

CLAIMS

1. A substrate transport apparatus comprising:

a support frame;

an articulated arm connected to the support frame and having at least one movable arm link and an end effector, connected to the movable arm link, with a substrate holding station located thereon;

wherein the movable arm link is a reconfigurable arm link having a modular composite arm link casing, formed of link case modules rigidly coupled to each other, and a pulley system cased in and extending through the rigidly coupled link case modules substantially end to end of the modular composite arm link casing, and wherein the rigidly coupled link case modules include link case end modules connected by at least one interchangeable link case extension module having a predetermined characteristic determining a length of the movable arm link; and

wherein the at least one interchangeable link case extension module is selectable, for connection to the link case end modules and forming the reconfigurable arm link, from a number of different interchangeable link case extension modules each with a different corresponding predetermined characteristic determining a corresponding different length of the movable arm link, so as to selectably set the modular composite arm link casing and reconfigurable arm link to a predetermined arm link length from a number of predetermined arm link lengths.

2. The substrate transport apparatus of claim 1, wherein the at least one interchangeable link case extension module and each of

the number of different interchangeable link case extension modules have a box shape cross section corresponding thereto, and the predetermined characteristic is that the interchangeable link case extension module and each of the number of different interchangeable link case extension modules have a different corresponding length and the corresponding box shape cross section being sized and shaped commensurate to the different corresponding lengths so as to maintain a predetermined stiffness for each different interchangeable link case extension module.

3. The substrate transport apparatus of claim 1, wherein the at least one interchangeable link case extension module and each of the number of different interchangeable link case extension modules have a box shape cross section corresponding thereto, and the predetermined characteristic is that the interchangeable link case extension module and each of the number of different interchangeable link case extension modules have a different corresponding length and the corresponding box shape cross section being sized and shaped commensurate to the different corresponding length so as to maintain a predetermined stiffness for each different selectable predetermined arm link length.

4. The substrate transport apparatus of claim 1, wherein the at least one interchangeable link case extension module and each of the number of different interchangeable link case extension modules is an extrusion member having a box shape cross section.

5. The substrate transport apparatus of claim 1, wherein the at least one interchangeable link case extension module and each of the number of different interchangeable link case extension modules has a box shape cross section made of a material different from a material of the link case end modules.

6. The substrate transport apparatus of claim 1, wherein a material of the at least one link case extension module and each of the number of different interchangeable link case extension modules has a higher stiffness than a material of the link case end modules.

7. The substrate transport apparatus of claim 1, wherein a material of the at least one link case extension module and each of the number of different interchangeable link case extension modules has a stiffness commensurate with a material stiffness of a pulley transmission of the pulley system.

8. The substrate transport system of claim 1, wherein the pulley system is engaged to the modular composite arm link casing, and is arranged so that, powered by a drive section, the pulley system effects articulation of the at least one arm link or the end effector.

9. The substrate transport apparatus of claim 1, wherein the at least one interchangeable link case extension module and each of the number of different interchangeable link case extension modules has a box shape cross section made of stainless steel.

10. The substrate transport apparatus of claim 1, wherein the at least one interchangeable link case extension module is mechanically fastened to each of the link case end modules to form the modular composite arm link casing and arranged so that the modular composite arm link casing formed matches a misalignment tolerance of a pulley transmission connecting pulley wheels of the pulley system for a selected predetermined arm link length.

11. The substrate transport apparatus of claim 1, wherein the at least one interchangeable link case extension module is

mechanically fastened with mechanical fastener joints to each of the link case end modules to form the modular composite arm link casing, and the mechanical fastener joints are configured so that the modular composite arm link casing formed matches a misalignment tolerance of a pulley transmission connecting pulley wheels of the pulley system for a selected predetermined arm link length.

12. The substrate transport apparatus of claim 1, wherein at least one of the link case end modules houses a pulley wheel of the pulley system.

13. The substrate transport apparatus of claim 1, wherein the modular composite arm link casing is a low profile casing having a compact height for a selected predetermined arm length commensurate with a bi-symmetrically flexible pulley transmission, connecting pulley wheels of the pulley system, that has a compact substantially bi-symmetrical cross section.

14. The substrate transport apparatus of claim 13, wherein the compact height is smaller than a band pulley transmission housing height for a comparable number of pulley systems having comparable lengths.

15. The substrate transport apparatus of claim 13, wherein the flexible pulley transmission connecting the pulley wheels is a cable or wire pulley transmission.

16. The substrate transport apparatus of claim 1, wherein at least one of the link case end modules houses a pulley wheel of the pulley system mounted with a crossed roller bearing so that position and alignment of the pulley wheel is dependent and controlled by engagement with the crossed roller bearing.

17. The substrate transport apparatus of claim 1, wherein the modular composite arm link casing is a low profile casing having a compact height for a selected predetermined arm length commensurate with a crossed roller bearing mounted pulley wheel of the pulley system housed in at least one of the link case end modules.

18. The substrate transport apparatus of claim 1, wherein a pulley transmission to pulley wheel engagement of a respective pulley wheel of the pulley system is arranged so as to determine rotation of a respective pulley wheel of the pulley system through at least 360° rotation of the respective pulley wheel between wound and unwound positions of the pulley transmission on the respective pulley wheel.

19. The substrate transport apparatus of claim 1, wherein a pulley transmission to pulley wheel engagement of a respective pulley wheel of the pulley system is arranged so as to determine rotation of the end effector through at least 360° rotation of the end effector relative to the at least one movable arm link between wound and unwound positions of the pulley transmission on a respective pulley wheel.

20. A substrate transport apparatus comprising:

a support frame;

an articulated arm connected to the support frame and having at least one movable arm link and an end effector, connected to the at least one movable arm link, with a substrate holding station located thereon;

wherein the at least one movable arm link has a modular composite arm link casing, formed of link case modules rigidly

coupled to each other, and a pulley system cased in and extending through the rigidly coupled link case modules substantially end to end of the modular composite arm link casing, the pulley system is mounted and engaged to the modular composite arm link casing, and is arranged so that, powered by a drive section, the pulley system effects articulation of the at least one movable arm link or the end effector relative to the at least one movable arm link, and

wherein the rigidly coupled case link modules include link case end modules connected by at least one link case extension module that is mechanically fastened to each of the link case end modules to form the modular composite arm link casing and arranged so that the modular arm link casing formed matches a misalignment tolerance of a pulley transmission connecting pulley wheels of the pulley system housed in the link case end modules at the ends of the modular composite arm link casing.

21. The substrate transport apparatus of claim 20, wherein the at least one movable arm link is a reconfigurable arm link, wherein the link case extension module is interchangeable from a number of different interchangeable link case extension modules each having a different corresponding predetermined characteristic determining a length of the at least one movable arm link.

22. The substrate transport apparatus of claim 21, wherein the link case extension module and each of the number of different interchangeable link case extension modules have a box shape cross section corresponding thereto, and the predetermined characteristic is that the link case extension module and each of the number of different interchangeable link case extension modules have a different corresponding length and the

corresponding box shape cross section being sized and shaped commensurate to the different corresponding lengths so as to maintain a predetermined stiffness for each different interchangeable link case extension module.

23. The substrate transport apparatus of claim 21, wherein the link case extension module and each of the number of different interchangeable link case extension modules have a box shape cross section corresponding thereto, and the predetermined characteristic is that the link case extension module and each of the number of different interchangeable link case extension modules have a different corresponding length and the corresponding box shape cross section being sized and shaped commensurate to the different corresponding length so as to maintain a predetermined stiffness for each different selectable predetermined arm link length.

24. The substrate transport apparatus of claim 21, wherein the link case extension module and each of the number of different interchangeable link case extension modules is an extrusion member having a box shape cross section.

25. The substrate transport apparatus of claim 21, wherein the link case extension module and each of the number of different interchangeable link case extension modules has a box shape cross section made of a material different from a material of the link case end modules.

26. The substrate transport apparatus of claim 21, wherein a material of the link case extension module and each of the number of different interchangeable link case extension modules has a higher stiffness than a material of the link case end modules.

27. The substrate transport apparatus of claim 21, wherein a material of the link case extension module and each of the number of different interchangeable link case extension modules has a stiffness commensurate with a material stiffness of the pulley transmission of the pulley system.

28. The substrate transport apparatus of claim 21, wherein the link case extension module and each of the number of different interchangeable link case extension modules has a box shape cross section made of stainless steel.

29. The substrate transport apparatus of claim 21, wherein the pulley transmission is a bi-symmetrically flexible pulley transmission and the modular composite arm link casing is a low profile casing having a compact height for a selected predetermined arm length commensurate with the bi-symmetrically flexible pulley transmission, connecting the pulley wheels of the pulley system, that has a compact substantially by-symmetrical cross section.

30. The substrate transport apparatus of claim 29, wherein the compact height is smaller than a band pulley transmission housing height for a comparable number of pulley systems having comparable lengths.

31. The substrate transport apparatus of claim 29, wherein the flexible pulley transmission connecting the pulley wheels is a cable or wire pulley transmission.

32. The substrate transport apparatus of claim 21, wherein the modular composite arm link casing is a low profile casing having a compact height for a selected predetermined arm length commensurate with a crossed roller bearing mounted pulley wheel

of the pulley system housed in at least one of the link case end modules.

33. The substrate transport apparatus of claim 20, wherein at least one of the pulley wheels of the pulley system is mounted with a crossed roller bearing so that position and alignment of the at least one of the pulley wheels is dependent and controlled by engagement with the crossed roller bearing.

34. The substrate transport apparatus of claim 20, wherein a pulley transmission to pulley wheel engagement of the pulley wheels of the pulley system is arranged so as to determine rotation of at least one of the pulley wheels of the pulley system through at least 360° rotation of the at least one of the pulley wheels between wound and unwound positions of the pulley transmission on the at least one of the pulley wheels.

35. The substrate transport apparatus of claim 20, wherein a pulley transmission to pulley wheel engagement of the pulley wheels of the pulley system is arranged so as to determine rotation of the end effector through at least 360° rotation of the end effector relative to the at least one movable arm link between wound and unwound positions of the pulley transmission on at least one of the pulley wheels.

36. A method comprising:

providing a substrate transport apparatus that includes

a support frame, and

an articulated arm connected to the support frame and having at least one movable arm link and an end effector,

connected to the movable arm link, with a substrate holding station located thereon; and

reconfiguring the movable arm link, where the movable arm link is a reconfigurable arm link having a modular composite arm link casing, formed of link case modules rigidly coupled to each other, and a pulley system cased in and extending through the rigidly coupled link case modules substantially end to end of the modular composite arm link casing, and wherein the rigidly coupled link case modules include link case end modules connected by at least one interchangeable link case extension module having a predetermined characteristic determining a length of the movable arm link; and

wherein the at least one interchangeable link case extension module is selectable, for connection to the link case end modules and forming the reconfigurable arm link, from a number of different interchangeable link case extension modules each with a different corresponding predetermined characteristic determining a corresponding different length of the movable arm link, so as to selectably set the modular composite arm link casing and reconfigurable arm link to a predetermined arm link length from a number of predetermined arm link lengths.

37. The method of claim 36, wherein the at least one interchangeable link case extension module and each of the number of different interchangeable link case extension modules have a box shape cross section corresponding thereto, and the predetermined characteristic is that the interchangeable link case extension module and each of the number of different interchangeable link case extension modules have a different corresponding length and the corresponding box shape cross section being sized and shaped commensurate to the different

corresponding lengths so as to maintain a predetermined stiffness for each different interchangeable link case extension module.

38. The method of claim 36, wherein the at least one interchangeable link case extension module and each of the number of different interchangeable link case extension modules have a box shape cross section corresponding thereto, and the predetermined characteristic is that the interchangeable link case extension module and each of the number of different interchangeable link case extension modules have a different corresponding length and the corresponding box shape cross section being sized and shaped commensurate to the different corresponding length so as to maintain a predetermined stiffness for each different selectable predetermined arm link length.

39. The method of claim 36, wherein the at least one interchangeable link case extension module and each of the number of different interchangeable link case extension modules is an extrusion member having a box shape cross section.

40. The method of claim 36, wherein the at least one interchangeable link case extension module and each of the number of different interchangeable link case extension modules has a box shape cross section made of a material different from a material of the link case end modules.

41. The method of claim 36, wherein a material of the at least one link case extension module and each of the number of different interchangeable link case extension modules has a higher stiffness than a material of the link case end modules.

42. The method of claim 36, wherein a material of the at least one link case extension module and each of the number of

different interchangeable link case extension modules has a stiffness commensurate with a material stiffness of a pulley transmission of the pulley system.

43. The method of claim 36, wherein the pulley system is engaged to the modular composite arm link casing, and is arranged so that, powered by a drive section, the pulley system effects articulation of the at least one arm link or the end effector.

44. The method of claim 36, wherein the at least one interchangeable link case extension module and each of the number of different interchangeable link case extension modules has a box shape cross section made of stainless steel.

45. The method of claim 36, further comprising mechanically fastening the at least one interchangeable link case extension module to each of the link case end modules to form the modular composite arm link casing where modular composite arm link casing formed matches a misalignment tolerance of a pulley transmission connecting pulley wheels of the pulley system for a selected predetermined arm link length.

46. The method of claim 36, further comprising mechanically fastening the at least one interchangeable link case extension module with mechanical fastener joints to each of the link case end modules to form the modular composite arm link casing, and the mechanical fastener joints are configured so that the modular composite arm link casing formed matches a misalignment tolerance of a pulley transmission connecting pulley wheels of the pulley system for a selected predetermined arm link length.

47. The method of claim 36, wherein at least one of the link case end modules houses a pulley wheel of the pulley system.

48. The method of claim 36, wherein the modular composite arm link casing is a low profile casing having a compact height for a selected predetermined arm length commensurate with a bi-symmetrically flexible pulley transmission, connecting pulley wheels of the pulley system, that has a compact substantially by-symmetrical cross section.

49. The method of claim 48, wherein the compact height is smaller than a band pulley transmission housing height for a comparable number of pulley systems having comparable lengths.

50. The method of claim 48, wherein the flexible pulley transmission connecting the pulley wheels is a cable or wire pulley transmission.

51. The method of claim 36, wherein at least one of the link case end modules houses a pulley wheel of the pulley system mounted with a crossed roller bearing so that position and alignment of the pulley wheel is dependent and controlled by engagement with the crossed roller bearing.

52. The method of claim 36, wherein the modular composite arm link casing is a low profile casing having a compact height for a selected predetermined arm length commensurate with a crossed roller bearing mounted pulley wheel of the pulley system housed in at least one of the link case end modules.

53. The method of claim 36, wherein a pulley transmission to pulley wheel engagement of a respective pulley wheel of the pulley system is arranged so as to determine rotation of a respective pulley wheel of the pulley system through at least 360° rotation of the respective pulley wheel between wound and unwound positions of the pulley transmission on the respective pulley wheel.

54. The method of claim 36, wherein a pulley transmission to pulley wheel engagement of a respective pulley wheel of the pulley system is arranged so as to determine rotation of the end effector through at least 360° rotation of the end effector relative to the at least one movable arm link between wound and unwound positions of the pulley transmission on a respective pulley wheel.

55. A method comprising:

providing a substrate transport apparatus that includes

a support frame,

an articulated arm connected to the support frame and having at least one movable arm link and an end effector, connected to the at least one movable arm link, with a substrate holding station located thereon; and

effecting, with a pulley system that is mounted and engaged to a modular composite arm link casing of the at least one movable arm, articulation of the at least one movable arm link or the end effector relative to the at least one movable arm link wherein the modular composite arm link casing is formed of link case modules rigidly coupled to each other and the pulley system is cased in and extends through the rigidly coupled link case modules substantially end to end of the modular composite arm link casing;

wherein the rigidly coupled case link modules include link case end modules connected by at least one link case extension module that is mechanically fastened to each of the link case end modules to form the modular composite arm link casing and arranged so that the modular arm link casing formed matches a

misalignment tolerance of a pulley transmission connecting pulley wheels of the pulley system housed in the link case end modules at the ends of the modular composite arm link casing.

56. The method of claim 55, further comprising reconfiguring the at least one movable arm link, wherein the link case extension module is interchangeable from a number of different interchangeable link case extension modules each having a different corresponding predetermined characteristic determining a length of the at least one movable arm link.

57. The method of claim 56, wherein the link case extension module and each of the number of different interchangeable link case extension modules have a box shape cross section corresponding thereto, and the predetermined characteristic is that the link case extension module and each of the number of different interchangeable link case extension modules have a different corresponding length and the corresponding box shape cross section being sized and shaped commensurate to the different corresponding lengths so as to maintain a predetermined stiffness for each different interchangeable link case extension module.

58. The method of claim 56, wherein the link case extension module and each of the number of different interchangeable link case extension modules have a box shape cross section corresponding thereto, and the predetermined characteristic is that the link case extension module and each of the number of different interchangeable link case extension modules have a different corresponding length and the corresponding box shape cross section being sized and shaped commensurate to the different corresponding length so as to maintain a predetermined

stiffness for each different selectable predetermined arm link length.

59. The method of claim 56, wherein the link case extension module and each of the number of different interchangeable link case extension modules is an extrusion member having a box shape cross section.

60. The method of claim 56, wherein the link case extension module and each of the number of different interchangeable link case extension modules has a box shape cross section made of a material different from a material of the link case end modules.

61. The method of claim 56, wherein a material of the link case extension module and each of the number of different interchangeable link case extension modules has a higher stiffness than a material of the link case end modules.

62. The method of claim 56, wherein a material of the link case extension module and each of the number of different interchangeable link case extension modules has a stiffness commensurate with a material stiffness of the pulley transmission of the pulley system.

63. The method of claim 56, wherein the link case extension module and each of the number of different interchangeable link case extension modules has a box shape cross section made of stainless steel.

64. The method of claim 56, wherein the pulley transmission is a bi-symmetrically flexible pulley transmission and the modular composite arm link casing is a low profile casing having a compact height for a selected predetermined arm length commensurate with the bi-symmetrically flexible pulley

transmission, connecting the pulley wheels of the pulley system, that has a compact substantially by-symmetrical cross section.

65. The method of claim 64, wherein the compact height is smaller than a band pulley transmission housing height for a comparable number of pulley systems having comparable lengths.

66. The method of claim 64, wherein the flexible pulley transmission connecting the pulley wheels is a cable or wire pulley transmission.

67. The method of claim 56, wherein the modular composite arm link casing is a low profile casing having a compact height for a selected predetermined arm length commensurate with a crossed roller bearing mounted pulley wheel of the pulley system housed in at least one of the link case end modules.

68. The method of claim 55, wherein at least one of the pulley wheels of the pulley system is mounted with a crossed roller bearing so that position and alignment of the at least one of the pulley wheels is dependent and controlled by engagement with the crossed roller bearing.

69. The method of claim 55, wherein a pulley transmission to pulley wheel engagement of the pulley wheels of the pulley system is arranged so as to determine rotation of at least one of the pulley wheels of the pulley system through at least 360° rotation of the at least one of the pulley wheels between wound and unwound positions of the pulley transmission on the at least one of the pulley wheels.

70. The method of claim 55, wherein a pulley transmission to pulley wheel engagement of the pulley wheels of the pulley system is arranged so as to determine rotation of the end

effector through at least 360° rotation of the end effector relative to the at least one movable arm link between wound and unwound positions of the pulley transmission on at least one of the pulley wheels.

71. A substrate transport apparatus comprising:

a support frame;

an articulated arm connected to the support frame and having at least one movable arm link and an end effector, connected to the at least one movable arm link, with a substrate holding station located thereon;

wherein the at least one movable arm link has a modular composite arm link casing that includes at least one extruded arm casing component and a pulley system cased in and extending through the extruded arm casing component substantially end to end of the modular composite arm link casing, the pulley system is mounted and engaged to the modular composite arm link casing, and is arranged so that, powered by a drive section, the pulley system effects articulation of the at least one movable arm link or the end effector relative to the at least one movable arm link, and

wherein the modular composite arm link casing includes link case end modules connected by the at least one extruded arm casing component that is mechanically fastened to each of the link case end modules to form the modular composite arm link casing and arranged so that the modular arm link casing formed matches a misalignment tolerance of a pulley transmission connecting pulley wheels of the pulley system housed in the link case end modules at the ends of the modular composite arm link casing.