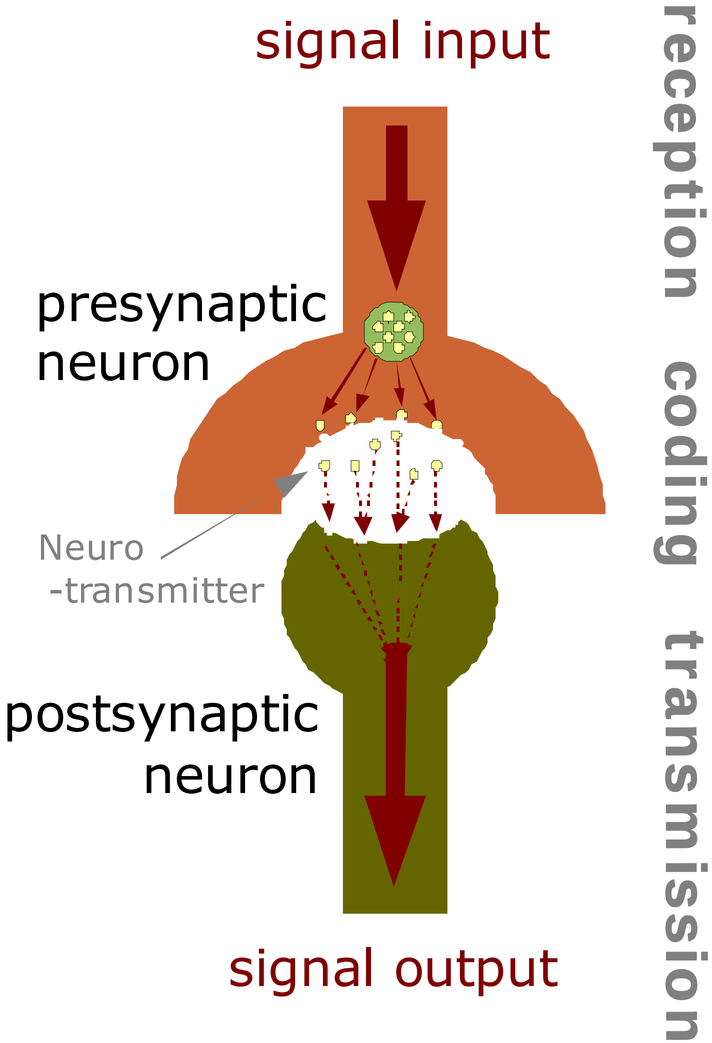
Demonstration of implicate memory in electronic circuits by using memresistive devices

Martin Ziegler, Mirko Hansen, and Hermann Kohlstedt

Nanoelektronik, Technische Fakultät der Christian-Albrechts-Universität zu Kiel, Germany

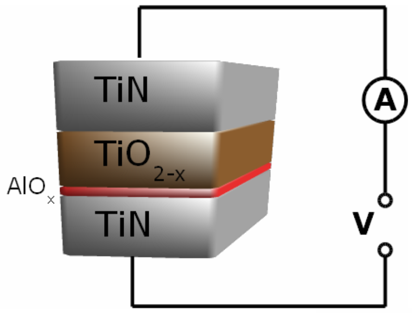
Neurotransmission: synaptic decoding



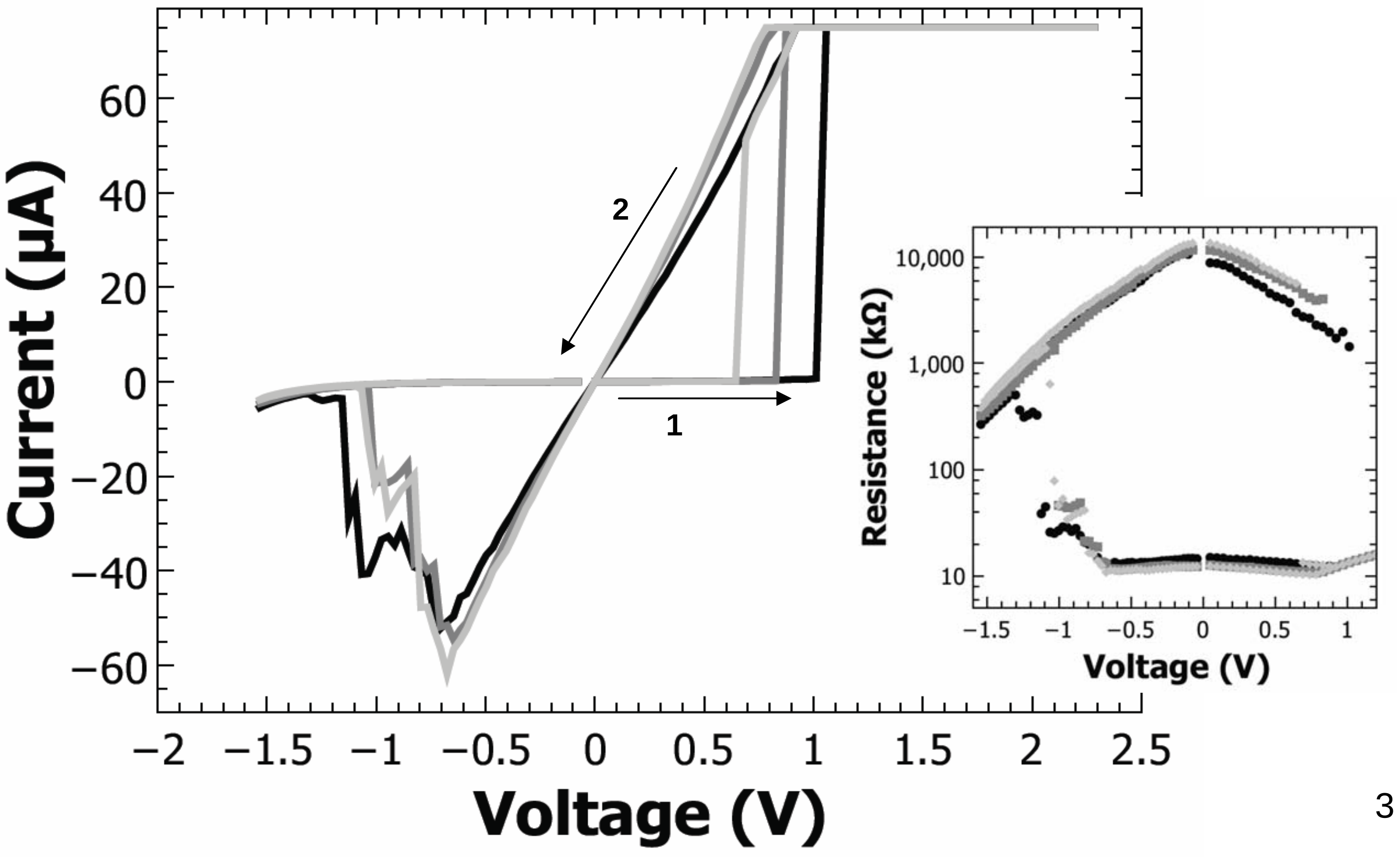
- information is analogue encoded in synapses

biological	electronic
Duration +Intensity	Pulse width +Signal height
Neurotrans-mitter concentration	Resistive state of the device

Memristive Devices for Neuromorphic Systems

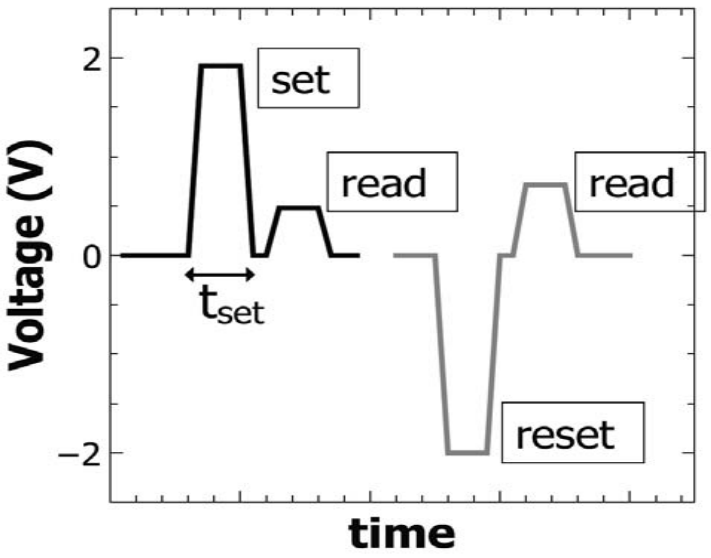


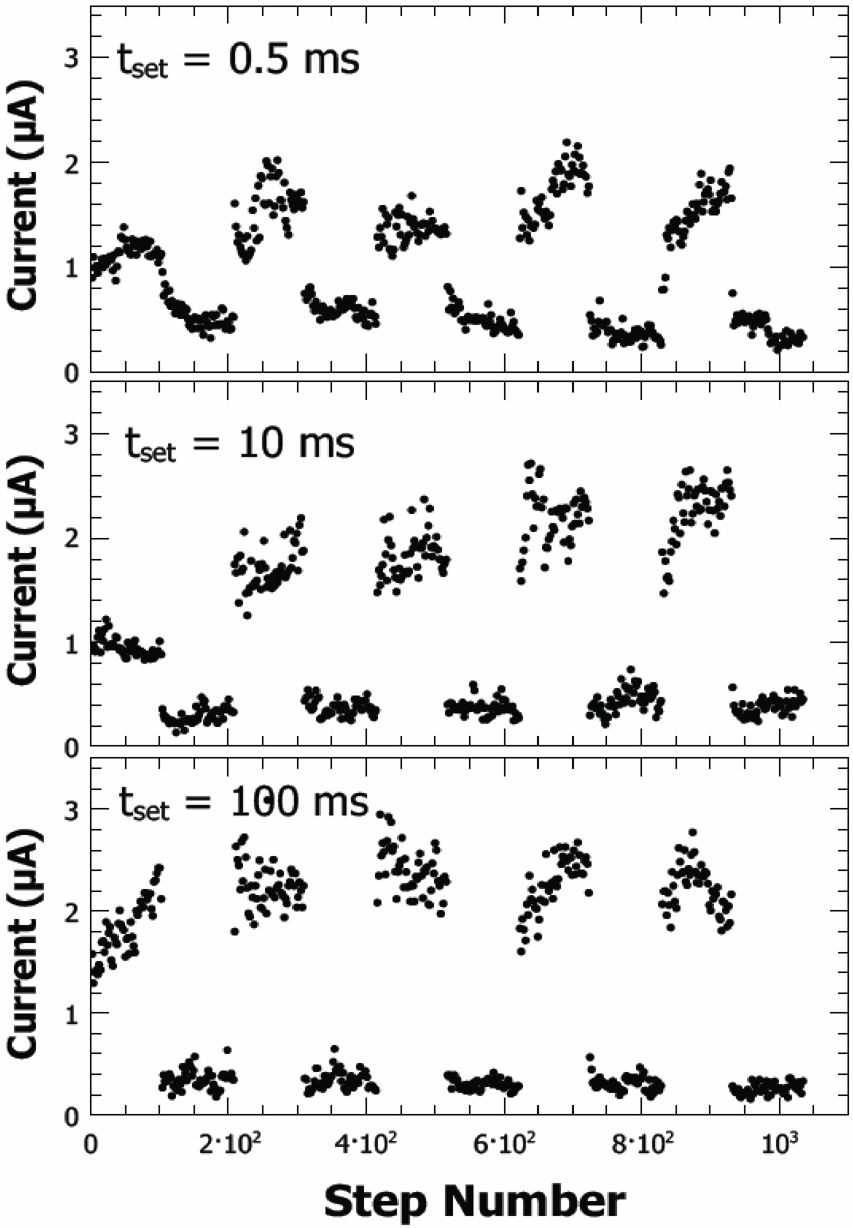
- **memristive devices must exhibits a threshold voltage**
  M. Ziegler et al., Adv. Func. Mat. (2012).
- **for dense arrays a low low power consumption is needed**
  C. Zamarreño-Ramos et al., Front. Neurosci. ***5****, 26 (2011).*



Synaptic potentiation

*Sung Hyun Jo et al., Nano Lett. **10**, 1297-1301 (2010).*
*T. Ohno et al**.,** Nature Materials **10**, 591–595 (2011).*



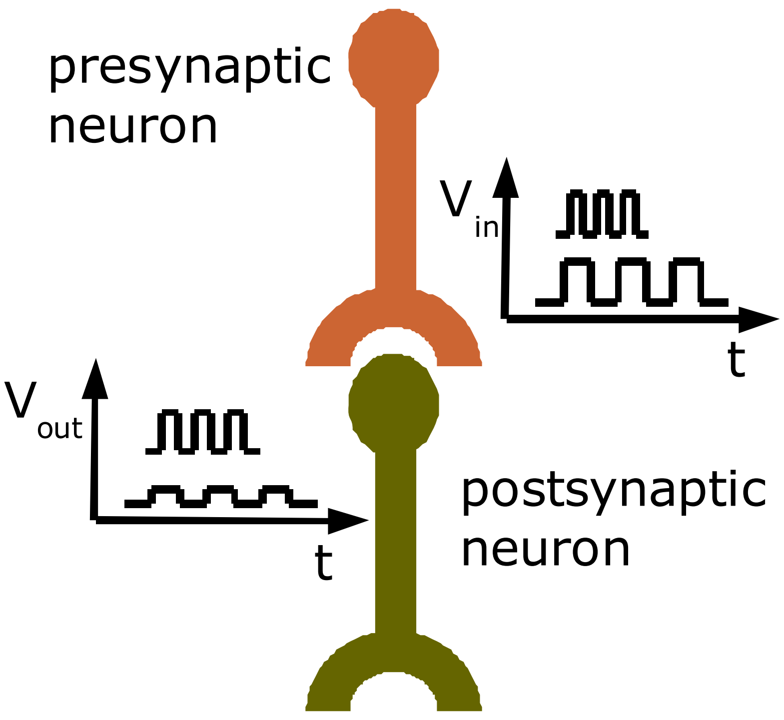


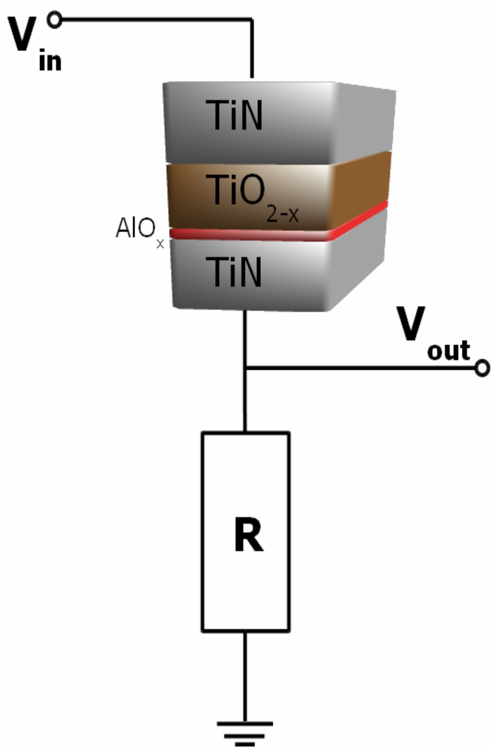
- neural plasticity can be mimicked by voltages pulses with different voltage amplitude and pulse width

→ Neurotransmission?

Neural mediating circuit

- **Post-synaptic potential (PSP)** is mimicked within a memristive cell forming a voltage divider in combination with a linear 10 kΩ resistor.



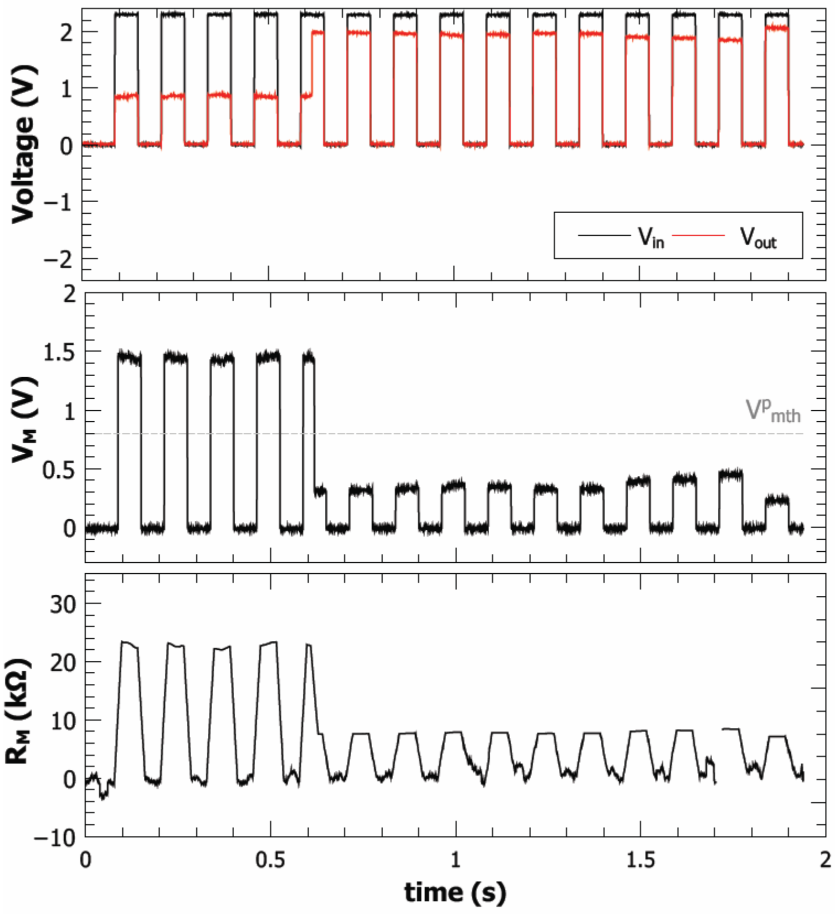


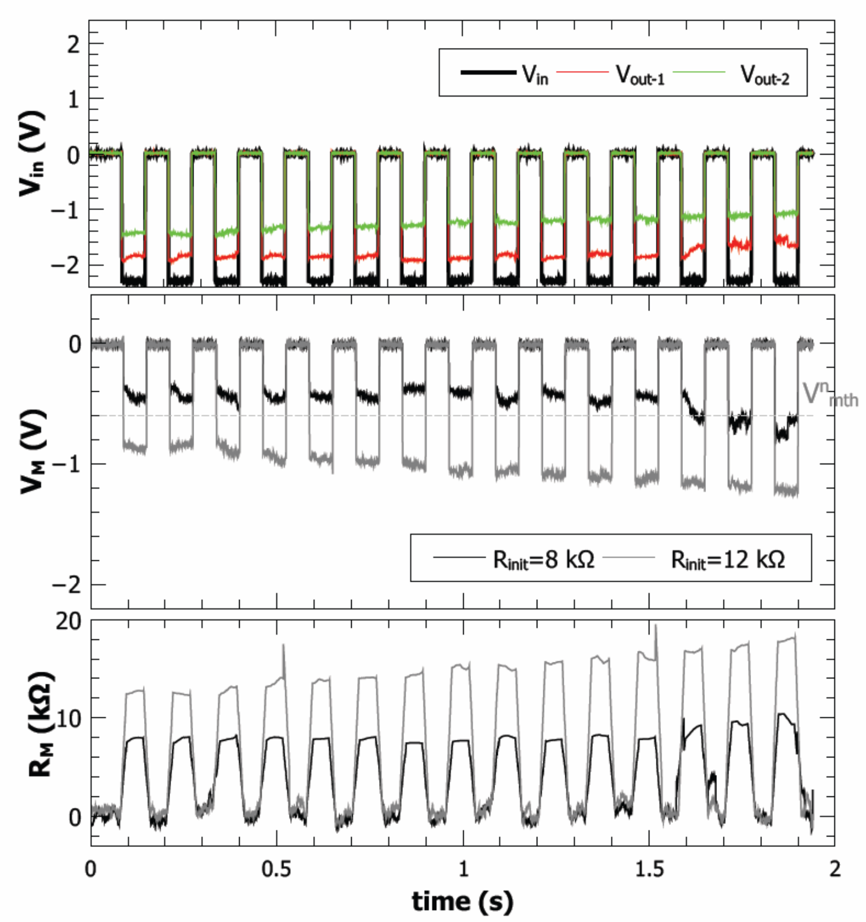
M. Ziegler et al., Adv. Func. Mat. (2012).

Neurotransmission in an electronic circuit

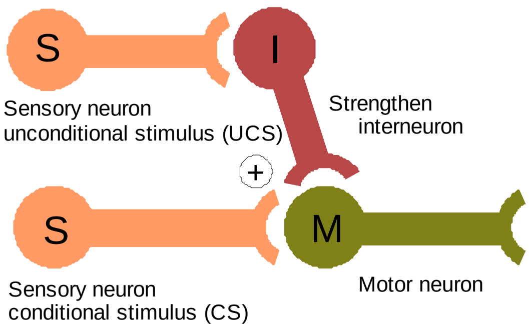
- **synaptic plasticity mimicked with pos. and neg. voltages pulses**

M. Ziegler et al., Adv. Func. Mat. (2012).



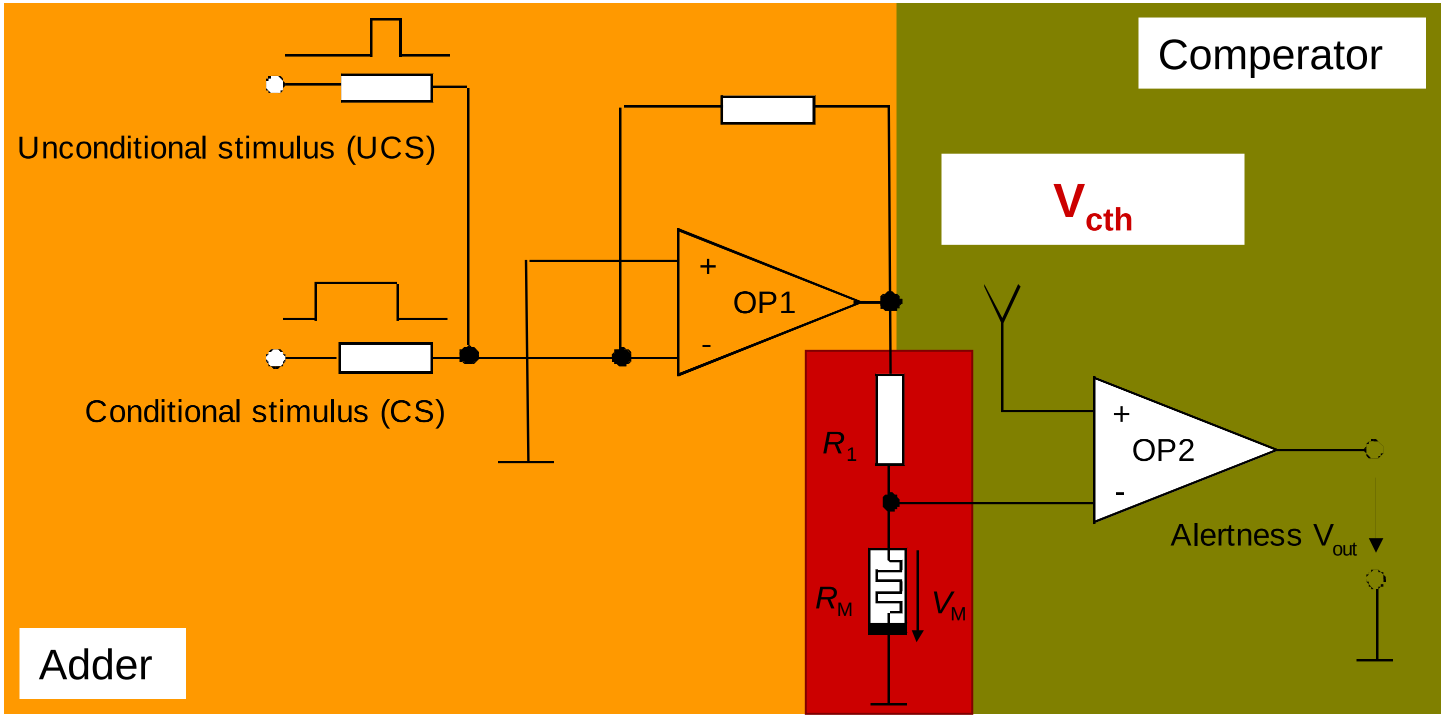


Neural mediating circuit for associative learning



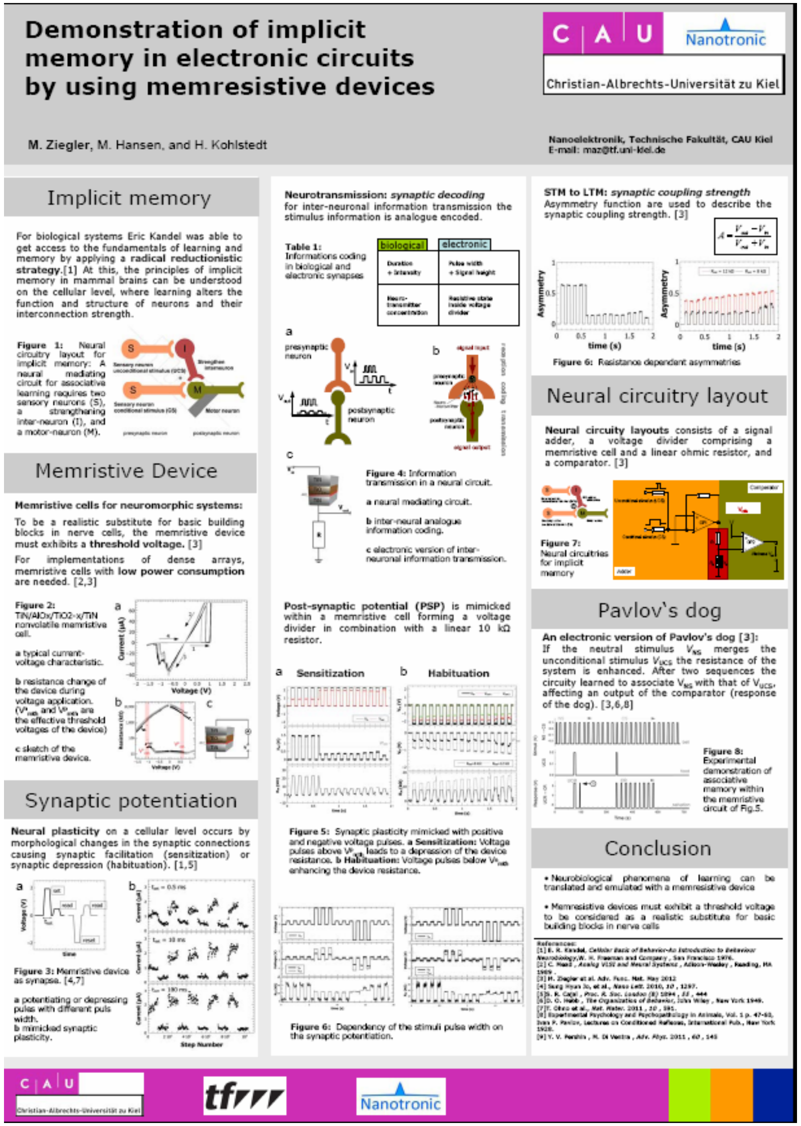
- Electrical circuit layout: single memristive device implemented in an analogue circuitry

M. Ziegler et al., Adv. Func. Mat. (2012).



- Voltage divider compromizing a memristive device

Conclusions



- Neurobiological phenomena of learning can be translated and emulated with a single memresistive device.
- effective threshold voltages and device resistances are fundamental design parameters.
- … more on the poster

Thanks for your attention!