

Conmutación Resistiva

Memristores, ReRAM y computación neuromórfica.

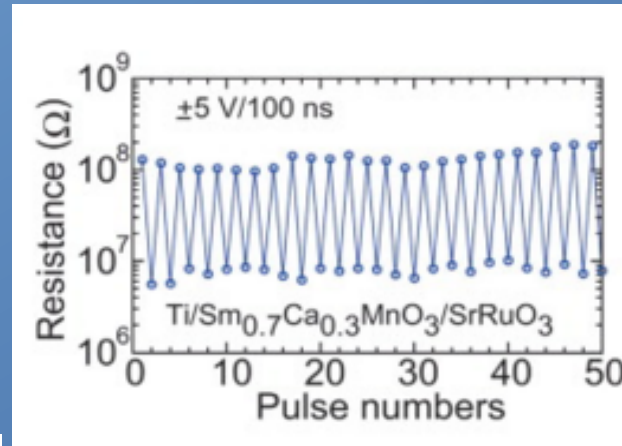
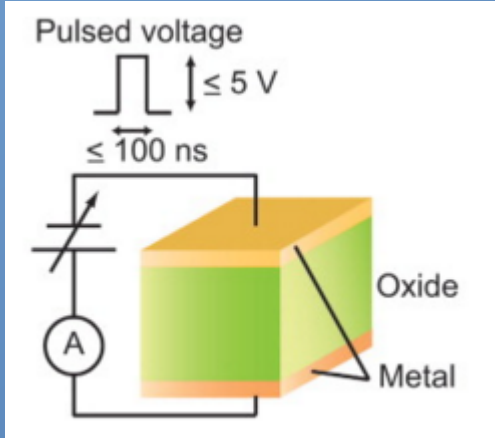
Federico Tesler

Director: Marcelo Rozenberg

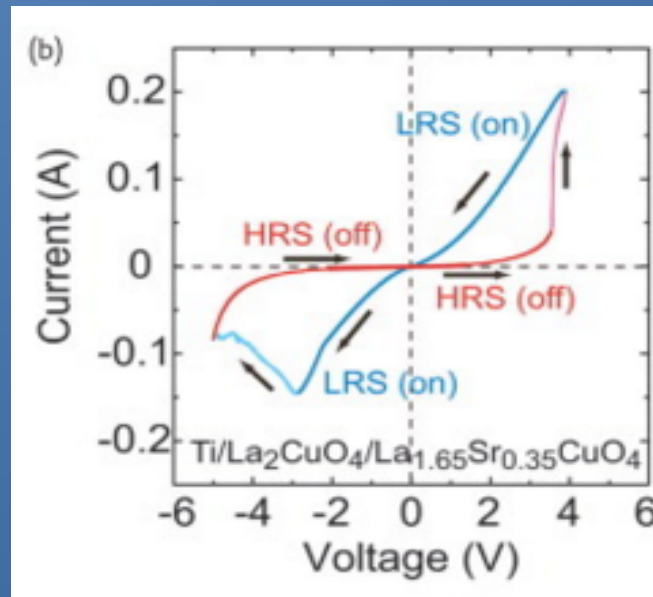
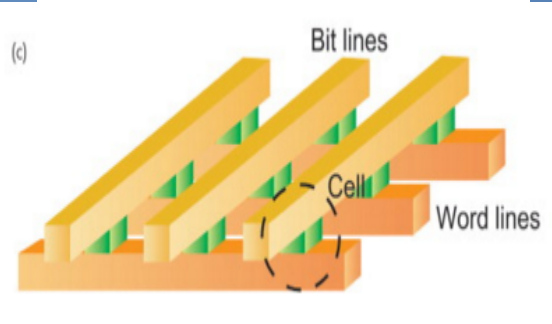
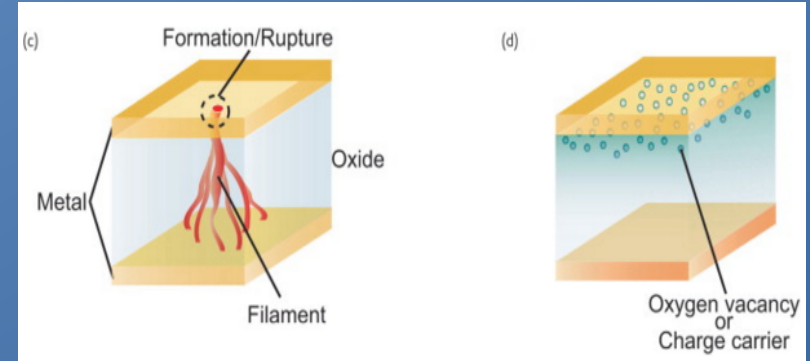
Co-director: Alberto Camjayi

Conmutación resistiva y memristores

Dispositivo estándar



Mecanismos básicos



Características

- Non-volatile
- Reversible
- Fast

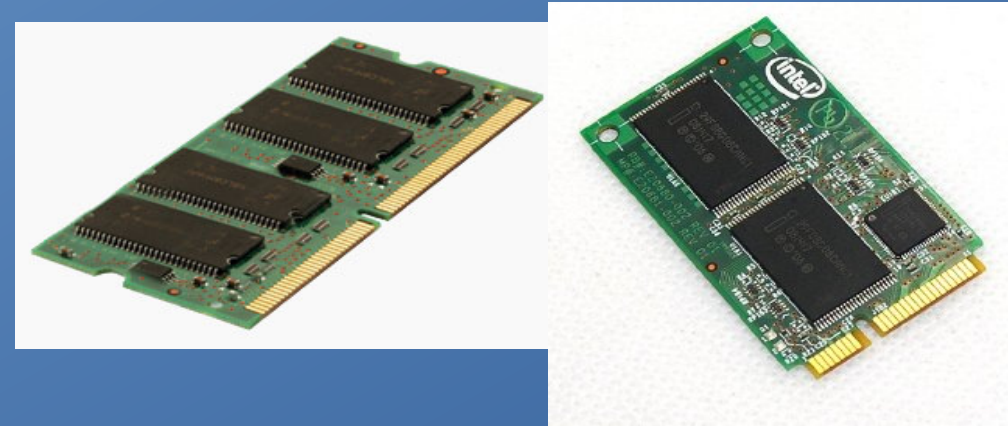
Summary of common inorganic storage media and corresponding switching characteristics				
Storage medium	Switching mode	ON/OFF ratio	Operation speed	Endurance (cycles)
<i>Binary oxides</i>				
MgO ₂	Unipolar, bipolar	>10 ⁵	-	>4 × 10 ⁷
AlO ₂	Unipolar, bipolar	>10 ⁶	<10 ns; <10 ns	>10 ⁷
SiO ₂	Unipolar, bipolar	>10 ⁷	<100 ps; <100 ps	>10 ⁸
TiO ₂	Unipolar, bipolar	>10 ³	<5 ns; <5 ns	>2 × 10 ⁷
CrO ₂	Bipolar	>10 ²	<4 μs; <5 μs	>6 × 10 ⁵
MnO ₂	Unipolar, bipolar	>10 ⁴	<100 ns; <200 ns	>10 ⁷
FeO ₂	Bipolar	>10 ³	<10 ns; <10 ns	>6 × 10 ⁵
CoO ₂	Unipolar, bipolar	>5 × 10 ³	<20 ns; <20 ns	>10 ⁷
NiO ₂	Unipolar, bipolar	>10 ⁶	<10 ns; <20 ns	>10 ⁷
CuO ₂	Unipolar, bipolar	>10 ³	<50 ns; <50 ns	>1.2 × 10 ⁷
ZnO ₂	Unipolar, bipolar	>10 ³	<5 ns; <5 ns	>10 ⁷
GaO ₂	Bipolar	>10 ³	<400 ns; <600 ns	>10 ⁷
GeO ₂	Unipolar, bipolar	>10 ³	<20 ns; <20 ns	>10 ⁷
ZrO ₂	Unipolar, bipolar	>10 ⁶	<10 ns; <10 ns	>10 ⁷
NbO ₂	Unipolar, bipolar	>10 ⁶	<100 ns; <100 ns	>10 ⁷
MoO ₂	Unipolar, bipolar	>10	<1 μs; <1 μs	>10 ⁶
HfO ₂	Unipolar, bipolar	>10 ⁶	<300 ps; <300 ps	>10 ⁸
TaO ₂	Unipolar, bipolar	>10 ⁶	<105 ps; <120 ps	>10 ⁸
WO ₂	Unipolar, bipolar	>10 ⁴	<300 ns; <50 ns	>10 ⁷
CxO ₂	Unipolar, bipolar	>10	<1 μs; <200 ns	>10 ⁴
GdO ₂	Unipolar, bipolar	>5 × 10 ³	<1 ns; <1 ns	>10 ⁷
YbO ₂	Unipolar, bipolar	>10 ³	-	>10 ³
LuO ₂	Unipolar, bipolar	>10 ⁴	<10 ns; <30 ns	>8 × 10 ⁷
<i>Ternary and more complex oxides</i>				
LaAlO ₃	Bipolar	>10 ⁴	-	>10 ⁷
SrTiO ₃	Bipolar	>10 ³	<5 ns; <5 ns	>10 ⁶
BaTiO ₃	Unipolar, bipolar	>10 ⁴	<10 ns; <70 ns	>10 ⁷
LC(or SMO)	Bipolar	>10 ³	<25 ns; <25 ns	>10 ⁷
PCMO	Bipolar	>10 ³	<8 ns; <8 ns	>10 ¹⁰
BiFeO ₃	Unipolar, bipolar	>10 ³	<50 ns; <100 μs	>10 ⁷
<i>Chalcogenides</i>				
Cu ₂ S	Bipolar	>10 ⁶	<100 μs; <100 μs	>10 ⁴
Ge ₂ S	Bipolar	>10 ³	<50 ns; <50 ns	>7.5 × 10 ⁶
Ag ₂ S	Bipolar	>10 ⁶	<200 ns; <200 ns	-
Ge ₂ Se ₃	Bipolar	>10 ⁶	<100 ns; <100 ns	>3.2 × 10 ¹⁰
<i>Nitrides</i>				
AlN	Unipolar, bipolar	>10 ³	<10 ns; <10 ns	>10 ⁸
SiN	Unipolar, bipolar	>10 ⁷	<100 ns; <100 ns	>10 ⁹
<i>Others</i>				
a-C	Unipolar, bipolar	>3 × 10 ³	<50 ns; <10 ns	>10 ⁴
a-Si	Bipolar	>10 ³	<5 ns; <10 ns	>10 ⁴
AgI	Bipolar	>10 ⁶	<50 ns; <150 ns	>4 × 10 ³

Aplicaciones

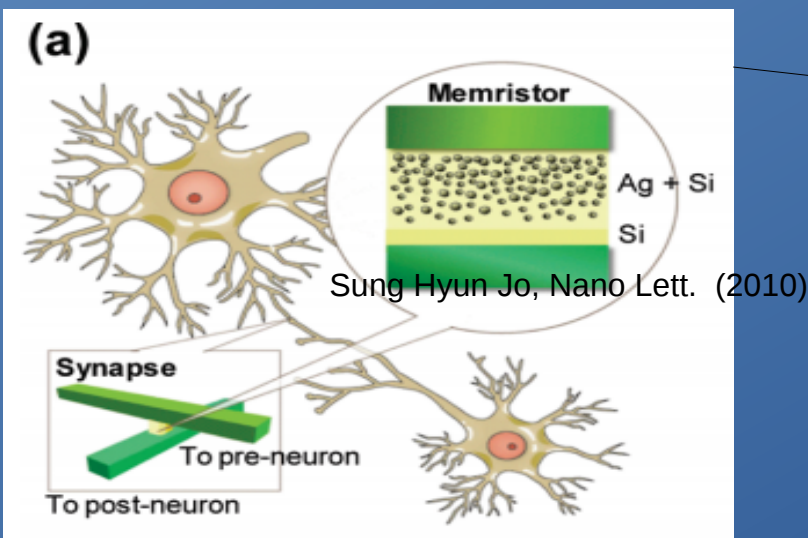
Disco duros y SSD



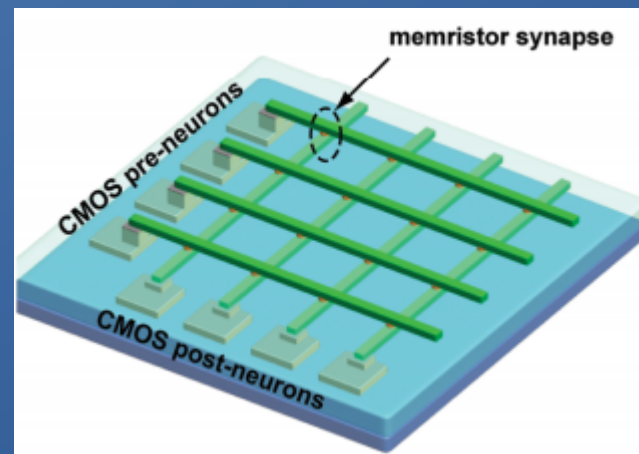
RAM y Cache memory



Artificial neuron synapse



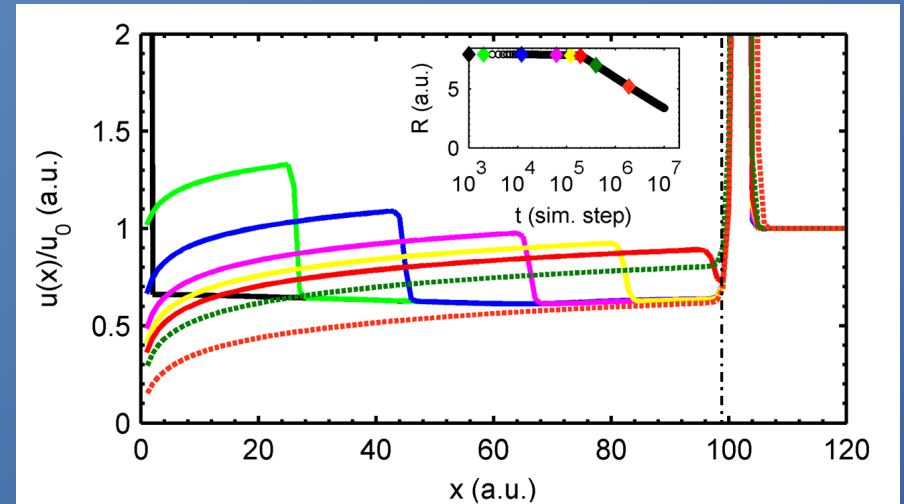
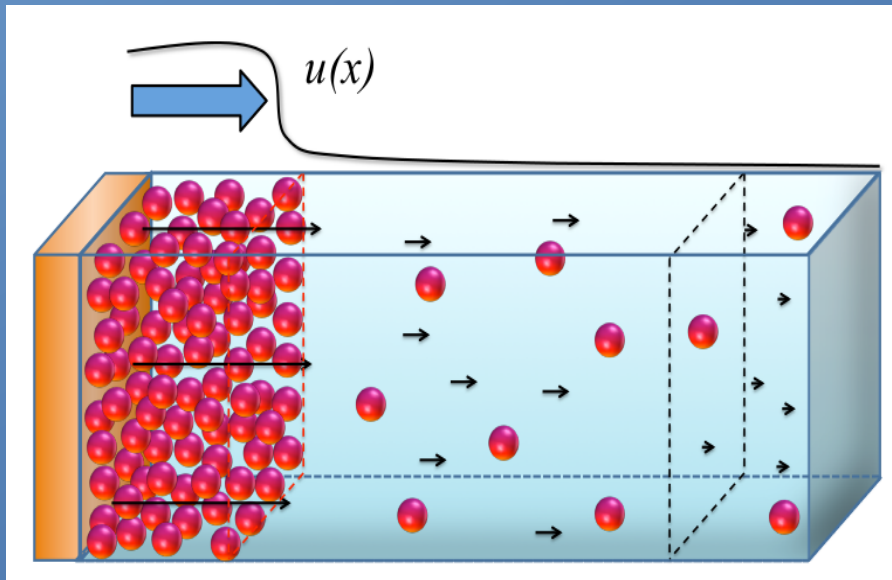
Redes neuronales y Computación neuromórfica



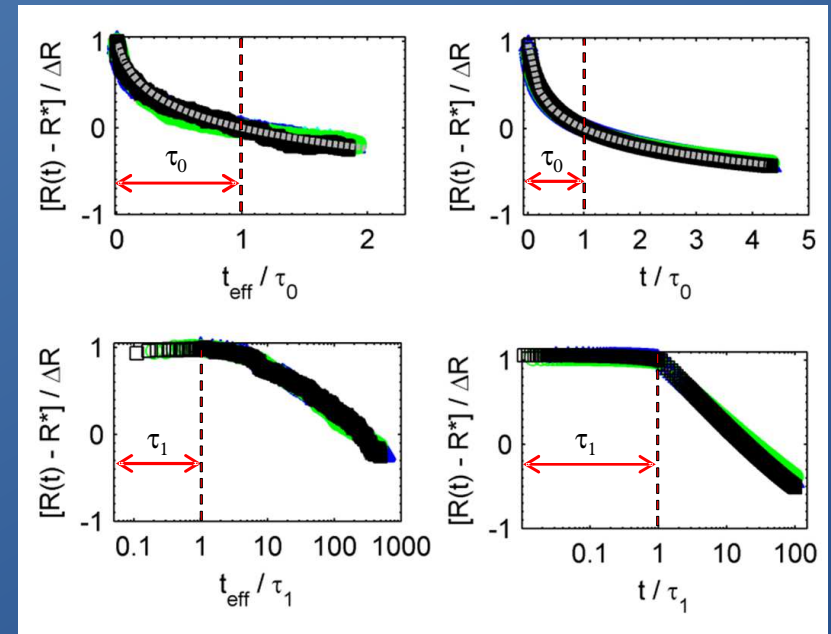
Current Trends:

- Machine Learning
- Deep learning
- Data mining

Ondas de choque en manganitas



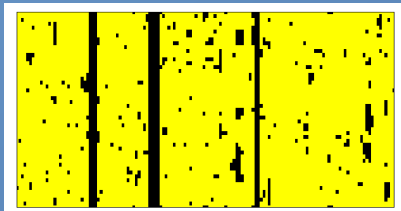
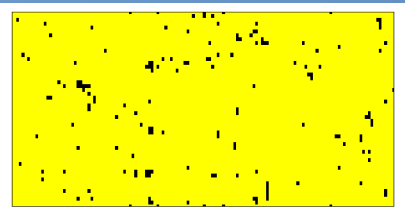
$$\partial_t u + f(u) \partial_x u = D \partial_{xx} u$$



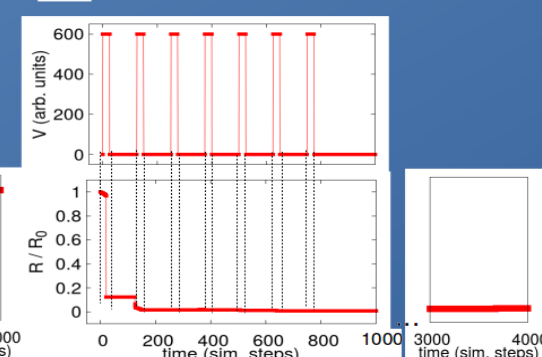
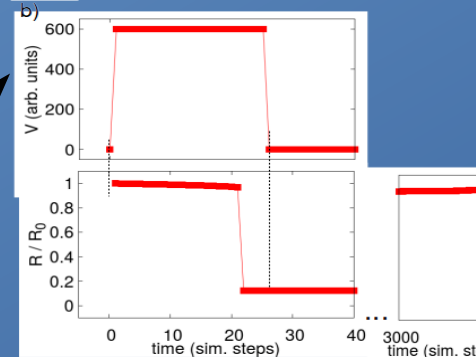
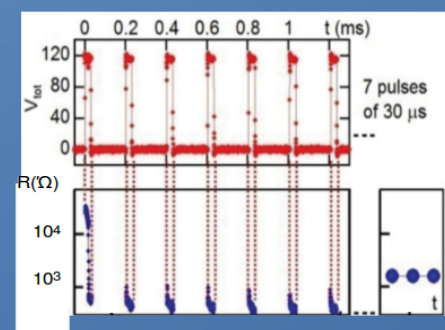
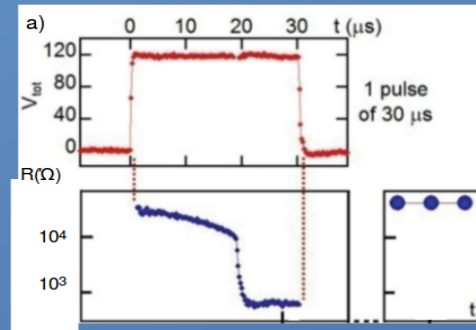
Aisladores de Mott (AM4Q8)

Antes

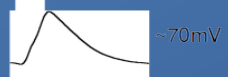
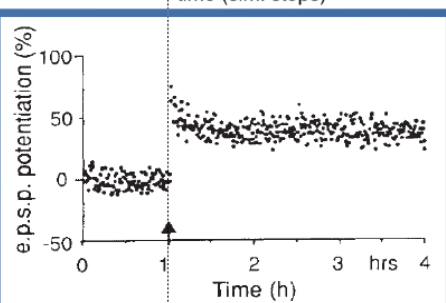
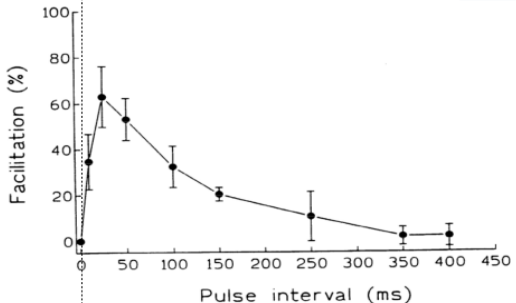
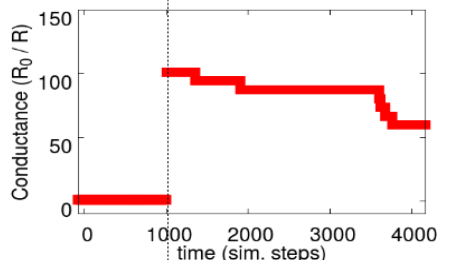
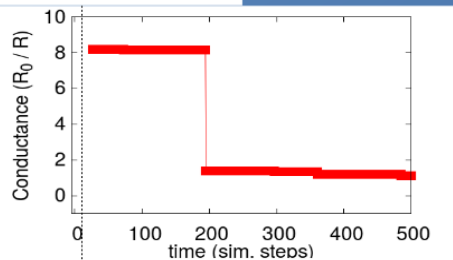
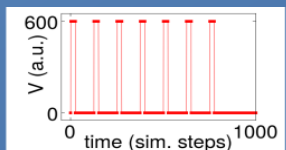
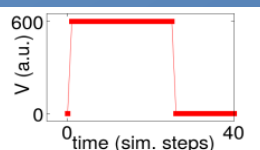
Después



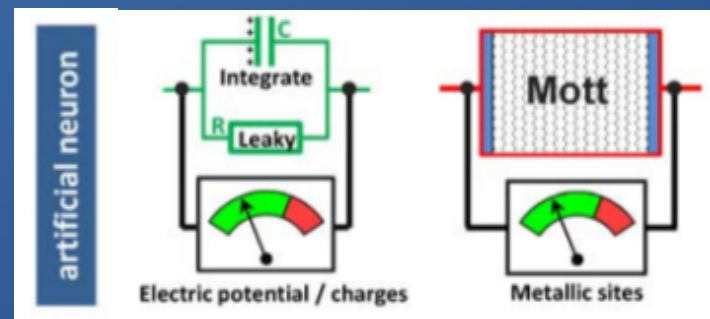
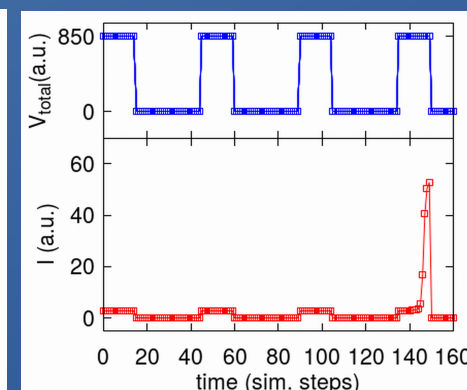
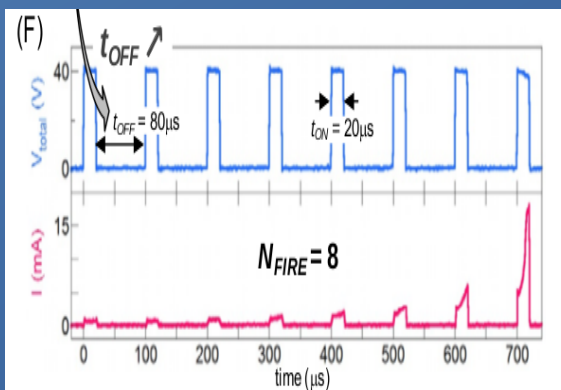
Retentividad variable
(volátil a no-volátil)



Potenciación sináptica de corto y largo plazo



Neurona LIF



Electric potential / charges

Metallic sites

Gracias!!!