coupled to a multiphase alternating current power source;

providing at least one reaction platen of paramagnetic, diamagnetic, or non-magnetic conductive material disposed to cooperate with the electromagnets of the at least one multiphase actuator unit; and

exciting the electromagnets with alternating current to generate levitation and propulsion forces against the reaction platen that controllably levitate and propel the reaction platen along the at least one drive line, in a controlled attitude relative to the drive plane;

~~wherein the electromagnets are sequentially excited, with a controller operably coupled to the array of electromagnets and alternating current power source, with multiphase alternating current so that a reaction platen is levitated and propelled, wherein each alternating current phase, of the multiphase alternating current, is dynamically allocated between respective electromagnets so that the alternating current phase of each respective electromagnet, of the electromagnet group of the at least one multiphase actuator unit, changes from a first alternating current phase to a second different alternating current phase so in effect the electromagnet group moves virtually and the at least one multiphase actuator unit formed by the electromagnet group moves virtually via dynamic phase allocation along the drive line.~~

~~35. The method of claim 34, wherein the reaction platen is levitated and propelled with up to six degrees of freedom including at least one of attitude and yaw control with the virtually moving at least one multiphase actuator unit.~~

~~36. The method of claim 35, wherein the controller controls the up to six degrees of freedom, generated by the array of electromagnets, including at least the reaction platen attitude with the reaction platen levitated and propelled so as to move relative to the array of electromagnets along the at least one drive line from a first predetermined position with respect to the chamber to a second different predetermined position with respect to the chamber.~~

~~37. The method of claim 35, wherein the controller controls the up to six degrees of freedom, generated by the array of electromagnets, including at least the reaction platen attitude and the reaction platen yaw with the reaction platen levitated and~~

~~stationary relative to the array of electromagnets in a predetermined position along the at least one drive line with respect to the chamber.~~

~~38. The method of claim 34, wherein the dynamic phase allocation is controlled so that the virtually moving at least one multiphase actuator unit moves virtually along the drive line substantially coincident with reaction platen movement along the drive line from propulsion by the virtually moving at least one multiphase actuator unit.~~

~~39. The method of claim 34, wherein the controller controls the propulsion forces, generated by the array of electromagnets, across the reaction platen so as to impart a controlled yaw moment on the reaction platen, yawing the reaction platen about a yaw axis, substantially normal to the drive plane, from a first predetermined orientation relative to the chamber, to a second different predetermined orientation relative to the chamber.~~

~~40. The method of claim 34, wherein the controller controls the propulsion forces, generated by the array of electromagnets, so as to impart a moment couple on the reaction platen effecting controlled yaw of the reaction platen so as to effect at least one of positioning and centering of a wafer payload on the reaction platen relative to a predetermined wafer holding location of the chamber.~~

~~41. The method of claim 34, wherein the controller controls the levitation forces, generated by the array of electromagnets, so as to impart differential levitation forces across the reaction platen that effect a controlled inclination of the reaction platen, relative to the drive plane, that controls a predetermined reaction~~

~~platen attitude in at least one of reaction platen pitch and reaction platen roll.~~

~~42. The method of claim 34, wherein the controller controls the levitation forces, generated by the array of electromagnets, so as to effect a predetermined bias attitude of the reaction platen, relative to the drive plane, that imparts a bias reaction force, from a reaction platen payload seating surface on a payload supported by the reaction platen seating surface, in a direction countering payload inertial force arising from acceleration of the reaction platen along the drive plane.~~

~~43. The method of claim 42, further comprising sensing, with the position feedback sensors distributed on the chamber, position of the reaction platen along the drive plane and communicably coupled to the controller so the controller registers the sensed position of the reaction platen, wherein the controller is configured to sequentially excite the electromagnets of the array of electromagnets corresponding to the sensed position.~~

~~44. The method of claim 43, wherein the controller determines acceleration of the reaction platen along the drive plane at least from changes in the sensed position, and in response to the acceleration determined, control a bias attitude of the reaction platen to provide the predetermined bias attitude countering the payload inertial force arising from the acceleration of the reaction platen.~~

~~45. The method of claim 34, wherein the controller controls excitation of the electromagnets of the array of electromagnets so as to set the reaction platen attitude to bias the reaction platen against inertial forces tending to displace a payload, seated~~

~~against the reaction platen, relative to the reaction platen along a seat between the payload and the reaction platen.~~

~~46. The method of claim 34, wherein the dynamic phase allocation is controlled so that the respective electromagnets energized by the multiphase alternating current present, with respect to the reaction platen, a substantially steady state multiphase distribution across respective electromagnets of the virtually moving at least one multiphase actuator unit.~~