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Easily integrable metal insulator metal selector devices for high density ReRAM crossbar arrays

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Advances in ReRAM : Materials and Interfaces
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Electronics & Computer Science
University of Southampton

NANO RESEARCH GROUP

Contents

1 ReRAM Crossbar arrays
2 Selector devices
3 Integrability
4 MIM selector
5 Conclusions

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ReRAM Crossbar Arrays

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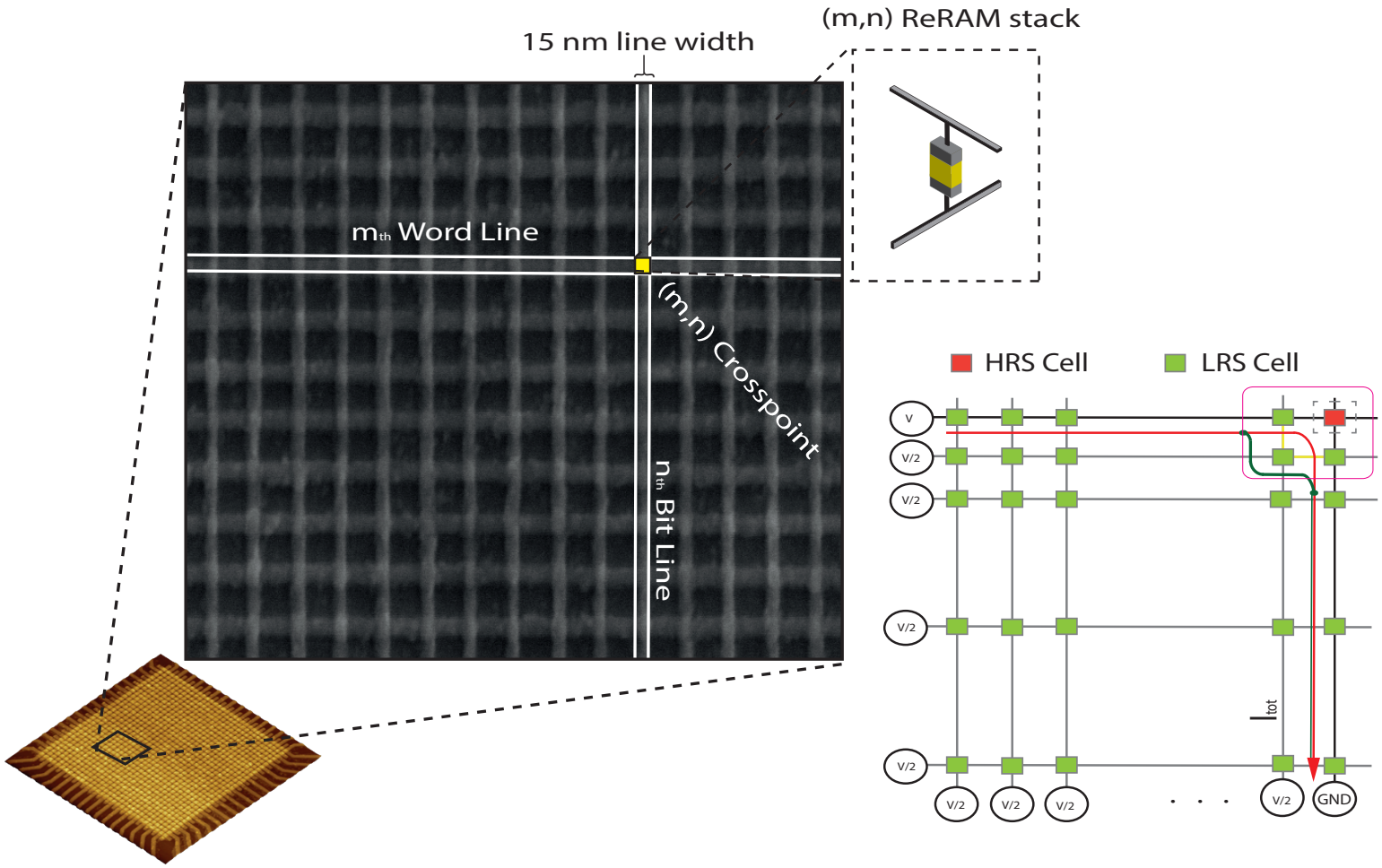

2 µm x 2 µm Crossbar Array

1 Selector 1 Resistor (1S1R) CBs

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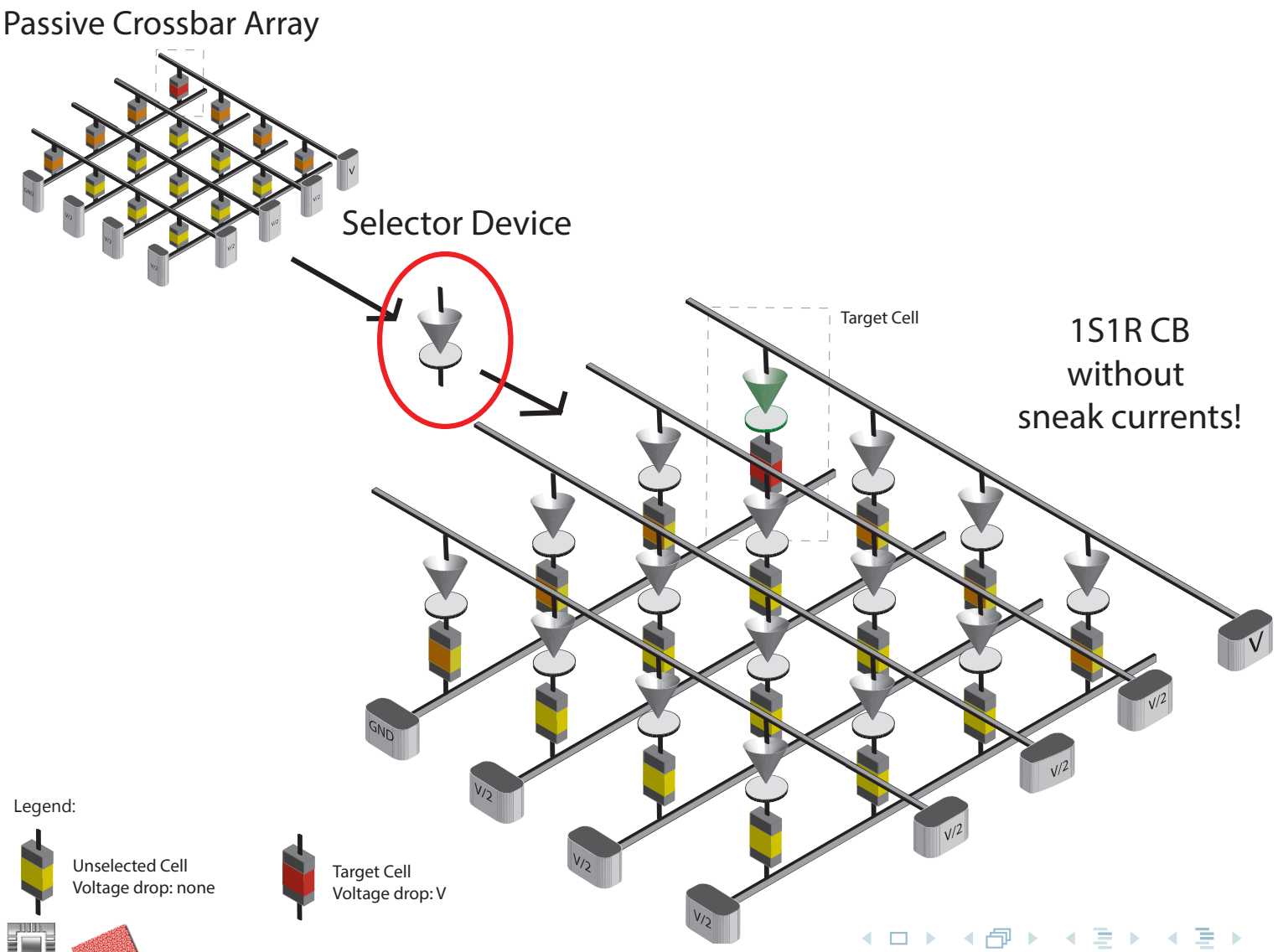

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Selector device

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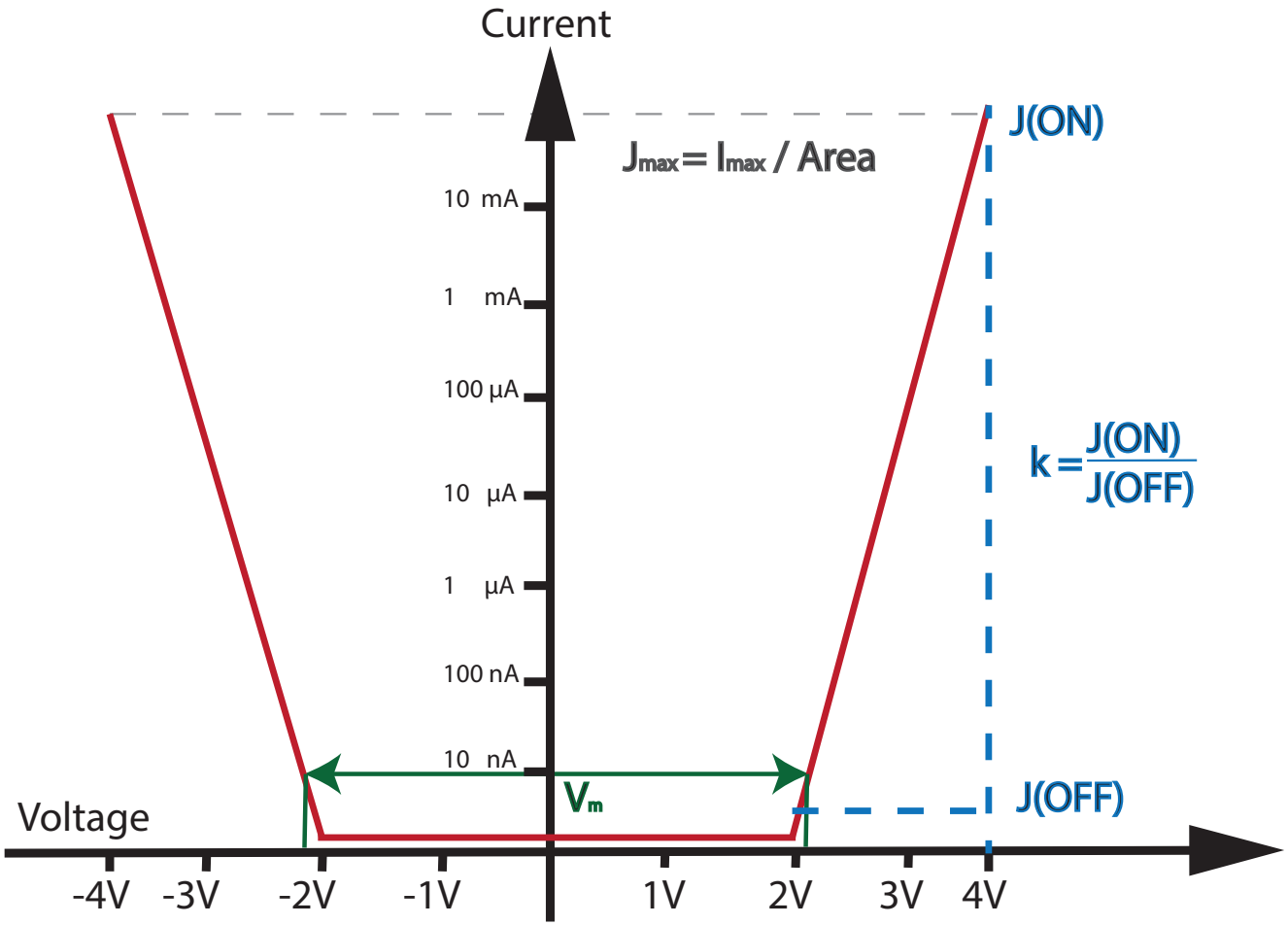
An attempt of definition

A selector device is a passive, ReRAM-compatible, highly non linear device able to achieve an efficient suppression of sneak currents in a CB withouth compromising ReRAM operativity in terms of current and voltage.

Selector Device: parameters



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Integrability co-strains

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Warning!

Selector MUST be integrated into a Crossbar. It is ***pointless*** to have the best selector in the world if it can't be integrated.

Hence:

- Feature Size: Ideally, $4F^2$, same as ReRAMs.
- Thermal Budget: $\leq 400°C$.
- Best if no rare materials are involved.

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MIM Selector
Fabrication

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Thermal SiO_2 substrate

↓

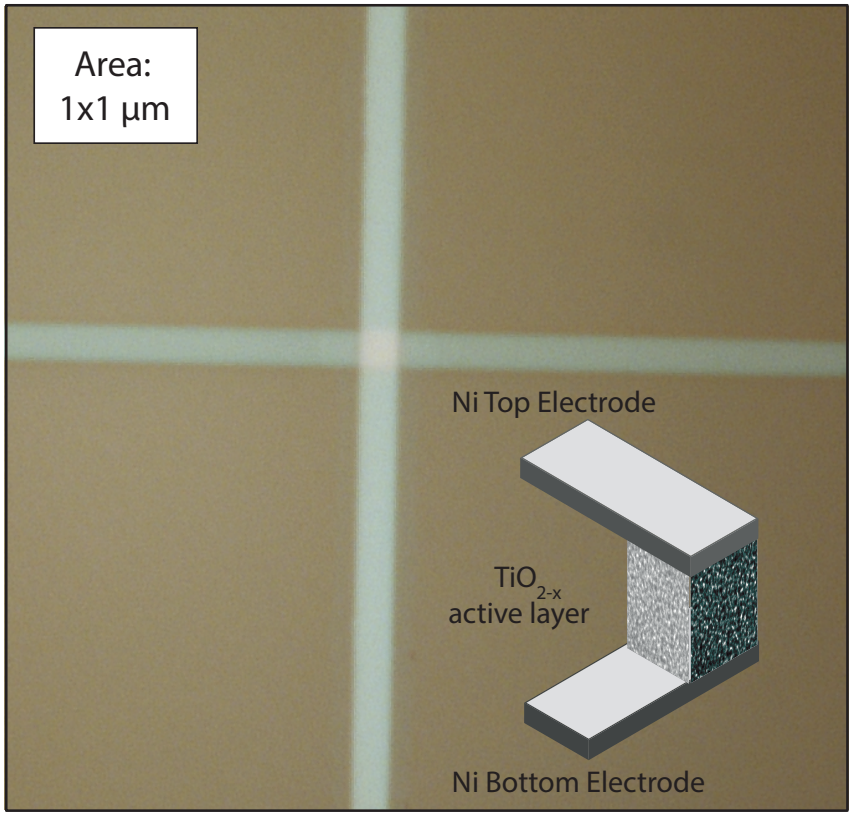
Evaporation of Ni back electrode

↓

10 nm TiO_2 Sputtering (RT)

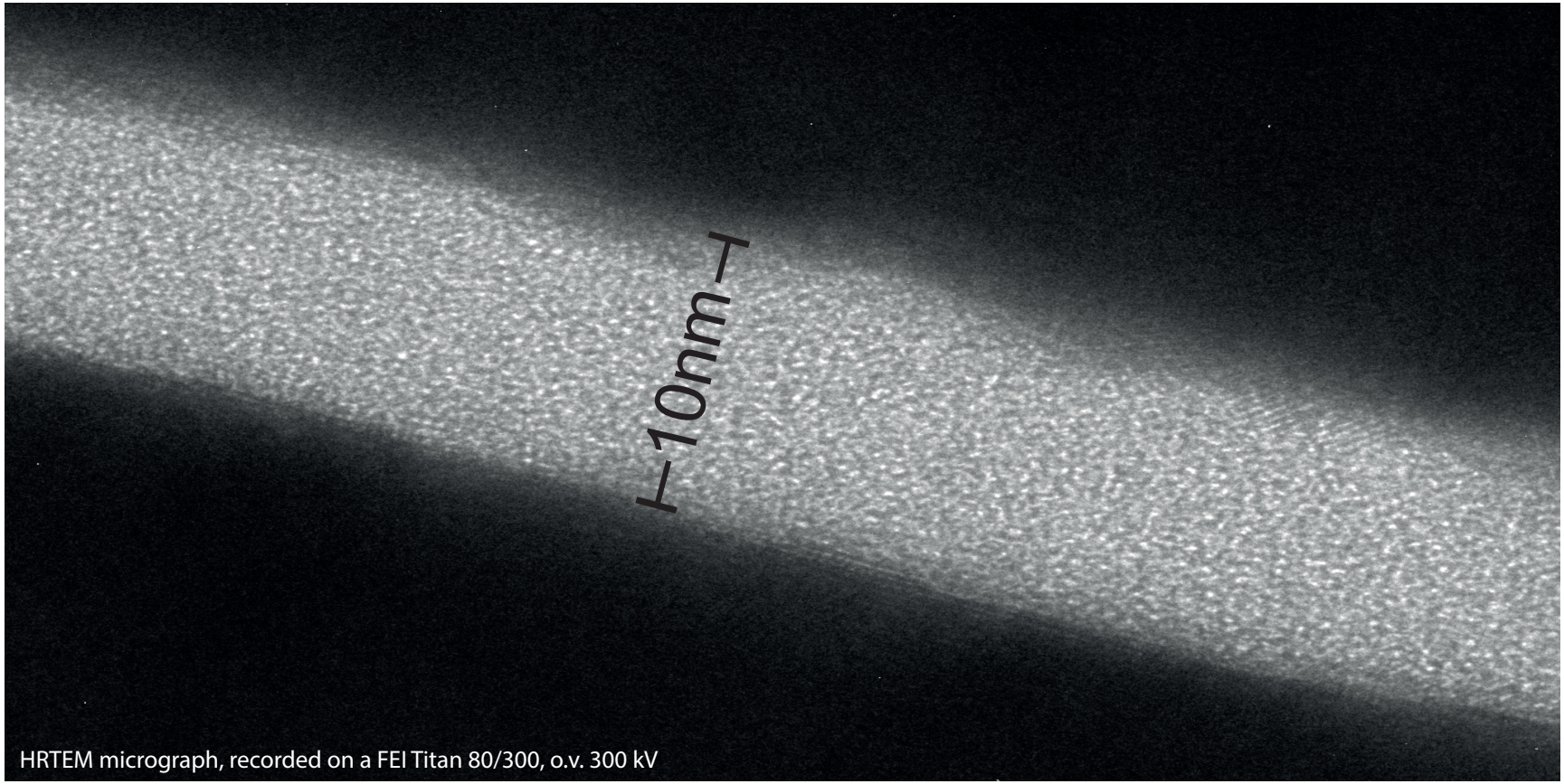
↓

Evaporation of Ni top electrode



Film characterization

Amorphous TiO_2



HRTEM micrograph, recorded on a FEI Titan 80/300, o.v. 300 kV

Electrical Characterization - I

Amorphous TiO_2

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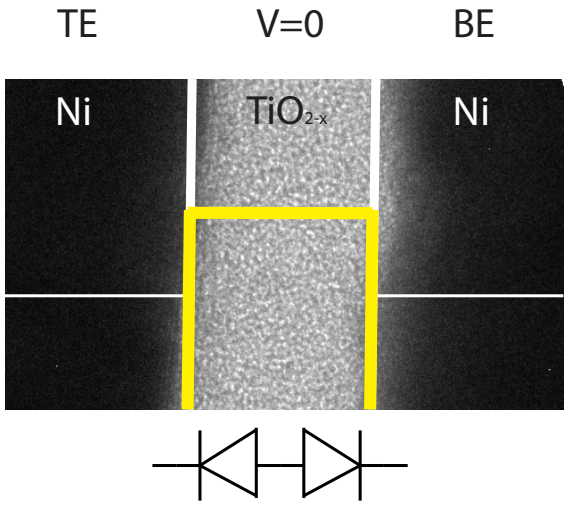
Schottky Barrier Height φ

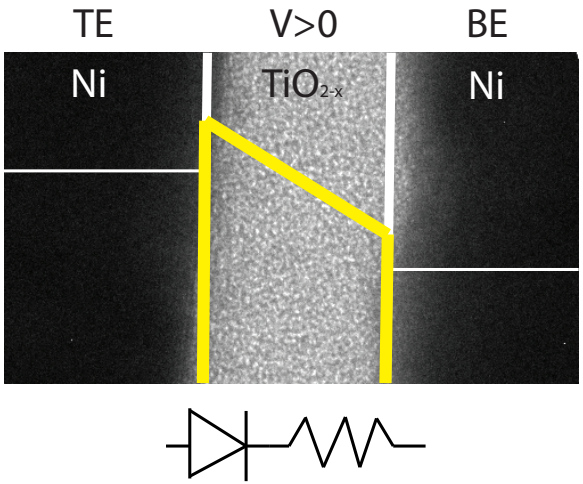
$$q\varphi = q(\psi - \chi)$$

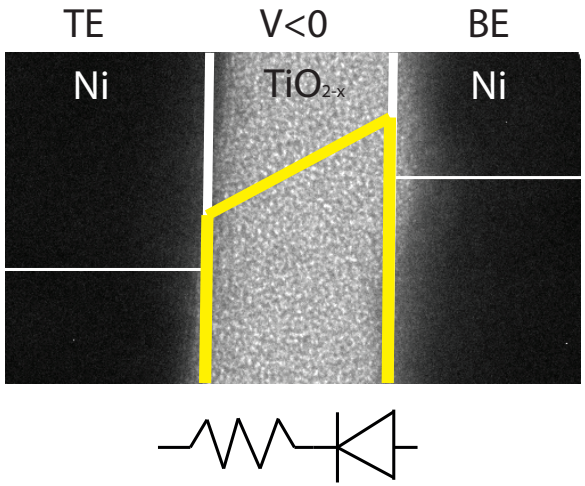
ψ: Ni workfunction
χ : TiO_{2-x} electron affinity



Schottky Diode equation

$$J \propto \exp\left(V^{\frac{1}{2}} - \varphi\right)$$





Electrical Characterization - II

DC and Pulsed

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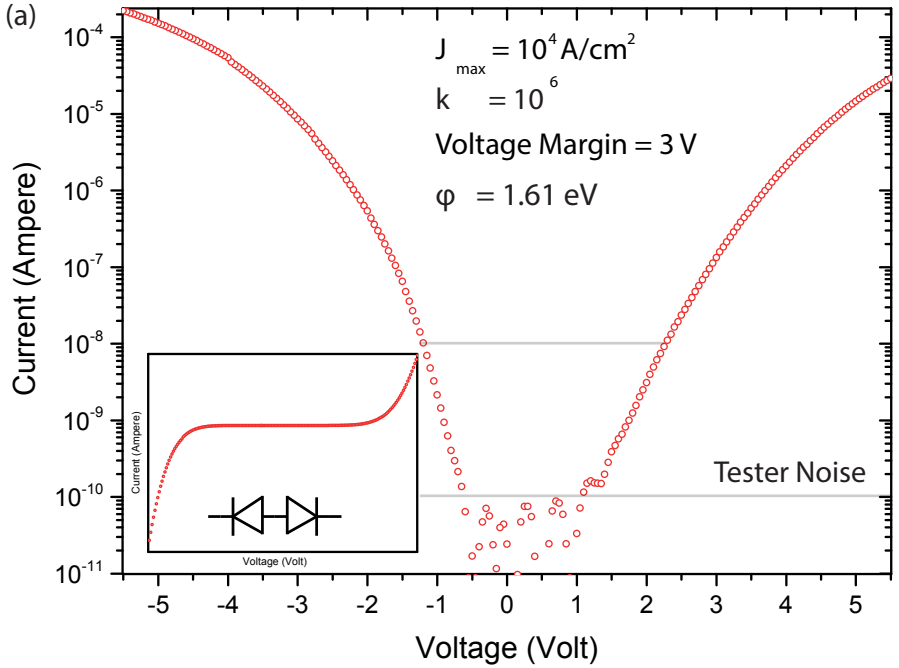
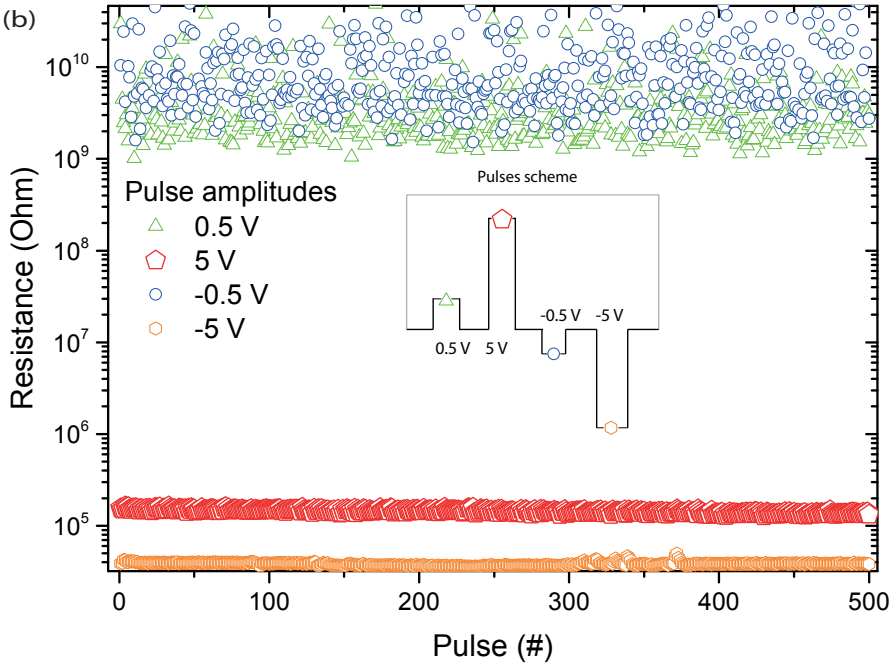
Testings carried out using a Keithley SCS 4200 - Semiconductor device analyzer.





Electrical Characterization - III

Tunable Voltage Margin

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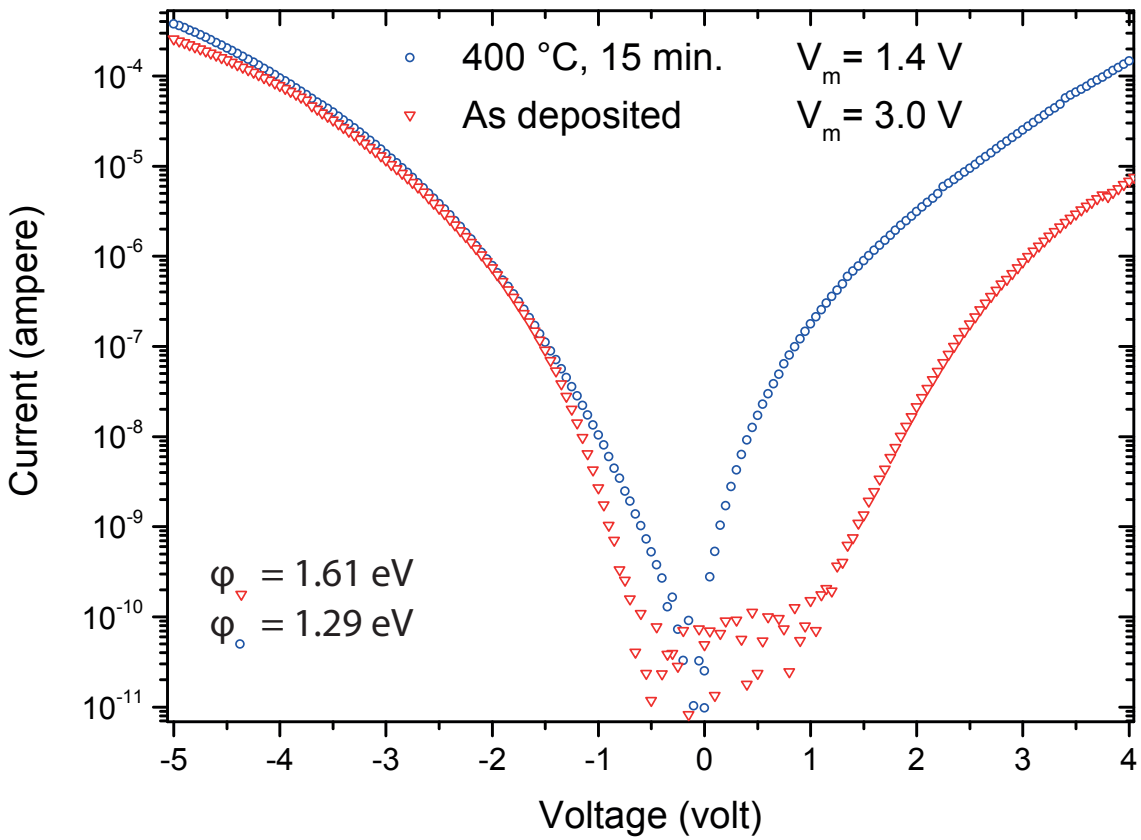
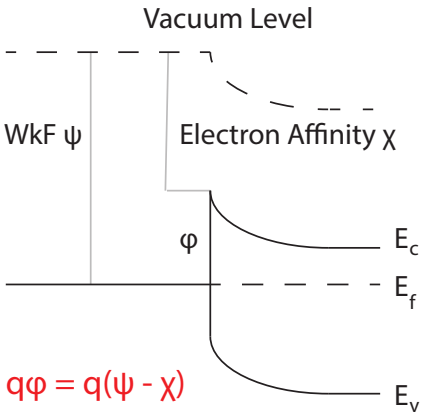
Annealing 400 C for 15 minutes: V_m decreases from 3 V to 1.4 V.





Nickel
Work function ψ = 5.04 eV

TiO_2

Anatase	χ = 4.80 [1] eV
Rutile	χ = 5.10 [1] eV
As dep.	χ = 3.43 eV
Annealed	χ = 3.75 eV

[1] Scanlon et al. Nat. Mat. 12, 789-901 (2013)

AFM Characterization

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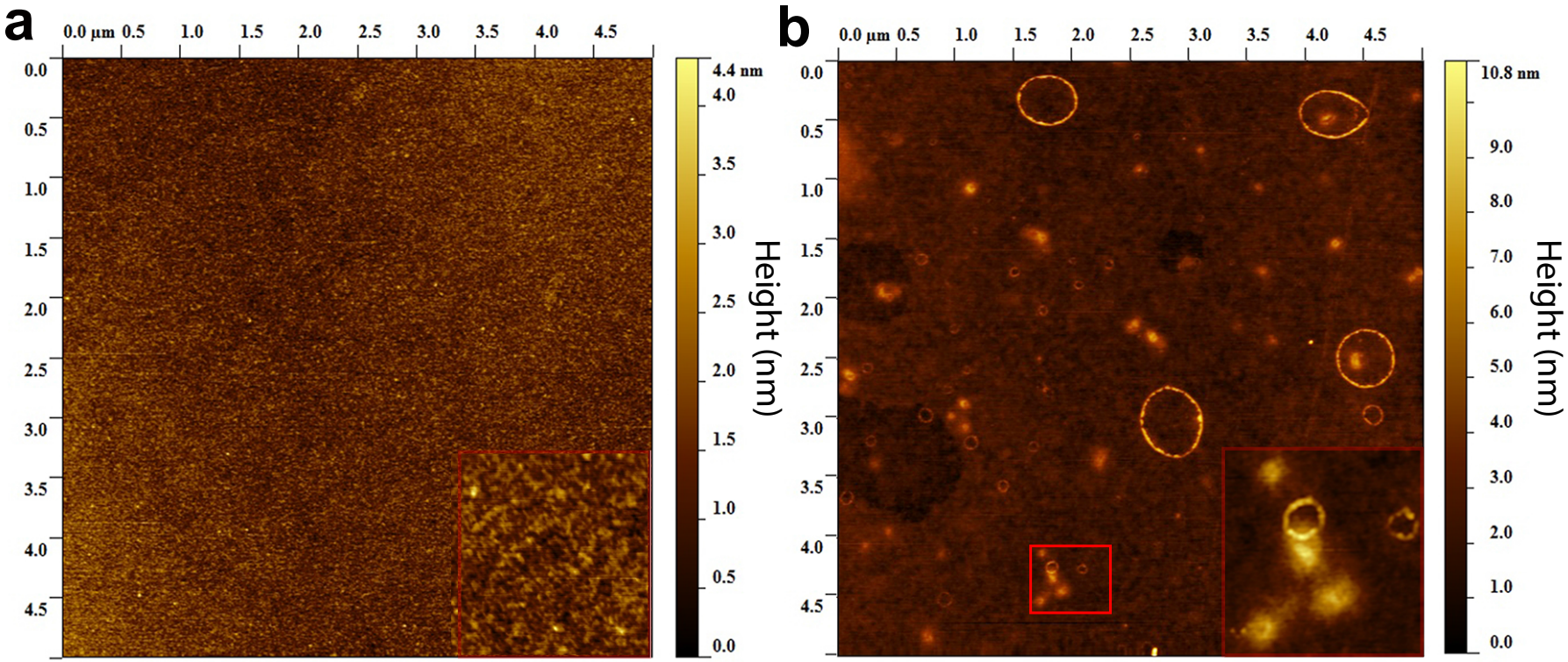

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Conclusion

What has been done so far..

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MIM selector device final overview:

- High voltage margin of 3 V.
- Tunable voltage margin by rapid thermal annealing at 400°C, without compromising device characteristics.
- Selector non linearity: 10^6.
- Current density: 10^4 A/cm^2.
- Compatibility: high, already crossbar-manufacturable.

Conclusion

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Thanks for your attention.

Question time

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Any question?