What is claimed is:

1. A system for operating a microfluidic device, the system comprising:

a first surface configured to interface and operatively couple with a microfluidic device; and

a lid configured to retain the microfluidic device on the first surface, the lid comprising:

a first lid portion having a first fluid port configured to operatively couple with and flow fluidic medium into and/or out of a first fluid inlet/outlet of the microfluidic device; and

a second lid portion having a second fluid port configured to operatively couple with and flow fluidic medium into and/or out of a second fluid inlet/outlet of the microfluidic device,

wherein the second lid portion is separable from the first lid portion and movable between a closed position in which the second fluid port of the second lid portion is operatively coupled with the second fluid inlet/outlet of the microfluidic device and an open position in which a portion of the microfluidic device that contains the second fluid inlet/outlet is exposed.

2. The system of claim 1, wherein the first lid portion retains the microfluidic device on the first surface when the second lid portion is in the open position.

3. The system of claim 1, wherein the first fluid port of the first lid portion remains operatively coupled with the first fluid inlet/outlet of the microfluidic device when the second lid portion is in the open position.

4. The system of claim 3, wherein the first fluid port of the first lid portion is connected to a pump configured to remove fluid from the microfluidic device.

5. The system of claim 3, wherein the first lid portion further comprises a first fluid line connected to the first fluid port.

6. The system of claim 5, wherein the second lid portion further comprises a second fluid line connected to the second fluid port.

7. The system of claim 1, wherein the lid further comprises a hinge configured to move the second portion of the cover between the open position and the closed position.

8. The system of claim 1, wherein the lid further comprises a latch configured to releasably hold the second lid portion in the closed position.

9. The system of any one of claims 1 to 8, further comprising an insert configured to operatively couple with and flow fluidic medium into the second fluid inlet/outlet of the microfluidic device when the second lid portion is in the open position.

10. The system of claim 9, wherein the insert is configured to interface with the first lid portion.

11. The system of claim 9, wherein the insert contains a fluid well configured to fluidically communicate with the second fluid inlet/outlet of the microfluidic device.

12. The system of claim 11, wherein the fluid well is configured to hold a fluid sample of about 25 microliters or less.

13. The system of claim 11, wherein the fluid well is configured to hold a fluid sample ranging from about 5 microliters to about 15 microliters.

14. The system of claim 1, wherein the first surface is comprised by a support.

15. The system of claim 14, wherein the support comprises a socket configured to receive and interface with the microfluidic device.

16. The system of claim 1, further comprising an electrical signal generation subsystem configured to apply a biasing voltage across a pair of electrodes in the microfluidic device when the microfluidic device is operatively coupled with the first surface or the support.

17. The system of claim 1, further comprising a thermal control subsystem configured to regulate a temperature of the microfluidic device when the microfluidic device is operatively coupled with the first surface or the support.

18. The system of claim 1, wherein the support further comprises a microprocessor that controls one or both of the electrical signal generation subsystem and the thermoelectric power module.

19. The system of claim 18, wherein the support comprises a printed circuit board (PCB), and wherein at least one of the electrical signal generation subsystem, the thermoelectric power module, and the microprocessor are mounted on and/or integrated with the PCB.

20. The system of claim 1 further comprising a light modulating subsystem configured to emit structured light onto the microfluidic device when the microfluidic device is operatively coupled with the first surface (or support).

21. The system of claim 20, wherein the first surface, the support, and/or the light modulating subsystem is/are configured to be mounted on a light microscope.

22. The system of claim 20, wherein the first surface, the support, and/or said light modulating subsystem are integral components of a light microscope.

23. The system of claim 6, further comprising at least one flow controller operatively coupled with one or both of the first and second fluid lines.

24. The system of claim 23, wherein the at least one flow controller comprises a first thermally-controlled flow controller operatively coupled with the first fluid line and/or the second fluid line, to selectively allow fluid to flow therethrough.

25. A microscope configured for operating a microfluidic device, said microscope comprising:

a support configured to hold and operatively couple with a microfluidic device according to claim 14;

a light modulating subsystem configured to emit structured light; and

an optical train,

wherein when the microfluidic device is held by, and operatively coupled with, the support, the optical train is configured to:

(1) focus structured light emitted by the light modulating subsystem onto at least a first region of the microfluidic device,

(2) focus unstructured light emitted by an unstructured light source onto at least a second region of the microfluidic device, and

(3) capture reflected and/or emitted light from the microfluidic device and direct the captured light to a detector.

26. A method for analyzing a fluid sample, the method comprising:

connecting a microfluidic device to a system for operating the microfluidic device, wherein the system comprises:

a first surface configured to interface and operatively couple with a microfluidic device; and

a lid configured to retain the microfluidic device on the first surface, the lid comprising:

a first lid portion having a first fluid port configured to operatively couple with and flow fluidic medium into and/or out of a first fluid inlet/outlet of the microfluidic device; and

a second lid portion having a second fluid port configured to operatively couple with and flow fluidic medium into and/or out of a second fluid inlet/outlet of the microfluidic device,

wherein the second lid portion is separable from the first lid portion and movable between a closed position in which the second fluid port of the second portion of the cover is operatively coupled with the second fluid inlet/outlet of the microfluidic device and an open position in which a portion of the microfluidic device that contains the second fluid inlet/outlet is exposed;

moving the second lid portion from the closed position to the open position, thereby exposing the second fluid inlet/outlet of the microfluidic device;

providing a fluid sample in fluidic communication with the second fluid inlet/outlet of the microfluidic device;

applying suction to the first fluid line, thereby pulling at least a portion of the fluid sample into the microfluidic device; and

processing the at least a portion of the fluid sample that is pulled into the microfluidic device.

27. The method of claim 26, further comprising:

placing an insert in the location previously occupied by the second lid portion in the closed position, the insert containing a fluid well configured to fluidically communicate with the second fluid inlet/outlet of the microfluidic device;

wherein providing the fluid sample comprises introducing the fluid sample into the fluid well of the insert.

28. The method of claim 26 or 27, wherein the system is the system of claim 1.

29. The method of claim 26 or 27, wherein the system is the microscope of claim 25.

30. The method of claim 26 or 27, wherein suction is applied sufficient to pull a preselected volume of about 2 microliters to about 10 microliters of fluid sample into the microfluidic chip, at which point the suction is stopped.

31. The method of claim 26 or 27, wherein the fluid sample comprises micro-objects, optionally biological micro-objects.

32. The method of claim 26 or 27, wherein the microfluidic device comprises (i) a flow region having a plurality of microfluidic channels, and (ii) a plurality of chambers, wherein each chamber of the plurality is fluidically connected to one of the plurality of microfluidic channels.

33. The method of claim 32, wherein the method results in an imported cell density of at least 4x10^6.

34. The method of claim 32, wherein the method results in a coefficient of variation, CV, of the imported cell density in the different channels of less than 20%.

35. A system for operating a microfluidic device, said system comprising:

a support configured to hold and operatively couple with the microfluidic device;

a first fluid line having a distal end configured to be fluidically coupled to an inlet port of the microfluidic device, and a second fluid line having a proximal end configured to be fluidically coupled to an outlet port of the microfluidic device, respectively, when the microfluidic device is held by, and operatively coupled with, said support;

at least one (e.g., two or more, one of which can be a pump) flow controller operatively coupled with one or both of the first and second fluid lines, the at least one flow controller comprising a first thermally-controlled flow controller operatively coupled with a flow segment of one or both of said first fluid line and said second fluid line to selectively allow fluid to flow therethrough; and

a light modulating subsystem configured to emit structured light onto the microfluidic device when the microfluidic device is held by, and operatively coupled with, the support.

36. The system of claim 35, further comprising an electrical signal generation subsystem configured to apply a biasing voltage across a pair of electrodes in the microfluidic device when microfludic device is held by, and operatively coupled with, the support.

37. The system of claim 35, wherein the system comprises any of the elements of the system of claim 1.

38. The system of claim 35, wherein said first thermally-controlled flow controller further comprises:

a thermally conductive interface coupled with the flow segment of the first and second fluid lines; and

a Peltier thermoelectric device configured to contact the thermally conductive interface and controllably lower or raise a temperature of fluid contained in the flow segment of the first and/or second fluid lines.

39. The system of claim 38, wherein the temperature is lowered or raised sufficiently to freeze or thaw, respectively, the fluid contained in the flow segment of the first and/or second fluid line, and thereby selectively prevent or allow fluid to flow out of or into the first and/or second fluid inlet/outlet of the microfluidic device.

40. The system of claim 38 or 39, wherein the thermally conductive interface comprises a thermistor.

41. The system of claim 40, wherein the thermistor is positioned in a region located between the flow segments of the first and second fluid lines.

42. The system of claim 38, wherein the thermally conductive interface is located between at least two Peltier thermoelectric devices.

43. The system of claim 42, wherein the first thermally-controlled flow controller further comprises a conduit to conduct heat away from one of the at least two Peltier thermoelectric devices.

44. The system of claim 38, wherein the first thermally-controlled flow controller further comprises a heat sink.

45. The system of claim 38, wherein the thermally conductive interface is configured to directly contact an upper surface of the Peltier thermoelectric device.

46. The system of claim 38, wherein the first thermally-controlled flow controller comprises a cover containing guides for the flow segments of the first and second fluid lines to be inserted into the thermally conductive interface.

47. The system of claim 38, further comprising a barrier material located internal to the thermally-controlled flow controller, wherein the barrier material is sufficient to prevent ice formation.

48. The system of claim 47, wherein the barrier material substantially fills any empty space which would otherwise be present within the cover of the first thermally-controlled flow controller.

49. The system of claim 38, wherein the first thermally-controlled flow controller is configured to control fluid flow both into and out of a microfluidic device.

50. The system of claim 9, wherein the support contains a sensor configured to determine when the second lid portion is in the closed position.

51. The system of claim 50, wherein the sensor is further configured to determine when the insert interfaces with the microfluidic device.

52. The system of claim 50, wherein the sensor comprises a first optical switch configured to be interrupted and indicate when the second lid portion is in the closed position.

53. The system of claim 50, wherein the sensor comprises a second optical switch configured to be interrupted and indicate when the insert interfaces with the microfluidic device.

54. The system of claim 50, wherein the sensor contains a first extender configured to be extended into and thereby interrupt the first optical switch by a first actuator contained in the second lid portion.

55. The system of claim 50, wherein the sensor contains a second extender configured to be extended into and thereby interrupt the second optical switch by a second actuator contained in the insert.

56. The system of claim 50, wherein the sensor detects when the second lid portion is in the open position and the insert does not interface with the microfluidic device when the optical path of the first and second optical switches are not interrupted.

Claims

1. A system for operating a microfluidic device, the system comprising:

a first surface configured to operatively couple with a microfluidic device; and

a lid configured to retain the microfluidic device on the first surface, the lid comprising:

a first lid portion having a first fluid port configured to flow fluidic medium into and/or out of a first fluid inlet/outlet of the microfluidic device; and

a second lid portion having a second fluid port configured to flow fluidic medium into and/or out of a second fluid inlet/outlet of the microfluidic device,

wherein the second lid portion is separable from the first lid portion and movable between a closed position in which the second fluid port of the second lid portion is operatively coupled with the second fluid inlet/outlet of the microfluidic device and an open position in which a portion of the microfluidic device that contains the second fluid inlet/outlet is exposed.

2. The system of claim 1, wherein the first lid portion retains the microfluidic device on the first surface when the second lid portion is in the open position.

3. The system of claim 1, wherein the first fluid port of the first lid portion remains operatively coupled with the first fluid inlet/outlet of the microfluidic device when the second lid portion is in the open position.

4. The system of claim 3, wherein the first fluid port of the first lid portion is connected to a pump configured to remove fluid from the microfluidic device.

5. The system of claim 3, wherein the first lid portion further comprises a first fluid line connected to the first fluid port and wherein the second lid portion further comprises a second fluid line connected to the second fluid port.

6. The system of claim 1, wherein the lid further comprises a hinge configured to move the second lid portion between the open position and the closed position.

7. The system of claim 1, wherein the lid further comprises a latch configured to releasably hold the second lid portion in the closed position.

8. The system of claim 1, further comprising an insert configured to flow fluidic medium into the second fluid inlet/outlet of the microfluidic device when the second lid portion is in the open position.

9. The system of claim 8, wherein the insert is configured to interface with the first lid portion.

10. The system of claim 8, wherein the insert contains a fluid well configured to fluidically communicate with the second fluid inlet/outlet of the microfluidic device.

11. The system of claim 10, wherein the fluid well is configured to hold a fluid sample of about 25 microliters or less.

12. The system of claim 1, wherein the first surface comprises a support containing a socket configured to receive and interface with the microfluidic device.

13. The system of claim 12, further comprising an electrical signal generation subsystem configured to apply a biasing voltage across a pair of electrodes in the microfluidic device when the microfluidic device is operatively coupled with the support.

14. The system of claim 12, further comprising a thermal control subsystem configured to regulate a temperature of the microfluidic device when the microfluidic device is operatively coupled with the support.

15. The system of claim 12, further comprising a light modulating subsystem configured to emit structured light onto the microfluidic device when the microfluidic device is operatively coupled with the support.

16. The system of claim 15, wherein the first surface, the support, and/or the light modulating subsystem is/are configured to be mounted on a light microscope.

17. The system of claim 15, wherein the first surface, the support, and/or said light modulating subsystem are integral components of a light microscope.

18. The system of claim 5, further comprising at least one flow controller operatively coupled with one or both of the first and second fluid lines.

19. The system of claim 18, wherein the at least one flow controller comprises a first thermally-controlled flow controller operatively coupled with the first fluid line and/or the second fluid line, to selectively allow fluid to flow therethrough.

20. A microscope configured for operating a microfluidic device, said microscope comprising:

the support according to claim 12;

a light modulating subsystem configured to emit structured light; and

an optical train,

wherein when the microfluidic device is held by, and operatively coupled with, the support, the optical train is configured to:

(1) focus structured light emitted by the light modulating subsystem onto at least a first region of the microfluidic device,

(2) focus unstructured light emitted by an unstructured light source onto at least a second region of the microfluidic device, and

(3) capture reflected and/or emitted light from the microfluidic device and direct the captured light to a detector.

21. A method for analyzing a fluid sample, the method comprising:

connecting a microfluidic device to a system for operating the microfluidic device, wherein the system comprises:

a first surface configured to operatively couple with a microfluidic device; and

a lid configured to retain the microfluidic device on the first surface, the lid comprising:

a first lid portion having a first fluid port configured to flow fluidic medium into and/or out of a first fluid inlet/outlet of the microfluidic device; and

a second lid portion having a second fluid port configured to flow fluidic medium into and/or out of a second fluid inlet/outlet of the microfluidic device,

wherein the second lid portion is separable from the first lid portion and movable between a closed position in which the second fluid port of the second portion of the cover is operatively coupled with the second fluid inlet/outlet of the microfluidic device and an open position in which a portion of the microfluidic device that contains the second fluid inlet/outlet is exposed;

moving the second lid portion from the closed position to the open position, thereby exposing the second fluid inlet/outlet of the microfluidic device;

providing a fluid sample containing biological micro-objects in fluidic communication with the second fluid inlet/outlet of the microfluidic device;

applying suction to the first fluid line, thereby pulling at least a portion of the fluid sample into the microfluidic device; and

processing biological micro-objects in the at least a portion of the fluid sample that is pulled into the microfluidic device.

22. The method of claim 21, further comprising:

placing an insert in the location previously occupied by the second lid portion in the closed position, the insert containing a fluid well configured to fluidically communicate with the second fluid inlet/outlet of the microfluidic device;

wherein providing the fluid sample comprises introducing the fluid sample into the fluid well of the insert.

23. The method of claim 21, wherein the system comprises the microscope of claim 20.

24. The method of claim 21, wherein the suction is applied sufficient to pull a volume of about 2 microliters to about 10 microliters of the fluid sample into the microfluidic device.

25. The method of claim 21, wherein the microfluidic device comprises a flow region having a plurality of microfluidic channels and wherein the method results in an imported biological micro-object density of at least about 4x10^6 in the plurality of microfluidic channels.

26. The method of claim 25, wherein the method results in a coefficient of variation, CV, of the imported biological micro-object density in the plurality of microfluidic channels of less than about 20%.