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Termination-Dependence of Resistive Switching in $SrTiO_3$-Based Valence Change Memory

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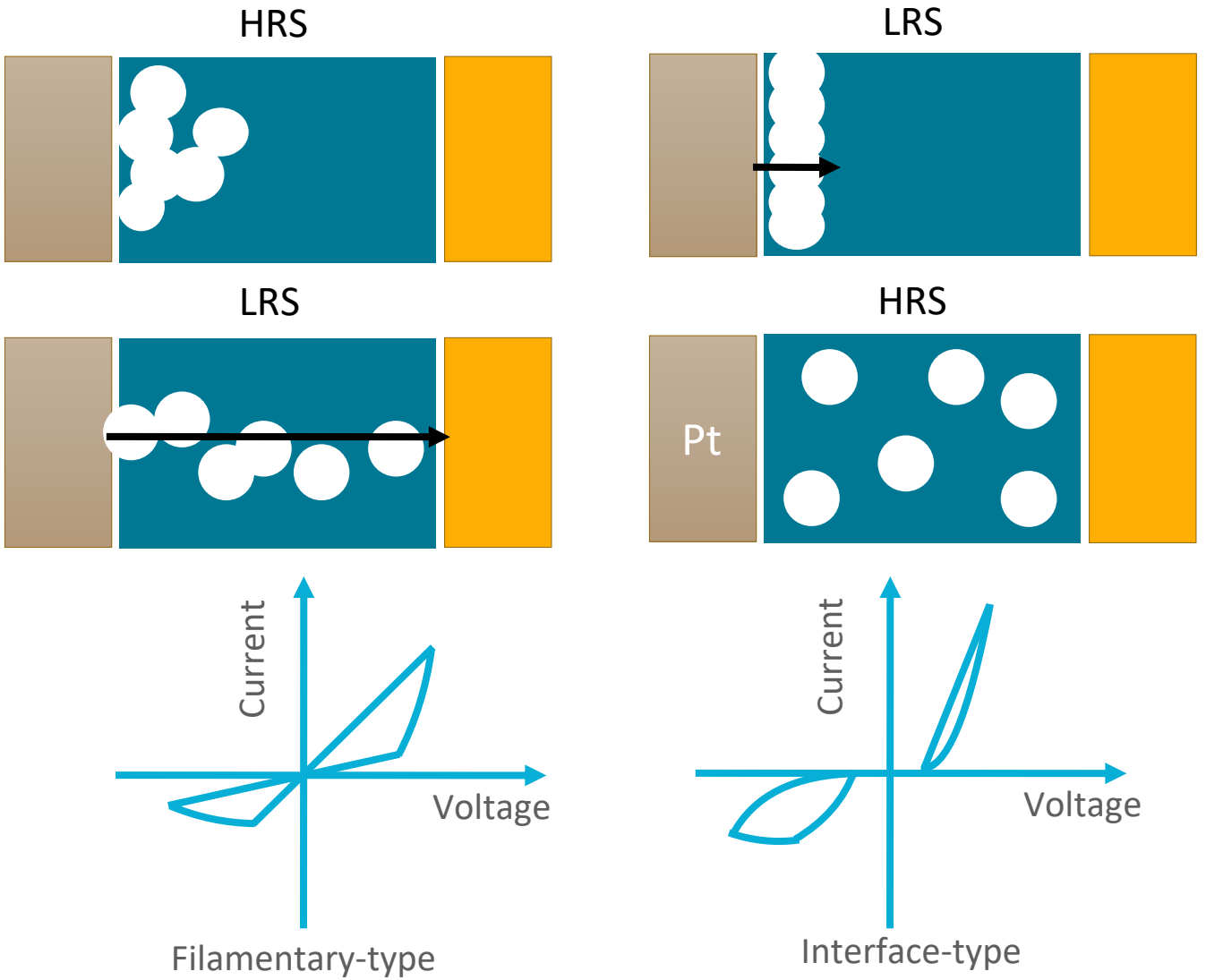
Outline

- Introduction
- Static model of switching in STO devices
- Dynamic model of switching in STO devices
- Conclusions

Introduction

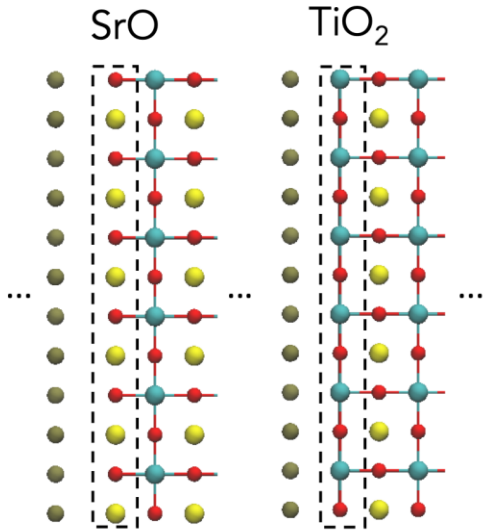
Valence change memory (VCM) cells: memristors whose resistance (conductance) is altered by changing the shape of the conductive filament that consists of oxygen vacancies

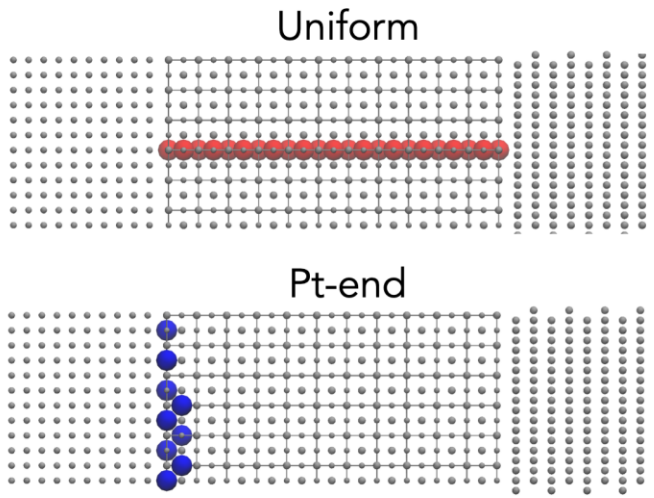


Possible mechanisms of interface-type switching:

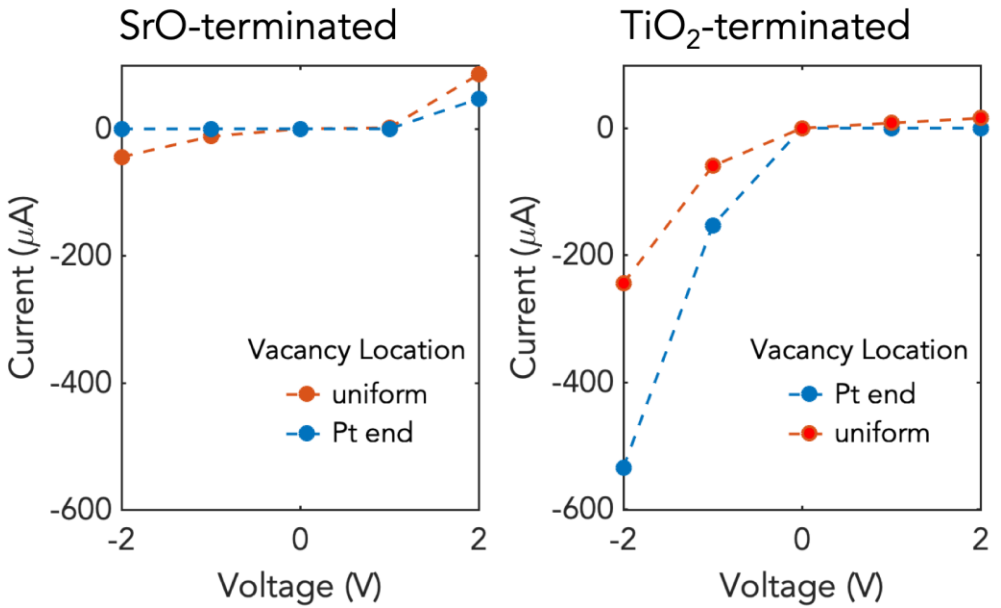
1. Vacancy relocation
2. Charge trapping
3. Vacancy generation at the interface

IV characteristics of STO devices





DFT → Transport



Filamentary type

Interface type

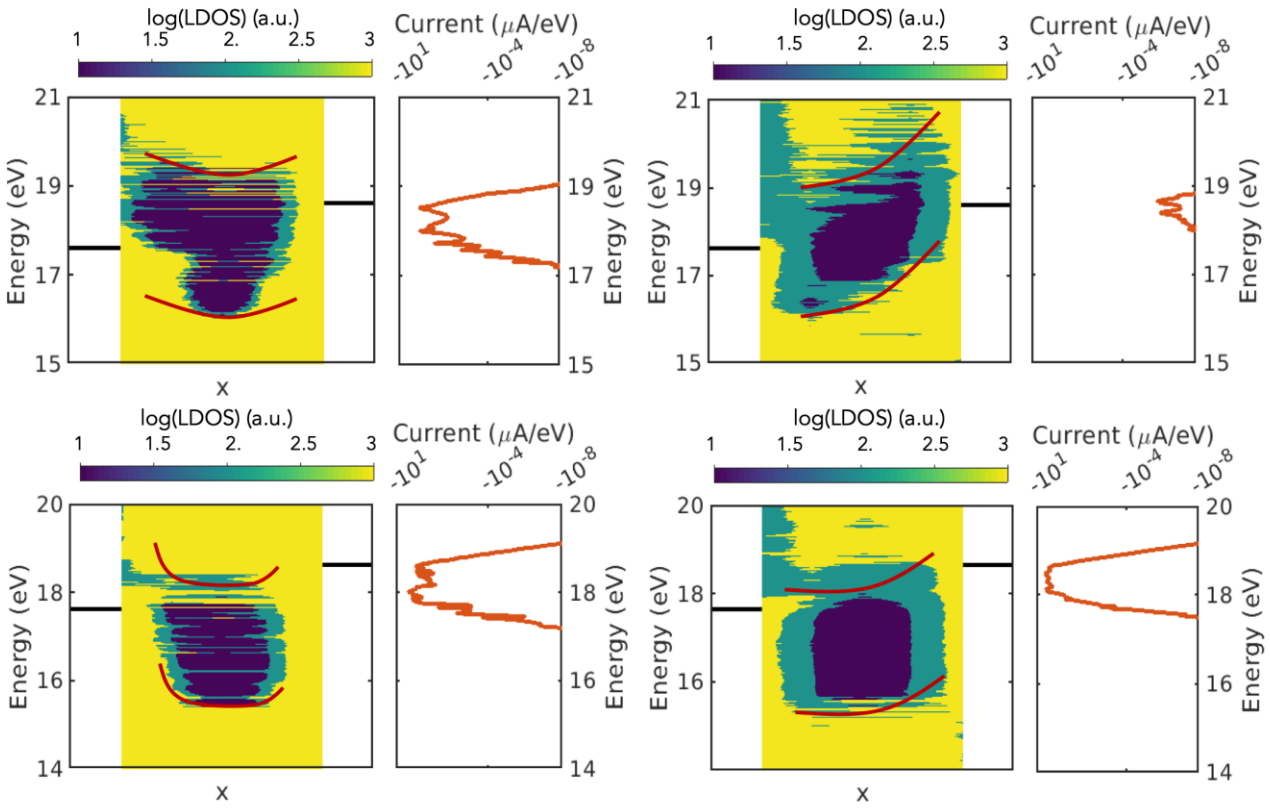
Band diagrams of STO devices

Uniform distribution

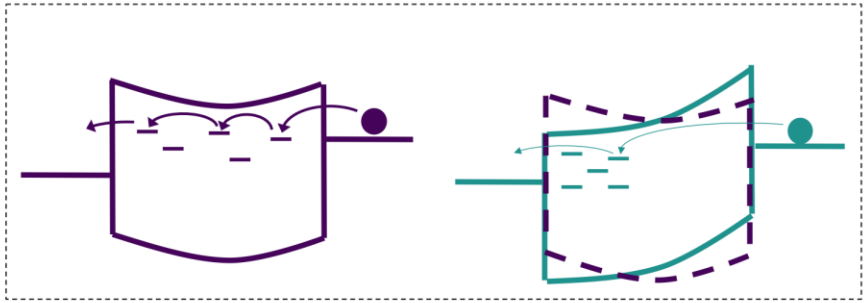
Pt end

SrO-terminated

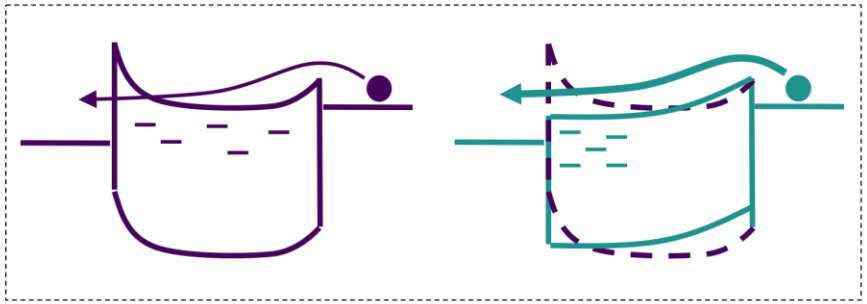
TiO_2-terminated



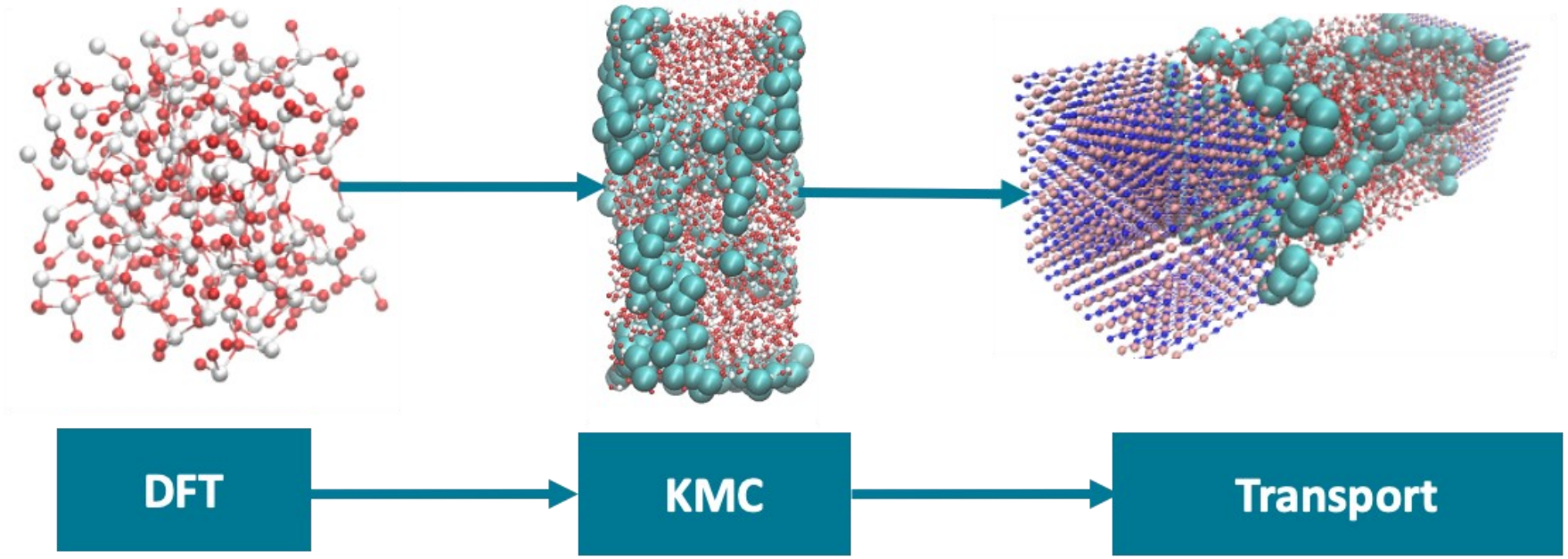
SrO-terminated



TiO_2-terminated



Dynamic Model: Overview

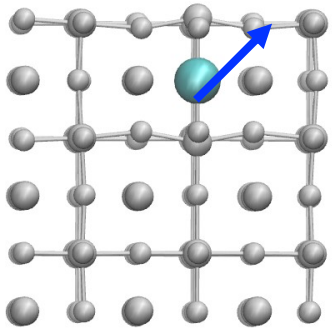


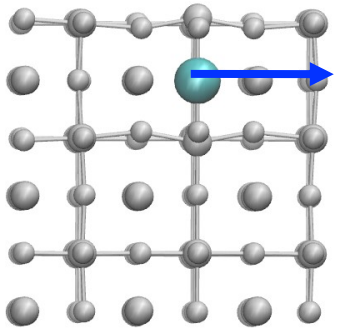
M. Kaniselvan, M. Luisier, and M. Mladenović, ACS Nano (2023)

DFT NEB Calculations: STO

Vacancy diffusion

0.34 eV



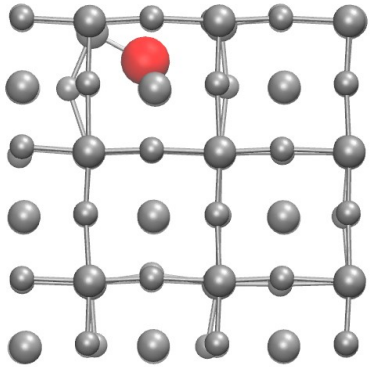


2.61 eV

Ion diffusion

Close to a vacancy	0.29 eV
Far from a vacancy	1.61 eV

Vacancy-ion pair generation in bulk

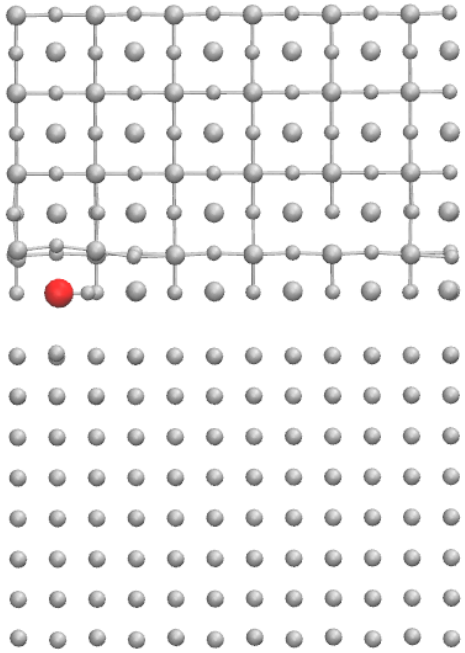


1.70 eV

Vacancy generation at the interface

STO

Pt

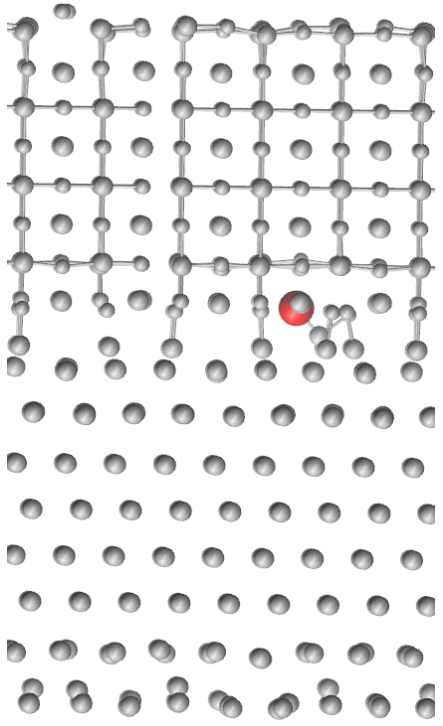


2.33 eV

1.50 eV

0.83 eV

2.05 eV

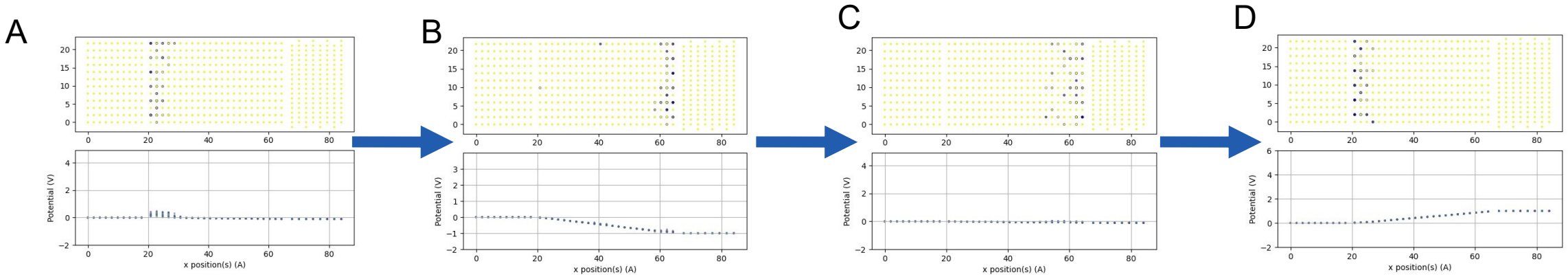


STO

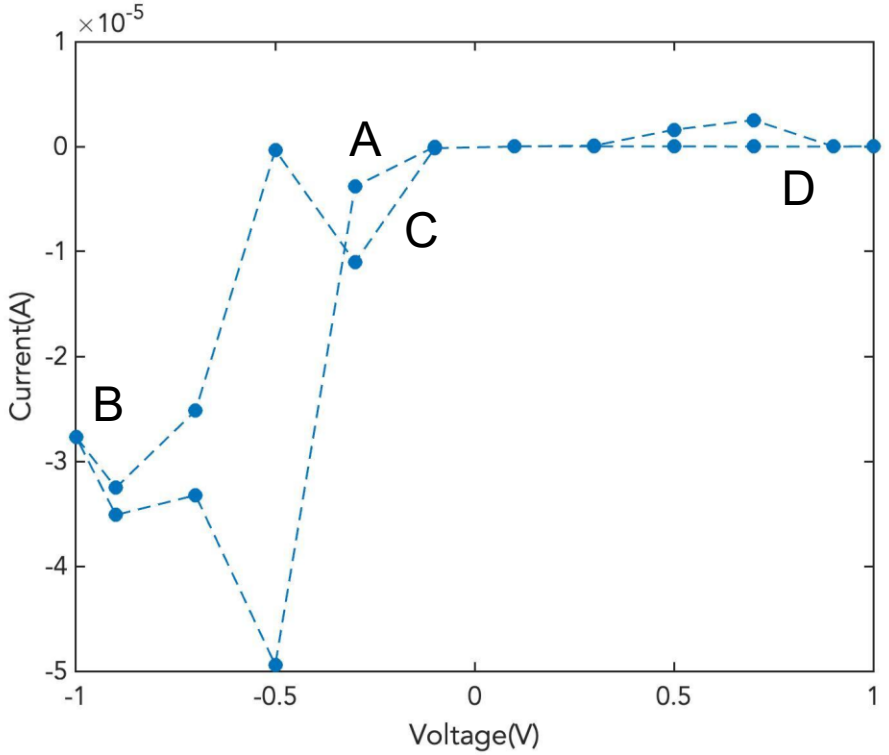
Ti

KMC simulations of STO devices

Switching cycle



0 V -1 V 0 V 1 V



1. Polarity-related asymmetry
2. Interface-type switching for the negative polarity

Conclusions

- Termination plays a role in defining the charge transport mechanism across a device
- Relocation of the vacancies can model the interface type switching
- Different interfaces exhibit different vacancies generation activation energies

Acknowledgements

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