Claims:

1. A microfluidic device, comprising:

a circuit substrate made of a semiconductor material in which circuit elements can be formed, the circuit substrate comprising a surface;

a chamber defined in part by said circuit substrate surface, wherein said chamber is configured to contain a fluidic medium;

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

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

dielectrophoresis (DEP) electrodes at different locations on or proximate to said circuit substrate surface, each disposed to be in electrical contact with said fluidic 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 electrically isolated from said second electrode and an ON state in which said corresponding DEP electrode is electrically connected with said second electrode;

photosensitive elements; and

control circuits, each operatively connected with a corresponding one of said photosensitive elements and a corresponding one or more of said switch mechanisms, wherein each said corresponding photosensitive element is configured to generate an output signal in response to a modulated light beam directed onto said photosensitive element, wherein the output signal comprises a succession of instructions for controlling said corresponding one or more said switch mechanisms for each time interval of a succession of time intervals, and each said control circuit comprises or is associated with a memory configured to at least temporarily store said succession of instructions of the output signal from said corresponding one of said photosensitive elements, and

wherein each said control circuit is configured to control whether each said one or more corresponding switch mechanisms is in said OFF state or said ON state for each time interval of the succession of time intervals based on the stored succession of instructions of the output signal.

2. The microfluidic device of claim 1, wherein said switch mechanisms comprise CMOS transistors connecting said corresponding DEP electrodes to said second electrode and/or said photosensitive elements comprise photodiodes.

3. The microfluidic device of claim 1, further comprising one or more electrically conductive leads in the circuit substrate, wherein each control circuit is operatively coupled with at least one of the one or more electrically conductive leads.

4. The microfluidic device of any one of claims 1-3, wherein each said control circuit is configured to receive a system clock/timing signal.

5. The microfluidic device of claim 4, wherein the respective modulated light beams and output signals generated by said photosensitive elements are synchronized with the system clock/timing signal.

6. The microfluidic device of any one of claims 1-5, wherein each said control circuit is configured to receive an initialization pulse/signal in response to which said control circuit initiates storing in said memory the succession of instructions of the output signal generated by said corresponding one of said photosensitive elements.

7. The microfluidic device of claim 6, wherein each said control circuit is configured to receive the initialization pulse/signal on a same one of said one or more electrically conductive leads on which said control circuit receives a system clock/timing signal.

8. The microfluidic device of claim 6, wherein each said control circuit is configured to receive the initialization pulse/signal from said corresponding one of said photosensitive elements.

9. The microfluidic device of any one of claims 4-8, wherein each said control circuit is configured to receive or otherwise generate a switching control signal having a switching control signal frequency that is lower than a frequency of the system clock/timing signal.

10. The microfluidic device of claim 9, wherein the switching control signal is derived from the system clock/timing signal.

11. The microfluidic device of claim 4, wherein each said control circuit is configured to receive a switching control signal on one of said one or more electrically conductive leads, the switching control signal having a switching control signal frequency that is lower than a frequency of the system clock/timing signal.

12. The microfluidic device of claim 11, wherein each said control circuit is configured to receive the switching control signal on a same one of said one or more electrically conductive leads on which said control circuit receives the system clock/timing signal.

13. The microfluidic device of any one of claims 9-12, wherein each said control circuit is configured to retrieve the respective stored succession of instructions from the corresponding memory and to control whether each said one or more corresponding switch mechanisms is in said OFF state or said ON state for each time interval of the succession of time intervals, respectively, at the switching control signal frequency.

14. The microfluidic device of any one of claims 1-13, wherein at least one of said control circuits is configured to control two or more corresponding switch mechanisms.

15. The microfluidic device of claim 14, wherein the output signal generated by said one of said photosensitive elements corresponding to said at least one control circuit comprises instructions for controlling each of said two or more of said switching mechanisms.

16. The microfluidic device of any one of claims 1-15, wherein two or more of said control circuits share a memory.

17. The microfluidic device of any one of claims 1-16, wherein the memory is a shared memory configured to store the succession of instructions of the output signals generated by each of two or more of said photosensitive elements.

18. A system including a microfluidic device as recited in any one of claims 1-17, the system further including a light emitting device, wherein one or both of the light emitting device and the microfluidic device are movable relative to the other one such that the light emitting device may be selectively positioned at each of a plurality of fields of view of the circuit substrate surface.

19. The system of claim 18, wherein the light emitting device comprises light emitting elements, each configured to direct a respective modulated light beam onto a corresponding one of said photosensitive elements located within a given field of view of the circuit substrate surface at which the light emitting device is positioned, and, optionally, wherein the light emitting device is configured so that modulated light beams can be simultaneously transmitted by said light emitting elements and directed onto each of said corresponding ones of said photosensitive elements located within the given field of view.

20. The system of claim 19, wherein the system is configured to automatically

(a) move one or both of the microfluidic device and the light emitting device relative to the other one so as to position the light emitting device at a first field of view of the circuit substrate surface,

(b) direct respective modulated light beams transmitted by said light emitting elements onto said corresponding ones of said photosensitive elements located within the first field of view,

(c) deliver an initialization pulse/signal to control circuits corresponding to said photosensitive elements located within the first field of view to thereby synchronize said corresponding control circuits with respective output signals generated by said photosensitive elements,

(d) move one or both of the microfluidic device and the light emitting device relative to the other one so as to position the light emitting device at a next field of view of the circuit substrate surface,

(e) direct respective modulated light beams transmitted by said light emitting elements onto said corresponding ones of said photosensitive elements located within the next field of view,

(f) deliver an initialization pulse/signal to control circuits corresponding to said photosensitive elements located within the next field of view to thereby synchronize said

corresponding control circuits with respective output signals generated by said photosensitive elements, and

(g) repeat (d) to (f) until the respective modulated light beams have been directed onto said corresponding photosensitive elements located in all fields of view of the circuit substrate surface.

21. A method of controlling a microfluidic device, the microfluidic device comprising a semiconductor circuit substrate and a chamber containing a fluidic medium disposed on a surface of said circuit substrate, wherein a dielectrophoresis (DEP) electrode is disposed on or proximate to said circuit substrate surface in electrical contact with said fluidic medium, the method 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 fluidic medium and said second electrode is electrically insulated from said fluidic medium;

directing a modulated light beam onto a photosensitive element in said circuit substrate, wherein said photosensitive element generates, in response to said light beam, an output signal comprising a succession of instructions for controlling said DEP electrode for each time interval of a succession of time intervals;

storing, at least temporarily, said succession of instructions of the output signal in a memory located within said circuit substrate, and

controlling, based on said instructions contained in said stored output signal, a switch mechanism located within said circuit substrate so that said switch mechanism is in one of an OFF state, in which said DEP electrode is electrically isolated from said second electrode, or an ON state, in which said DEP electrode is electrically connected with said second electrode, for each time interval of the succession of time intervals.

22. The method of claim 21, wherein said succession of time intervals commence after said succession of instructions of the output signal is stored in said memory.

23. The method of claim 21 or 22, wherein said switch mechanism is a CMOS transistor formed in said semiconductor circuit substrate, and controlling said switch mechanism comprises

switching said CMOS transistor between said OFF state and said ON state for each said time interval of the succession of time intervals in accordance with said succession of instructions; and/or wherein said photosensitive element is a photodiode formed in said semiconductor circuit substrate.

24. The method of claim 23, further comprising transmitting a system clock/timing signal to said control circuit.

25. The method of claim 24, further comprising transmitting an initialization pulse/signal to said control circuit, wherein, in response to receiving said initialization pulse/signal, said control circuit initiates storing the succession of instructions of the output signal in said memory.

26. The method of claim 24 or 25, wherein said control circuit is configured to generate a switching control signal, wherein the succession of time intervals is defined by the switching control signal, and wherein said succession of time intervals commence after said succession of instructions of the output signal is stored in said memory.

27. The method of claim 26, wherein said switching control signal has a switching control signal frequency that is lower than a frequency of the system clock/timing signal.

28. The method of claim 26 or 27, wherein said switching control signal is derived from the system clock/timing signal.

29. A method of controlling a microfluidic device, the microfluidic device comprising a circuit substrate and a chamber containing a fluidic medium disposed on a surface of said circuit substrate, wherein dielectrophoresis (DEP) electrodes are disposed on or proximate to said circuit substrate surface in electrical contact with said fluidic medium, the method comprising:

(a) positioning a light emitting device at a first field of view of the circuit substrate surface, the light emitting device comprising light emitting elements;

(b) directing respective modulated light beams from said light emitting elements onto corresponding photosensitive elements located on or proximate to the circuit substrate surface

within the first field of view, wherein each said photosensitive element generates an output signal in response to the respective modulated light beam, wherein the output signal comprises a succession of instructions for controlling a corresponding DEP electrode for each time interval of a succession of time intervals;

(c) delivering an initialization pulse/signal to respective control circuits corresponding to said photosensitive elements located in said first field of view to thereby synchronize said control circuits with the output signals generated by said photosensitive elements;

(d) storing, at least temporarily, said succession of instructions of the output signals in respective memories of or associated with said control circuits;

(e) 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 fluidic medium and said second electrode is electrically insulated from said fluidic medium; and

(f) controlling, based on said succession of instructions of the output signals stored in the respective memories, switch mechanisms located within said circuit substrate so that each said switch mechanism is in one of an OFF state, in which a DEP electrode corresponding to said switch mechanism is isolated from said second electrode, or an ON state, in which said corresponding DEP electrode is electrically connected with said second electrode, for each time interval of a succession of time intervals; the method further comprising transmitting a system clock signal to said control circuits, wherein said system clock signal is synchronized with said output signals generated by said photosensitive elements.

30. The method of claim 29, further comprising:

(g) positioning the light emitting device at a next field of view of the circuit substrate surface;

(h) directing respective modulated light beams from said light emitting elements onto corresponding photosensitive elements located on or proximate to the circuit substrate surface within the next field of view, wherein each said photosensitive element generates an output signal in response to the respective modulated light beam, wherein the output signal comprises a succession of instructions for controlling a corresponding DEP electrode for each time interval of a succession of time intervals;

(i) delivering an initialization pulse/signal to respective control circuits corresponding to said photosensitive elements located in said next field of view to thereby synchronize said control circuits with the output signals generated by said photosensitive elements;

(j) storing, at least temporarily, said succession of instructions of the output signals in respective memories of or associated with said control circuits; and

(k) repeating steps (g) – (j) until respective modulated light beams have been directed onto said corresponding photosensitive elements located in all fields of view of the circuit substrate surface.

31. The microfluidic device of claim 9 or the method of claim 27, wherein the frequency of the system clock/timing signal is in a range of at least 50 times to 100,000 times greater than the frequency of the switching control signal.