CLAIMS

1. A system for operating an electrokinetic device, said system comprising:

a support configured to hold and operatively couple with an electrokinetic device, wherein said support comprises;

a socket configured to receive and interface with said electrokinetic device;

an electrical signal generation subsystem configured to apply a biasing voltage across a pair of electrodes in said electrokinetic device when said electrokinetic device is held by, and operatively coupled with, said support;

a light modulating subsystem configured to emit structured light onto said electrokinetic device when said electrokinetic device is held by, and operatively coupled with, said support; and

a thermal control subsystem configured to regulate a temperature of said electrokinetic device when said electrokinetic device is held by, and operatively coupled with, said support, wherein said thermal control subsystem comprises a thermoelectric power module, a Peltier thermoelectric device, and a cooling unit, wherein said thermoelectric power module is configured to regulate a temperature of said Peltier thermoelectric device, and wherein said Peltier thermoelectric device is interposed between a surface of said electrokinetic device and a surface of said cooling unit.

2. The system of claim 1, wherein said Peltier thermoelectric device and said thermoelectric power module are mounted on and/or integrated with said support.

3. The system of claim 1 or 2 wherein said support further comprises a microprocessor that controls one or both of said electrical signal generation subsystem and said thermal control subsystem.

4. The system of claim 3, wherein said support comprises a printed circuit board (PCB), and wherein at least one of said electrical signal generation subsystem, said thermoelectric power module, and said microprocessor are mounted on and/or integrated with said PCB.

5. The system of claim 3 or 4, further comprising an external computational device operatively coupled with said microprocessor, wherein said external computational device comprises a graphical user interface configured to receive operator input and for processing and transmitting said operator input to said microprocessor for controlling one or both of said electrical signal generation subsystem and said thermal control subsystem.

6. The system of claim 5, wherein the microprocessor is configured to transmit to said external computational device data and/or information sensed or received, or otherwise calculated based upon

data or information sensed or received, from one or both of said electrical signal generation subsystem and said thermal control subsystem.

7. The system of claim 5 or 6, wherein said microprocessor and/or said external computational device are configured to measure and/or monitor an impedance of an electrical circuit across said electrodes of said electrokinetic device when said electrokinetic device is held by, and operatively coupled with, said support.

8. The system of claim 7, wherein said microprocessor and/or said external computational device are configured to:

determine a flow volume of a fluid path based upon a detected change in the measured and/or monitored impedance of said electrical circuit, said fluid path comprising at least part of a microfluidic circuit within said electrokinetic device;

determine a height of an interior microfluidic chamber of said electrokinetic device based upon a detected change in the measured and/or monitored impedance of said electrical circuit; or

determine one or more characteristics of chemical and/or biological material contained within the microfluidic circuit of said electrokinetic device based upon a detected change in the measured and/or monitored impedance of said electrical circuit.

9. The system of any of claims 1 to 8, wherein said support and/or said light modulating subsystem are configured to be mounted on a light microscope.

10. The system of any of claims 1 to 8, wherein said support and/or said light modulating subsystem are integral components of a light microscope.

11. The system of any of claims 1 to 10, wherein said electrokinetic device is an optically actuated electrokinetic device.

12. The system of any of claims 1 to 11, further comprising a first fluid line having a distal end configured to be fluidically coupled to an inlet port of said electrokinetic device, and a second fluid line having a proximal end configured to be fluidically coupled to an outlet port of said electrokinetic device, respectively, when said electrokinetic device is held by, and operatively coupled with, said support.

13. The system of claim 12, further comprising at least one flow controller operatively coupled with one or both of said first and second fluid lines wherein said at least one flow controller comprises

a first thermally-controlled flow controller operatively coupled with one of said first fluid line and said second fluid line to selectively allow fluid to flow therethrough.

14. The system of claim 13, wherein said first thermally-controlled flow controller comprises a first thermally conductive interface thermally coupled with a flow segment of the first fluid line, and at least one flow control Peltier thermoelectric device configured to controllably lower or raise a temperature of the first thermally conductive interface sufficiently to controllably freeze or thaw fluid contained in the flow segment of the first fluid line and thereby selectively prevent or allow fluid to flow through into or out of the inlet port of said electrokinetic device through the first fluid line.

15. The system of claim 14, wherein said first thermally-controlled flow controller further comprises:

a first housing having a first passageway through which the flow segment of the first fluid line extends, said housing further containing said first thermally conductive interface and the at least one flow control Peltier thermoelectric device; and/or

insulating material at least partially surrounding the flow segment of the first fluid line proximate the first thermally conductive interface.

16. The system of any of claims 13 to 15, wherein said at least one flow controller comprises a second thermally-controlled flow controller operatively coupled with the other one of said first fluid line and said second fluid line to selectively allow fluid to flow therethrough.

17. The system of claim 12, further comprising at least one flow controller operatively coupled with one or both of said first and second fluid lines, wherein said at least one flow controller comprises a thermally-controlled flow controller operatively coupled with said first and second fluid lines, said thermally-controlled flow controller comprising:

a thermally conductive interface having a first portion thermally coupled with a flow segment of the first fluid line, and a second portion thermally coupled with a flow segment of the second fluid line, and

at least one flow-control Peltier thermoelectric device configured to controllably lower or raise a temperature of the thermally conductive interface sufficiently to controllably freeze or thaw fluid contained in the respective flow segments of the first and second fluid lines and thereby selectively prevent or allow fluid to flow through the first fluid line into the inlet port of said electrokinetic device, or from the outlet port of said electrokinetic device through the outflow fluid line.

18. The system of claim 17, wherein said at least one flow-control Peltier thermoelectric device comprises at least a first flow-control Peltier thermoelectric device thermally coupled to the first portion of the thermally conductive interface proximate the flow segment of the first fluid line, and a second flow-control Peltier thermoelectric device thermally coupled to the second portion of the thermally conductive interface proximate the flow segment of the second fluid line.

19. The system of claim 17 or 18, the thermally-controlled flow controller further comprising a housing having a first passageway through which the flow segment of the first fluid line extends, and a second passageway through which the flow segment of the outflow fluid line extends, wherein the housing defines a thermally insulating chamber in which the thermally conductive interface is mounted.

20. The system of any of claims 1 to 19, wherein said light modulating subsystem comprises a digital mirror device (DMD) or a liquid crystal display (LCD).

21. The system of any of claims 1 to 20, wherein said light modulating subsystem includes a multi-input light pipe, said light pipe comprising:

a housing having a plurality of input apertures, each input aperture configured to receive light emitted from a respective light source, the housing further having an output aperture configured to emit light received through the input apertures;

a first light propagation pathway extending within the housing from a first input aperture to the output aperture;

a first dichroic filter positioned within the housing at an oblique angle across the first light propagation pathway, the first dichroic filter configured and positioned so that light received through the first light aperture passes through the first dichroic filter as it propagates along the first light propagation pathway to the output aperture; and

a second light propagation pathway extending within the housing from a second input aperture to the first dichroic filter, the second propagation pathway and first dichroic filter configured and dimensioned so that light received through the second input aperture propagates along the second light propagation pathway and is reflected onto the first light propagation pathway to the output aperture by the first dichroic filter,

wherein the respective input apertures, first and second light propagation pathways, first dichroic filter, and output aperture are sized, dimensioned and configured such that light emitted by at least one light source and received through at least one of the first and second input apertures is emitted at substantially uniform intensity out the output aperture.

22. The system of any one of claims 1 to 21, wherein said electrical signal generation subsystem further comprises:

a waveform amplification circuit configured to amplify the biasing voltage waveform generated by said waveform generator; and

an oscilloscope configured to measure the biasing voltage waveform, wherein data from said measurement is provided as feedback to said waveform generator.

23. A system for operating an electrokinetic device, said system comprising:

a support configured to hold and operatively couple with an electrokinetic device, wherein said support comprises;

a socket configured to receive and interface with said electrokinetic device; and

an electrical signal generation subsystem configured to apply a biasing voltage across a pair of electrodes in said electrokinetic device when said electrokinetic device is held by, and operatively coupled with, said support; and

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

wherein said support and/or said light modulating subsystem are integral components of a light microscope.

24. The system of claim 23, wherein said electrical signal generation subsystem comprises a waveform generator configured to generate a biasing voltage waveform to be applied across said electrode pair when said electrokinetic device is held by, and operatively coupled with, said support.

25. The system of claim 24, wherein said electrical signal generation subsystem further comprises:

a waveform amplification circuit configured to amplify the biasing voltage waveform generated by said waveform generator; and

an oscilloscope configured to measure the biasing voltage waveform, wherein data from said measurement is provided as feedback to said waveform generator.

26. The system of any of claims 23 to 25, further comprising a thermal control subsystem configured to regulate a temperature of said electrokinetic device when said electrokinetic device is held by, and operatively coupled with, said support.

27. The system of claim 26, said thermal control subsystem comprises a thermoelectric power module, a Peltier thermoelectric device, and a cooling unit, wherein said thermoelectric power module

is configured to regulate a temperature of said Peltier thermoelectric device, and wherein said Peltier thermoelectric device is interposed between a surface of said electrokinetic device and a surface of said cooling unit.

28. The system of claim 27, wherein said Peltier thermoelectric device and said thermoelectric power module are mounted on and/or integrated with said support.

29. The system of any of claims 26 to 28, wherein said support further comprises a microprocessor that controls one or both of said electrical signal generation subsystem and said thermal control subsystem.

30. The system of claim 29, wherein said support comprises a printed circuit board (PCB), and wherein at least one of said electrical signal generation subsystem, said thermoelectric power module, and said microprocessor are mounted on and/or integrated with said PCB.

31. The system of claim 29 or 30, further comprising an external computational device operatively coupled with said microprocessor, wherein said external computational device comprises a graphical user interface configured to receive operator input and for processing and transmitting said operator input to said microprocessor for controlling one or both of said electrical signal generation subsystem and said thermal control subsystem.

32. The system of claim 31, wherein the microprocessor is configured to transmit to said external computational device data and/or information sensed or received, or otherwise calculated based upon data or information sensed or received, from one or both of said electrical signal generation subsystem and said thermal control subsystem.

33. The system of claim 31 or 32, wherein said microprocessor and/or said external computational device are configured to measure and/or monitor an impedance of an electrical circuit across said electrodes of said electrokinetic device when said electrokinetic device is held by, and operatively coupled with, said support.

34. The system of claim 33, wherein said microprocessor and/or said external computational device are configured to:

determine a flow volume of a fluid path based upon a detected change in the measured and/or monitored impedance of said electrical circuit, said fluid path comprising at least part of a microfluidic circuit within said electrokinetic device;

determine a height of an interior microfluidic chamber of said electrokinetic device based upon a detected change in the measured and/or monitored impedance of said electrical circuit; or

determine one or more characteristics of chemical and/or biological material contained within the microfluidic circuit of said electrokinetic device based upon a detected change in the measured and/or monitored impedance of said electrical circuit.

35. The system of any of claims 23 to 34, wherein said electrokinetic device is an optically actuated electrokinetic device.

36. The system of any of claims 23 to 35, further comprising a first fluid line having a distal end configured to be fluidically coupled to an inlet port of said electrokinetic device, and a second fluid line having a proximal end configured to be fluidically coupled to an outlet port of said electrokinetic device, respectively, when said electrokinetic device is held by, and operatively coupled with, said support.

37. The system of claim 36, further comprising at least one flow controller operatively coupled with one or both of said first and second fluid lines, wherein said at least one flow controller comprises a first thermally-controlled flow controller operatively coupled with one of said first fluid line and said second fluid line to selectively allow fluid to flow therethrough.

38. The system of claim 37, wherein said first thermally-controlled flow controller comprises a first thermally conductive interface thermally coupled with a flow segment of the first fluid line, and at least one flow control Peltier thermoelectric device configured to controllably lower or raise a temperature of the first thermally conductive interface sufficiently to controllably freeze or thaw fluid contained in the flow segment of the first fluid line and thereby selectively prevent or allow fluid to flow through into or out of the inlet port of said electrokinetic device through the first fluid line.

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

a first housing having a first passageway through which the flow segment of the first fluid line extends, said housing further containing said first thermally conductive interface and the at least one flow control Peltier thermoelectric device; and/or

insulating material at least partially surrounding the flow segment of the first fluid line proximate the first thermally conductive interface.

40. The system of any of claims 37 to 39, wherein said at least one flow controller comprises a second thermally-controlled flow controller operatively coupled with the other one of said first fluid line and said second fluid line to selectively allow fluid to flow therethrough.

41. The system of claim 36, further comprising at least one flow controller operatively couples with one or both of said first and second fluid lines, wherein said at least one flow controller comprises a thermally-controlled flow controller operatively coupled with said first and second fluid lines, said thermally-controlled flow controller comprising:

a thermally conductive interface having a first portion thermally coupled with a flow segment of the first fluid line, and a second portion thermally coupled with a flow segment of the second fluid line, and

at least one flow-control Peltier thermoelectric device configured to controllably lower or raise a temperature of the thermally conductive interface sufficiently to controllably freeze or thaw fluid contained in the respective flow segments of the first and second fluid lines and thereby selectively prevent or allow fluid to flow through the first fluid line into the inlet port of said electrokinetic device, or from the outlet port of said electrokinetic device through the outflow fluid line.

42. The system of claim 41, wherein said at least one flow-control Peltier thermoelectric device comprises at least a first flow-control Peltier thermoelectric device thermally coupled to the first portion of the thermally conductive interface proximate the flow segment of the first fluid line, and a second flow-control Peltier thermoelectric device thermally coupled to the second portion of the thermally conductive interface proximate the flow segment of the second fluid line.

43. The system of claim 41 or 42, the thermally-controlled flow controller further comprising a housing having a first passageway through which the flow segment of the first fluid line extends, and a second passageway through which the flow segment of the outflow fluid line extends, wherein the housing defines a thermally insulating chamber in which the thermally conductive interface is mounted.

44. The system of any of claims 23 to 43, wherein said light modulating subsystem comprises a digital mirror device (DMD) or a liquid crystal display (LCD).

45. The system of any of claims 23 to 44, wherein said light modulating subsystem includes a multi-input light pipe, said light pipe comprising:

a housing having a plurality of input apertures, each input aperture configured to receive light emitted from a respective light source, the housing further having an output aperture configured to emit light received through the input apertures;

a first light propagation pathway extending within the housing from a first input aperture to the output aperture;

a first dichroic filter positioned within the housing at an oblique angle across the first light propagation pathway, the first dichroic filter configured and positioned so that light received through the first light aperture passes through the first dichroic filter as it propagates along the first light propagation pathway to the output aperture; and

a second light propagation pathway extending within the housing from a second input aperture to the first dichroic filter, the second propagation pathway and first dichroic filter configured and dimensioned so that light received through the second input aperture propagates along the second light propagation pathway and is reflected onto the first light propagation pathway to the output aperture by the first dichroic filter,

wherein the respective input apertures, first and second light propagation pathways, first dichroic filter, and output aperture are sized, dimensioned and configured such that light emitted by at least one light source and received through at least one of the first and second input apertures is emitted at substantially uniform intensity out the output aperture.