CLAIMS

1. A microfluidic apparatus comprising:

a circuit substrate comprising a surface and dielectrophoresis (DEP) electrodes at different locations on said surface;

a chamber configured to contain a liquid medium disposed on said surface of said circuit substrate;

a first electrode disposed to be in electrical contact with said medium;

a second electrode disposed to be electrically insulated from said medium;

switch mechanisms each disposed between a different corresponding one of said DEP electrodes and said second electrode, wherein each said switch mechanism is switchable between an off state in which said corresponding DEP electrode is deactivated and an on state in which said corresponding DEP electrode is activated; and

photosensitive elements each configured to provide an output signal for controlling a different corresponding one of said switch mechanisms in accordance with a beam of light directed onto said photosensitive element.

2. The apparatus of claim **1**, wherein each said DEP electrode comprises an electrically conductive terminal disposed on said surface of said circuit substrate to be in electrical contact with said medium in said chamber.

3. The apparatus of claim **1**, wherein:

while any one of said switch mechanisms is in said off state, there is a high electrical impedance between said corresponding DEP electrode and said second electrode that is greater than an electrical impedance of said medium in said chamber, and

in said on state, said any one of said switch mechanism provides a low electrical impedance between said corresponding DEP electrode and said second electrode that is less than said electrical impedance of said medium.

4. The apparatus of claim **3**, wherein said high electrical impedance is at least two times greater than said low electrical impedance.

5. The apparatus of claim **1**, wherein said circuit substrate comprises a semiconductor material in which circuit elements are formed.

6. The apparatus of claim **5**, wherein said circuit elements include complimentary metal-oxide semiconductor (CMOS), bipolar, or a combination of CMOS and bipolar circuit elements.

7. The apparatus of claim **5**, wherein:

each said switch mechanism comprises a switch and an amplifier in series that connect said corresponding DEP electrode to said second electrode, and

said circuit elements comprise said switch and said amplifier.

8. The apparatus of claim **5**, wherein:

each said switch mechanism comprises a transistor connecting said corresponding DEP electrode to said second electrode, and

said circuit elements comprise said transistor.

9. The apparatus of claim **8**, wherein said transistor is a field effect transistor or a bipolar transistor.

10. The apparatus of claim **8**, wherein:

each said photosensitive element comprises a photodiode, and

said circuit elements comprise said photodiode.

11. The apparatus of claim **1** further comprising control circuits each connecting a corresponding one of said photosensitive elements to a corresponding one of said switch mechanisms, wherein each said control circuit is configured to control whether said corresponding switch mechanism is in said off state or said on state in accordance with said output signal from said corresponding one of said photosensitive elements.

12. The apparatus of claim **1** further comprising an alternating current (AC) power source connected to said first electrode.

13. The apparatus of claim **12** further comprising:

a third electrode disposed to be electrically insulated from said second electrode and said medium in said chamber, and

an additional AC power source connected to said third electrode,

wherein each said switch mechanism is switchable between connecting said corresponding DEP electrode to said second electrode or to said third electrode.

14. The apparatus of claim **13**, wherein:

in said off state, each said switch mechanism connects said corresponding DEP electrode to said second electrode but not to said third electrode, and

in said on state, each said switch mechanism connects said corresponding DEP electrode to said third electrode but not to said second electrode.

15. The apparatus of claim **14**, wherein said additional AC power source is approximately one hundred eighty degrees out of phase with respect to said AC power source.

16. The apparatus of claim **1** further comprising indicator elements each configured to indicate whether a corresponding one of said switch mechanisms in said on state or said off state.

17. A process of controlling a microfluidic device comprising a circuit substrate and a chamber containing a liquid medium disposed on an inner surface of said circuit substrate, said process comprising:

applying alternating current (AC) power to a first electrode and a second electrode of said microfluidic device, wherein said first electrode is in electrical contact with said medium and said second electrode is electrically insulated from said medium; and

activating a dielectrophoresis (DEP) electrode on said inner surface of said circuit substrate, wherein said DEP electrode is one of a plurality of DEP electrodes on said inner surface that are in electrical contact with said medium, said activating comprising:

directing a light beam onto a photosensitive element in said circuit substrate,

providing, in response to said light beam, an output signal from said photosensitive element, and

switching, in response to said output signal, a switch mechanism in said circuit substrate from an off state in which said DEP electrode is deactivated to an on state in which said DEP electrode is activated.

18. The process of claim **17** further comprising:

removing said light beam from said photosensitive element; and

after said removing said light beam, maintaining said switch mechanism in said on state with control circuitry in said circuit substrate that connects said photosensitive element to said switch mechanism.

19. The process of claim **18**, wherein said maintaining comprises maintaining said switch mechanism in said on state until said light beam is again directed onto said photosensitive element.

20. The process of claim **17**, wherein:

said activating further comprises determining whether said output signal indicates that said light beam has a particular characteristic, and

said switching comprises switching said switch mechanism from said off state to said on state only if said output signal indicates that said light beam has said particular characteristic.

21. The process of claim **20** further comprising deactivating said DEP electrode, said deactivating comprising:

directing a second light beam onto said photosensitive element,

providing, in response to said second light beam, a second output signal from said photosensitive element, and

switching said switch mechanism from said on state to said off state only if said second output signal indicates that said second light beam has a second particular characteristic.

22. The process of claim **17**, wherein:

said directing comprises directing said light beam as a pulse onto said photosensitive element, and

thereafter toggling said switch mechanism between said on state and said off state in response to each subsequent pulse of said light beam directed onto said photosensitive element.

23. The process of claim **17**, wherein:

said switch mechanism comprises a transistor, and

said switching said switch mechanism comprises switching said transistor from an off state to an on state.

24. The process of claim **17**, wherein said switching changes an electrical impedance between said DEP electrode and said second electrode from a high impedance that is greater than an impedance of said medium in said chamber to

a low impedance that is less than said impedance of said medium.

25. The process of claim **24**, wherein said high impedance is at least two times greater than said low impedance.

26. The process of claim **17** further comprising applying a second AC power to said third electrode of said microfluidic device, wherein said third electrode is electrically insulated from said medium and said first electrode.

27. The process of claim **26**, wherein said switching comprises switching said switch mechanism from said off state in which said switch mechanism connects said DEP electrode to said second electrode but not to said third electrode to said on state in which said switch mechanism connects said DEP electrode to said third electrode but not to said second electrode.

28. The process of claim **27**, wherein said applying said second AC power comprises applying said second AC power to said third electrode substantially one-hundred and eighty degrees out of phase from said AC power applied to said second electrode.

29. A microfluidic apparatus comprising:

a circuit substrate;

a chamber configured to contain a liquid medium disposed on an inner surface of said circuit substrate; and

means for activating a dielectrophoresis (DEP) electrode at a first region of said inner surface of said circuit substrate in response to a beam of light directed onto a second region of said inner surface, wherein said second region is spaced apart from said first region.

30. The apparatus of claim **29**, wherein:

said circuit substrate comprises a semiconductor material, and

said means for activating comprises circuit elements formed in layers of said circuit substrate.

31. The apparatus of claim **30**, wherein said circuit elements include complimentary metal-oxide semiconductor (CMOS), bipolar, or a combination of CMOS and bipolar circuit elements.

32. The apparatus of claim **29**, wherein said means for activating is further for:

activating said DEP electrode in response to said beam of light having a first characteristic, and

deactivating said DEP electrode in response to said beam of light having a second characteristic.

33. The apparatus of claim **32**, wherein:

said first characteristic comprises said beam of light being a first color, and

said second characteristic comprises said beam of light being a second color that is different than said first color.

34. The apparatus of claim **32**, wherein:

said first characteristic comprises said beam of light having an intensity between a first threshold and a second threshold, and

said second characteristic comprises said beam of light having an intensity greater than said second threshold.

35. The apparatus of claim **29**, wherein said means for activating is further for activating said DEP electrode in response to a sequence of n pulses of said beam of light having a first characteristic.

36. The apparatus of claim **35**, wherein said means for activating is still further for deactivating said DEP electrode in response to a sequence of k pulses of said beam of light having a second characteristic.