

CLAIMS

What is claimed is:

1. An optical synapse comprising:
a memristive device for non-volatile storage of a synaptic weight dependent on resistance of the device; and
an optical modulator for volatile modulation of optical transmission in a waveguide; and
the memristive device and optical modulator being connected in control circuitry which is operable, in a write mode, to supply a programming signal to the memristive device to program the synaptic weight and, in a read mode, to supply an electrical signal, dependent on the synaptic weight, to the optical modulator whereby the optical transmission is controlled in a volatile manner in dependence on programmed synaptic weight.
2. The optical synapse of claim 1, wherein the control circuitry includes decoupling circuitry for electrically decoupling the optical modulator from the memristive device in the write mode.
3. The optical synapse of claim 1, wherein the memristive device is connected in a voltage divider and the electrical signal supplied to the optical modulator in the read mode is dependent on an output signal of the voltage divider.
4. The optical synapse of claim 1, wherein the memristive device and optical modulator are integrated in a monolithic integrated circuit.
5. The optical synapse of claim 1, wherein the optical modulator comprises an electro-optic modulator and the electrical signal comprises a drive voltage for the electro-optic modulator.
6. The optical synapse of claim 5, wherein the electro-optic modulator includes an optical phase shifter comprising a ferroelectric material, optically coupled to the waveguide, disposed between a pair of electrodes for applying the electrical signal, and wherein the control circuitry includes decoupling circuitry for electrically decoupling the

optical modulator from the memristive device to inhibit ferroelectric domain switching in the ferroelectric material in the write mode.

7. The optical synapse of claim 6, wherein the ferroelectric material comprises one of barium titanate, lithium niobate, and lead zirconate titanate.

8. The optical synapse of claim 6, wherein the memristive device and optical modulator are integrated in a monolithic integrated circuit and the memristive device is formed on one of the electrodes.

9. The optical synapse of claim 6, wherein the memristive device and optical modulator are integrated in a monolithic integrated circuit and the memristive device is formed on a ferroelectric layer.

10. The optical synapse of claim 1, wherein the optical modulator comprises a thermo-optic modulator and the electrical signal comprises a drive current for a heater of the thermo-optic modulator.

11. The optical synapse of claim 10, wherein the thermo-optic modulator includes an optical phase shifter and the heater comprises a metal layer, in thermal contact with the waveguide, disposed between a pair of contacts for applying the electrical signal.

12. The optical synapse of claim 11, wherein the memristive device and optical modulator are integrated in a monolithic integrated circuit and the memristive device is formed on one of the contacts.

13. The optical synapse of claim 1, wherein the optical modulator comprises a Mach-Zehnder interferometer.

14. The optical synapse of claim 1, wherein the optical modulator comprises a plasmonic modulator.

15. The optical synapse of claim 1, wherein the control circuitry includes synapse control logic, responsive to synaptic control signals, which is operable to vary, in

dependence on the synaptic control signals, electrical signals supplied to the optical modulator in the read mode to implement a desired short-term plasticity effect.

16. The optical synapse of claim 15, wherein:

the waveguide is arranged to transmit optical input signals from a pre-synaptic node to a post-synaptic node of a neuromorphic network in which the post-synaptic node transmits optical output signals in dependence on the optical input signals received thereby; and

the synaptic control signals are dependent on at least one selected from a group consisting of: the optical input signals, and the optical output signals.

17. The optical synapse of claim 15, wherein the synapse control logic is further operable to vary, in dependence on the synaptic control signals, programming signals supplied to the optical modulator in the write mode to implement a desired long-term plasticity effect.

18. The optical synapse of claim 17, wherein:

the waveguide is arranged to transmit optical input signals from a pre-synaptic node to a post-synaptic node of a neuromorphic network in which the post-synaptic node transmits optical output signals in dependence on the optical input signals received thereby; and

the synaptic control signals are dependent on at least one selected from a group consisting of: the optical input signals, and the optical output signals.

19. A neuromorphic network comprising a plurality of nodes in which pairs of nodes are interconnected via respective waveguides for transmission of optical signals between nodes of each pair, wherein each waveguide includes an optical synapse comprising:

a memristive device for non-volatile storage of a synaptic weight dependent on resistance of the device; and

an optical modulator for volatile modulation of optical transmission in the waveguide; and

the memristive device and optical modulator being connected in control circuitry which is operable, in a write mode, to supply a programming signal to the memristive device to program the synaptic weight and, in a read mode, to supply an electrical signal,

dependent on the synaptic weight, to the optical modulator whereby the optical transmission is controlled in a volatile manner in dependence on programmed synaptic weight.

20. The neuromorphic network of claim 19, wherein the control circuitry of each synapse includes decoupling circuitry for electrically decoupling the optical modulator from the memristive device of the synapse in the write mode.

21. The neuromorphic network of claim 19, wherein the memristive device of each synapse is connected in a voltage divider and the electrical signal supplied to the optical modulator of the synapse in the read mode is dependent on an output signal of the voltage divider.

22. The neuromorphic network of claim 19, wherein the optical modulator of each synapse comprises an electro-optic modulator and the electrical signal comprises a drive voltage for the electro-optic modulator.

23. The neuromorphic network of claim 19, wherein the optical modulator of each synapse comprises a thermo-optic modulator and the electrical signal comprises a drive current for a heater of the thermo-optic modulator.

24. The neuromorphic network of claim 19, wherein the control circuitry of each synapse includes synapse control logic, responsive to synaptic control signals, which is operable to vary, in dependence on the synaptic control signals, electrical signals supplied to the optical modulator in the read mode to implement a desired short-term plasticity effect.

25. The neuromorphic network of claim 24, wherein the synapse control logic is further operable to vary, in dependence on the synaptic control signals, programming signals supplied to the optical modulator of the synapse in the write mode to implement a desired long-term plasticity effect.