CLAIMS

~~What is claimed is:~~

1. An apparatus, comprising:

a shape memory alloy actuator assembly, comprising:

a housing comprising a pair of lateral sides each having a first end and a second end and a transverse section coupling the lateral sides;

a printed circuit board coupled to the first end of the housing;

an end plate coupled to the second end of the housing;

a plurality of shape memory alloy actuators positioned between the printed circuit board and the end plate, each shape memory alloy actuator comprising:

a pair of wire mounts coupled to opposing sides of the printed circuit board;

an actuator rod positioned between the lateral walls of the housing and including a wire guide; and

a shape memory alloy wire coupled to the wire mounts and positioned around the wire guide,

wherein applying a voltage to the shape memory alloy wire retracts the shape memory alloy wire and causes the corresponding actuator rod to move between a first position and a second position.

2. The apparatus of claim 1, further comprising an enclosure surrounding the housing and defining one or more vents positioned to enable air flow across the shape memory alloy wires.

3. The apparatus of claim 2, wherein the vents are elongate openings extending relative to one or more of the shape memory alloy wires.

4. The apparatus of ~~any one of claims 2 and 3~~ claim 2, wherein the enclosure has open sides.

5. The apparatus of claim 1, further comprising an enclosure surrounding the shape memory alloy wires.

6. The apparatus of claim 5, wherein the enclosure has a first enclosure assembly and a second enclosure assembly, each of the first enclosure assembly and the second enclosure assembly has an enclosure body coupled to the housing and an inlet port assembly.

7. The apparatus of claim 6, wherein the inlet port assembly has an inlet port and a diffuser.

8. The apparatus of claim 7, wherein the inlet port assembly further comprises a pressure homogenizer and a nozzle array, the pressure homogenizer positioned between the nozzle array and the diffuser and the diffuser positioned between the pressure homogenizer and the inlet port.

9. The apparatus of claim 8, wherein axes of nozzles of the nozzle array are substantially parallel to an axis of the inlet port.

10. The apparatus of ~~any one of the preceding claims~~ claim 1, further comprising an air flow assembly to flow air or gas across the shape memory alloy wires.

11. The apparatus of claim ~~6~~10, wherein the air flow assembly comprises a fan.

~~12. The apparatus of any one of the preceding claims, wherein the shape memory alloy actuator assembly is a first shape memory alloy actuator assembly, and further comprising a second shape memory alloy actuator assembly opposing the first shape memory alloy actuator assembly.~~

~~13. The apparatus of claim 12, wherein each of the plurality of shape memory alloy actuators of the first shape memory alloy actuator assembly apply a pulling force and each of a plurality of shape memory alloy actuators of the second shape memory alloy actuator assembly apply a pushing force.~~

~~14. The apparatus of claim 13, wherein the pulling force is less than the pushing force.~~

~~15. The apparatus of any one of the preceding claims, further comprising a plurality of biasing elements positioned to bias the actuator rods toward the first position.~~

~~16. The apparatus of any one of the preceding claims, wherein the first position in a closed position of an associated valve.~~

~~17. The apparatus of any one of the preceding claims, wherein the first position in an open position of an associated valve.~~

~~18. The apparatus of any one of claims 15 – 17, wherein the biasing elements are positioned between the printed circuit board and spring seats of the actuator rods.~~

~~19. The apparatus of any one of claims 15 – 18, wherein the biasing elements comprise coil springs.~~

~~20. The apparatus of any one of the preceding claims, wherein the transverse section includes a plurality of lateral guide slots and each actuator rod is positioned in a corresponding lateral guide slot.~~

~~21. The apparatus of claim 20, wherein the lateral guide slots include first lateral guide slots defined on a first side of the transverse section and second lateral guide slots defined on a second side of the transverse section.~~

~~22. The apparatus of claim 21, wherein the first lateral guide slots are staggered relative to the second lateral guide slots.~~

~~23. The apparatus of any one of the preceding claims, wherein each actuator rod includes a plunger portion arranged to actuate an associated valve.~~

~~24. The apparatus of any one of claims 23, wherein the end plate defines a plurality of slots positioned to receive the plunger portions.~~

~~25~~12. An apparatus, comprising:

a system including a flow cell receptacle and a valve drive assembly including a shape memory alloy actuator including a pair of shape memory alloy wires; and

a flow cell disposable within the flow cell receptacle and having a membrane valve,

wherein the system actuates the membrane valve, via the shape memory alloy actuator, by causing a voltage to be applied to a first one of the shape memory alloy wires and the system not applying the voltage to a second one of the shape memory alloy wires.

~~26~~13. The apparatus of claim ~~25~~12, wherein the system comprises a counter that counts a number of instances that the system causes the voltage to be applied to the first one of the shape memory alloy wires and wherein the system causes the voltage to be applied to the second one of the shape memory alloy wires and to not be applied to the first one of the shape memory alloy wires when the number of instances satisfies a reference number.

~~27~~14. The apparatus of ~~any one of claims 25 – 26~~ claim 12, wherein the system tests operability of the first one of the shape memory alloy wires and causes the voltage to be applied to the second one of the shape memory alloy wires and to not be applied to the first one of the shape memory alloy wires when the system identifies the first one of the shape memory alloy wires being inoperable.

~~28. The apparatus of any one of claims 25 – 27, further comprising a fan mounted to the system to cool the shape memory alloy wires and spaced from the shape memory alloy actuator to deter vibration from the fan from being imparted to the shape memory alloy actuator.~~

~~29. The apparatus of claim 28, wherein the fan is operable at a first speed when the flow cell and the associated membrane valve are spaced a first distance from the fan and operable at a second speed when the flow cell and the associated membrane valve are spaced a second distance from the fan.~~

~~30. A method, comprising:~~

~~causing a voltage to be applied to a first one of shape memory alloy wires of a shape memory alloy actuator and not applying the voltage to a second one of the shape memory alloy wires of the shape memory alloy actuator; and~~

~~responsive to applying the voltage to the first one of the shape memory alloy wires, actuating a membrane valve with the shape memory alloy actuator.~~

~~31. The method of claim 30, further comprising counting a number of instances that the voltage is applied to the first one of the shape memory alloy wires and causing the voltage to be~~

applied to the second one of the shape memory alloy wires and to not be applied to the first one of the shape memory alloy wires when the number of instances satisfies a reference number.

32. The method of any one of claims 30 – 31, further comprising testing operability of the first one of the shape memory alloy wires.

33. The method of claim 32, further identifying the first one of the shape memory alloy wires being inoperable and causing the voltage to be applied to the second one of the shape memory alloy wires and to not be applied to the first one of the shape memory alloy wires after identifying the first one of the shape memory alloy wires being inoperable.

34. The method of any one of claims 30 – 33, further comprising cooling the shape memory alloy wires.

35. The method of claim 34, wherein cooling the shape memory alloy wires comprises using a fan.

36. The method of claim 35, further comprising deterring vibrations from the fan from being imparted to the shape memory alloy actuator.

37. An apparatus, comprising:

a system including a valve drive assembly including plurality of shape memory alloy actuators; and

a flow cell assembly comprising a flow cell inlet, a flow cell outlet, a flow cell, and a manifold assembly, the manifold assembly, comprising:

a common fluidic line having a first side and a second side, the flow cell being coupled to the common fluidic line;

a plurality of reagent fluidic lines disposed on the second side of the common fluidic line; and

a plurality of membrane valves selectively fluidically coupling the common fluidic line and a corresponding one of the plurality of reagent fluidic lines,

wherein each shape memory alloy actuator corresponds to one of the membrane valves and is actuatable to selectively control a flow of reagent between each of the reagent fluidic lines and the common fluidic line.

38. The apparatus of claim 37, wherein the membrane valves are volcano valves.

39. The apparatus of any one of claims 37 – 38, wherein each shape memory alloy actuator includes a plunger, a spring that biases the plunger, and a shape memory alloy wire.

40. The apparatus of claim 39, wherein actuating the shape memory alloy actuator comprises the system causing a voltage to be applied to the shape memory alloy wire that retracts the plunger against a force of the spring.

41. The apparatus of any one of claims 38 – 40, wherein each of the shape memory alloy actuators comprise a pair of shape memory alloy wires and wherein actuating the shape memory alloy actuator comprises the system causing a voltage to be applied to a first one of the shape memory alloy wires and the system not applying the voltage to a second one of the shape memory alloy wires.

42. An apparatus, comprising:

a shape-memory alloy actuator comprising:

a guide defining an aperture and including wire mounts;

an actuator rod movable through the aperture and including a plunger at a distal end, a wire guide, and a spring seat;

a spring positioned between the guide and the spring seat; and

a shape memory alloy wire coupled to the wire mounts and positioned around the wire guide,

wherein applying a voltage to the shape memory alloy wire retracts the shape memory alloy wire and causes the actuator rod to move between a first position and a second position.

43. The apparatus of claim 42, wherein the shape memory alloy wire is a first shape memory alloy wire and the actuator rod includes a second wire guide, further comprising a second shape memory alloy wire coupled to the wire mounts and positioned around the second wire guide.

44. The apparatus of claim 43, wherein the voltage is applied to the first shape memory alloy wire to actuate the shape-memory alloy actuator when voltage is not applied to the second shape memory alloy wire.

45. The apparatus of claim 44, further comprising applying a voltage to the second shape memory alloy wire when voltage is not applied to the first shape memory alloy wire.

46. The apparatus of claim 45, wherein the voltage is not applied to the first shape memory alloy wire after a threshold amount of time, after a threshold number of cycles, or if the first shape memory alloy wire is damaged.

47. The apparatus of any one of claims 42 – 46, wherein the shape memory alloy wire is a first shape memory alloy wire, the guide is a first guide, and the actuator rod includes a second wire guide, further comprising a second guide having wire mounts and a second shape memory alloy wire coupled to the wire mounts of the second guide and positioned around the second wire guide.

48. The apparatus of claim 47, wherein applying the voltage to the first shape memory alloy wire retracts the first shape memory alloy wire and causes the actuator rod to move between the first position and the second position and applying a voltage to the second shape memory alloy wire retracts the second shape memory alloy wire and causes the actuator rod to move between the second position and the first position.

49. An apparatus, comprising:

a system, comprising:

a flow cell receptacle; and

a plurality of shape memory alloy actuators.

50. The apparatus of claim 49, wherein the plurality of shape memory alloy actuators comprise a first row of shape memory alloy actuators and a second row of the shape memory alloy actuators, the shape memory alloy actuators of the first row being staggered relative to the shape memory alloy actuators of the second row.

51. The apparatus of any one of claims 49 – 50, wherein the plurality of shape memory alloy actuators comprise first shape memory alloy actuators on a first side of the flow cell receptacle and second shape memory alloy actuators on a second side of the flow cell receptacle.

52. The apparatus of claim 51, wherein the first shape memory alloy actuators oppose the second shape memory alloy actuators.

~~53. The apparatus of any one of claims 49 – 52, wherein the first shape memory alloy actuators apply a pulling force and the second shape memory alloy actuators apply a pushing force.~~

~~54. The apparatus of claim 53, wherein the pulling force is less than the pushing force.~~

~~55. The apparatus of any one of claims 49 – 54, further comprising a fan positioned to flow air toward the plurality of shape memory alloy actuators.~~

~~56~~15. ~~———~~An apparatus, comprising:

a shape memory alloy actuator assembly, comprising:

a housing comprising a pair of lateral sides each having a first end and a second end and a transverse section coupling the lateral sides;

a printed circuit board coupled to the first end of the housing;

a plurality of shape memory alloy actuators positioned between the printed circuit board and the second end, each shape memory alloy actuator comprising:

a pair of wire mounts coupled to opposing sides of the printed circuit board;

an actuator rod positioned between the lateral walls of the housing and including a wire guide, the actuator rod comprising a side port and an end face having a vacuum port and a plunger portion, the side port being fluidically coupled to the vacuum port; and

a shape memory alloy wire coupled to the wire mounts and positioned around the wire guide; and

an actuator manifold assembly coupled to the printed circuit board, the actuator manifold assembly comprising:

a body having an outlet port and a plurality of inlet ports; and

a plurality of pneumatic lines, each pneumatic line coupled between the side port of one of the actuator rods and one of the inlet ports of the actuator manifold assembly;

wherein applying a voltage to the shape memory alloy wire retracts the shape memory alloy wire and causes the corresponding actuator rod to move between a first position and a second position.

~~57. The apparatus of any one of claim 56, wherein each shape memory alloy actuator comprises a sensor or a target carried by the actuator rod and the housing carries the other of the sensor or the target.~~

~~58~~16. The apparatus of ~~any one of claims 56 – 57~~ claim 15, further comprising a flow cell assembly comprising:

a flow cell inlet;

a flow cell outlet;

a flow cell; and

a manifold assembly, the manifold assembly, comprising:

a common fluidic line, the flow cell being coupled to the common fluidic line;

a plurality of reagent fluidic lines; and

a plurality of membrane valves selectively fluidically coupling the common fluidic line and a corresponding one of the plurality of reagent fluidic lines, each membrane valve comprising a body and a membrane coupled to a surface of the body, the body including a valve seat and defining a chamber fluidically coupled to the corresponding reagent fluidic line and covered by a portion of the membrane.

~~59~~17. The apparatus of claim ~~58~~16, wherein opening the membrane valves includes the vacuum port of the corresponding shape memory actuator sealingly engaging~~es~~ the portion of the membrane and moving between the first position and the second position.

~~60. The apparatus of any one of claims 58 – 59, wherein each shape memory alloy actuator comprises a sensor or a target carried by the actuator rod and each membrane valve carries the other of the sensor or the target.~~

~~61. The apparatus of claim 60, wherein responsive to a distance between the sensor and the target being greater than a threshold value, the shape memory alloy actuator causes the actuator rod to move toward the portion of membrane and for the vacuum port of the corresponding shape memory actuator to sealing engage the portion of the membrane.~~

~~62~~18. The apparatus of ~~any one of claims 58 – 61~~ claim 16, wherein the chamber and the portion of the membrane have a width greater than a width of the valve seat.

~~63~~19. The apparatus of ~~any one of claims 58 – 62~~ claim 16, wherein the chamber and the portion of the membrane are squircle shaped.

6420. The apparatus of ~~any one of claims 58 – 63~~ claim 16, wherein the chamber and the portion of the membrane are tear-drop shaped.

~~65. The apparatus of any one of claims 58 – 64, wherein closing the membrane valves includes the plunger portion of the corresponding shape memory actuator moving the membrane from the second position to the first position and urging the membrane into engagement with the valve seat.~~

~~66. The apparatus of any one of claims 56 – 65, wherein the actuator rods comprises a second side port and the end face has a second vacuum port, the plunger portion positioned between the vacuum port and the second vacuum port.~~

~~67. The apparatus of any one of claims 58 – 66, wherein each membrane valve defines a second chamber covered by a second portion of the membrane, the valve seat positioned between the chamber and the second chamber.~~

~~68. The apparatus of claim 67, wherein opening the membrane valves further includes the second vacuum port of the corresponding shape memory actuator sealingly engages the second portion of the membrane and moving between the first position and the second position.~~

~~69. The apparatus of any one of claims 56 – 68, wherein the pneumatic lines of the actuator manifold assembly are coupled between a second side port of the actuator rods and corresponding inlet ports of the actuator manifold assembly.~~

~~70. A method, comprising:~~

~~sealingly engaging a portion of a membrane of a membrane valve with a vacuum port of an actuator rod of a shape memory alloy actuator;~~

~~causing a voltage to be applied to a shape memory alloy wire of the shape memory alloy actuator; and~~

~~responsive to applying the voltage to the shape memory alloy wire, moving the actuator rod and the portion of the membrane between a first position and a second position.~~

~~71. The method of claim 70, further comprising identifying a distance between the actuator rod and a membrane valve being greater than a threshold value and, responsive to the distance between the actuator rod and the membrane valve being greater than the threshold value, causing the actuator rod to move toward the portion of the membrane and for the vacuum port of the shape memory actuator to sealing engage the portion of the membrane.~~

~~72. The method of any one of claims 70 – 71, further comprising closing the membrane valve by moving the portion of the membrane from the second position to the first position using a plunger portion of the actuator rod and urging the portion of the membrane into engagement with a valve seat of the membrane valve.~~