Application of memristive devices as synapse emulators

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Info Day on FP7 Call 9
Brussels, January 18th 2012
Memristor (memory-resistor) the 4th missing passive element???

The ‘resistor with memory’ behaves like a pipe whose diameter varies according to the amount and direction of the current passing through it. If the current is turned off, the pipe’s diameter stays the same until it is switched on again - it “remembers” what current has flowed through it.

Intentionally planted deficiencies are introduced in a very controlled way, allowing them to be displaced under appropriate biasing.


The charge displacement alters the overall conductance of the device.


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Conventional Applications
Memory

Highly scalable

Bi-stable operation

Bi-stable operation

Multilevel switching


T. Prodromakis et al., unpublished material.
Biomimetic Applications

Synapse emulator

Neurobiological models

Potentiation/Depression pulses

Measured synaptic weight change vs spike separation

Modelling the *Outer Plexiform Layer* of the retina with Memristive grids

**Biomimetic Applications**

- **Photoreceptors**
- **OPL**
- **Horizontal Cells**
- **Bipolar Cells**

Chemical Synapses

Electrical Synapses (Gap Junctions)

Memristive Synaptic Triads

- Photoreceptor spike-based biasing
- Memristive fuses

Edge-detection thresholding

ON/OFF bipolar cells

**Hexagonal Memristive Network**

- Image Smoothing
- Edge Detection
- Noise Rejection
- Brightness Adaptation