

Current-density-modulated Antiferromagnetic Domain Switching in CoO(001)/Pt Bilayer Revealed by Optical Imaging

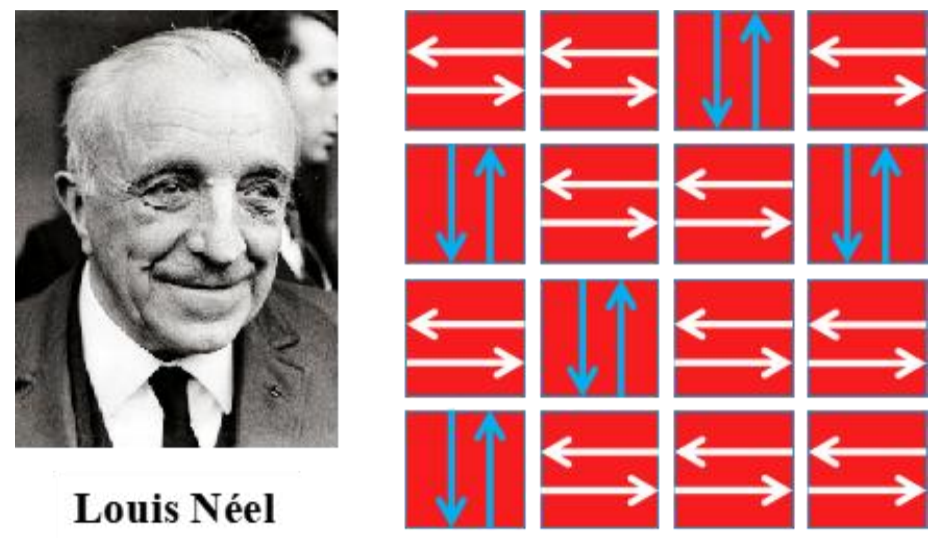


Tong Wu¹, Haoran Chen¹, Jia Xu¹, Yizheng Wu¹

¹ Physics department, Fudan University, Shanghai, China

Motivation

Antiferromagnetic Spintronics

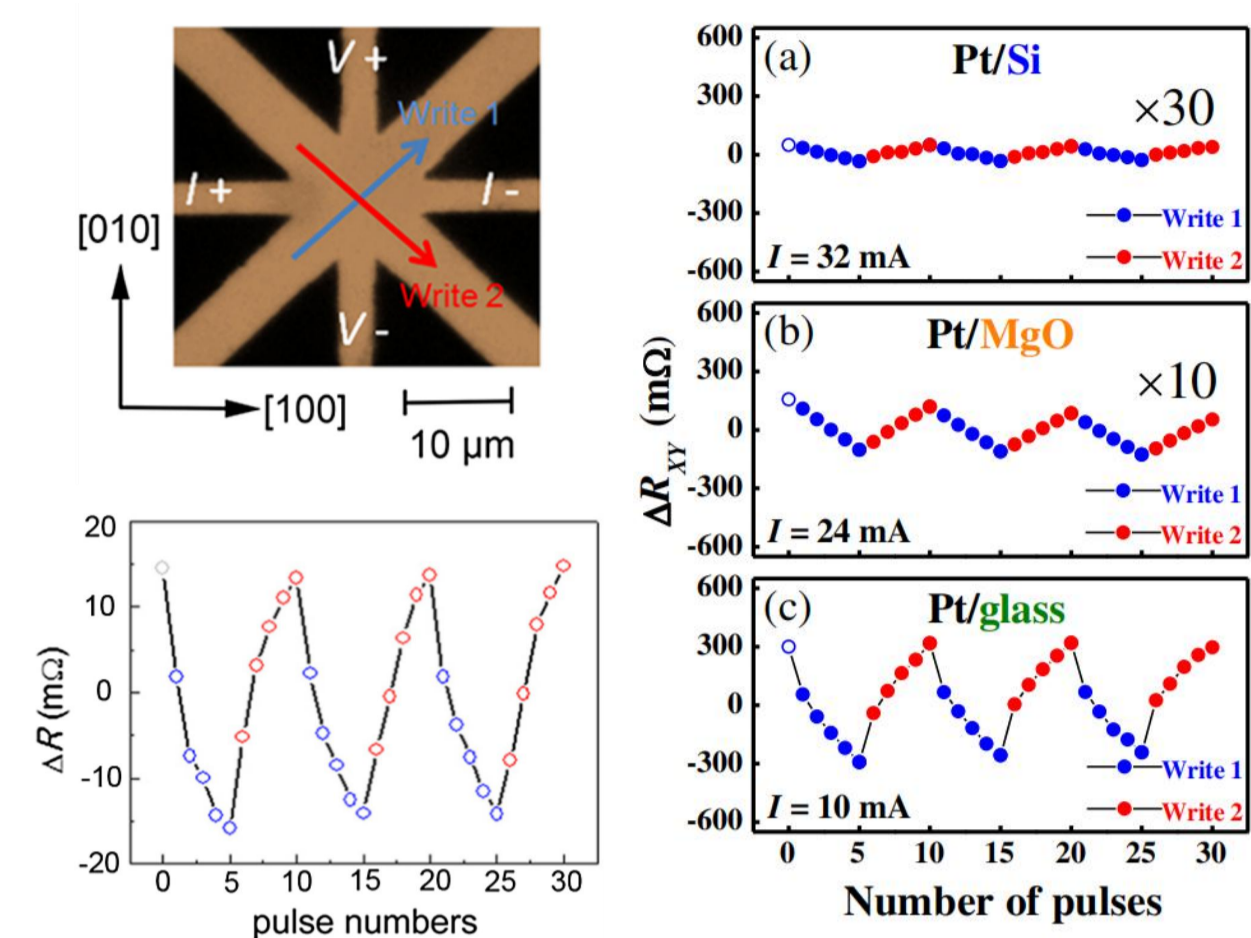


Louis Néel

- ✓ High-density data storage
- ✓ Absence of stray fields
- ✓ Ultrafast dynamics (THz)
- ✓ High energy efficiency

➤ Attractive and promising!

Electrical detection of AFM domain switching

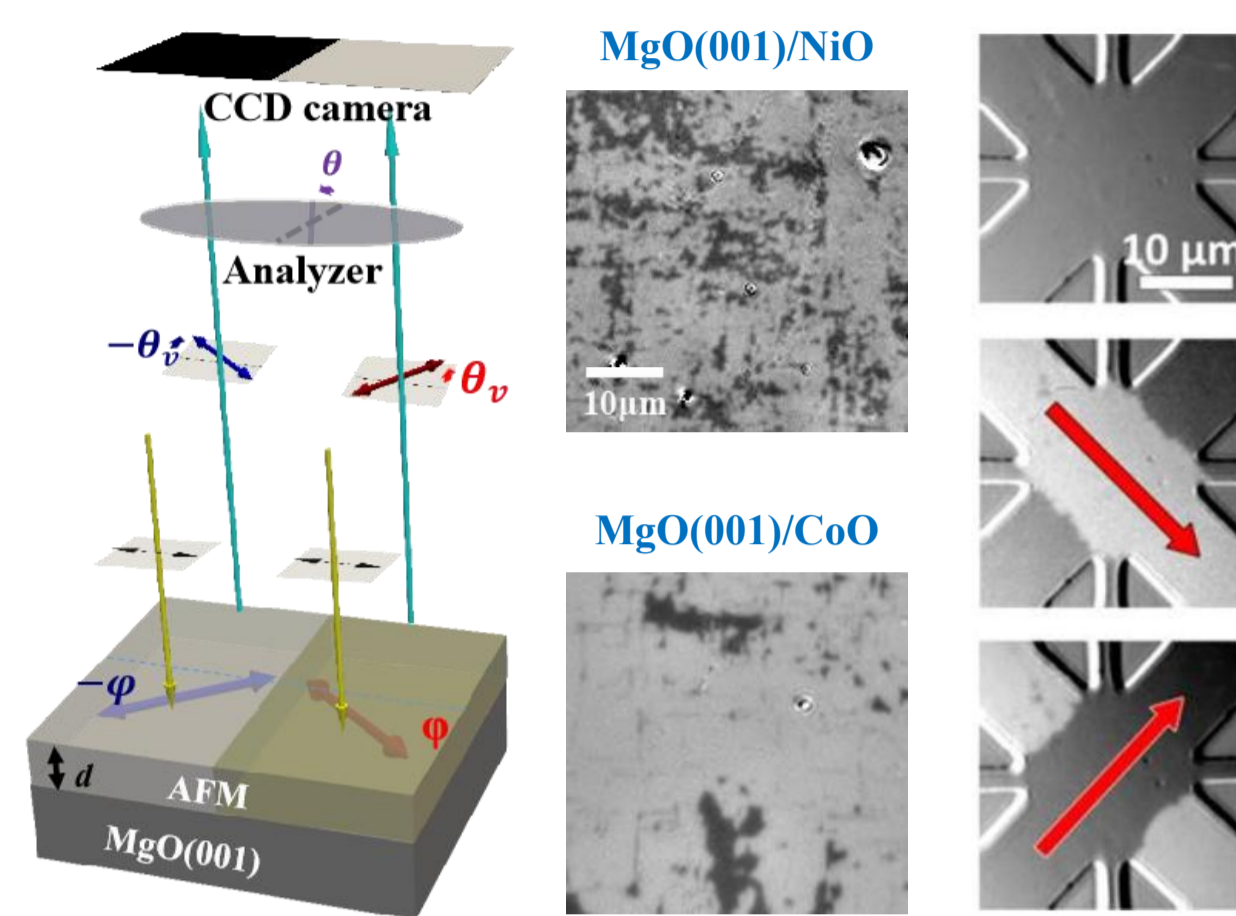


X.Z. Chen, et al. PRL (2018)

C. C. Chiang, et al. PRL (2019)

➤ Non-magnetic origin?

Direct imaging of AFM domain



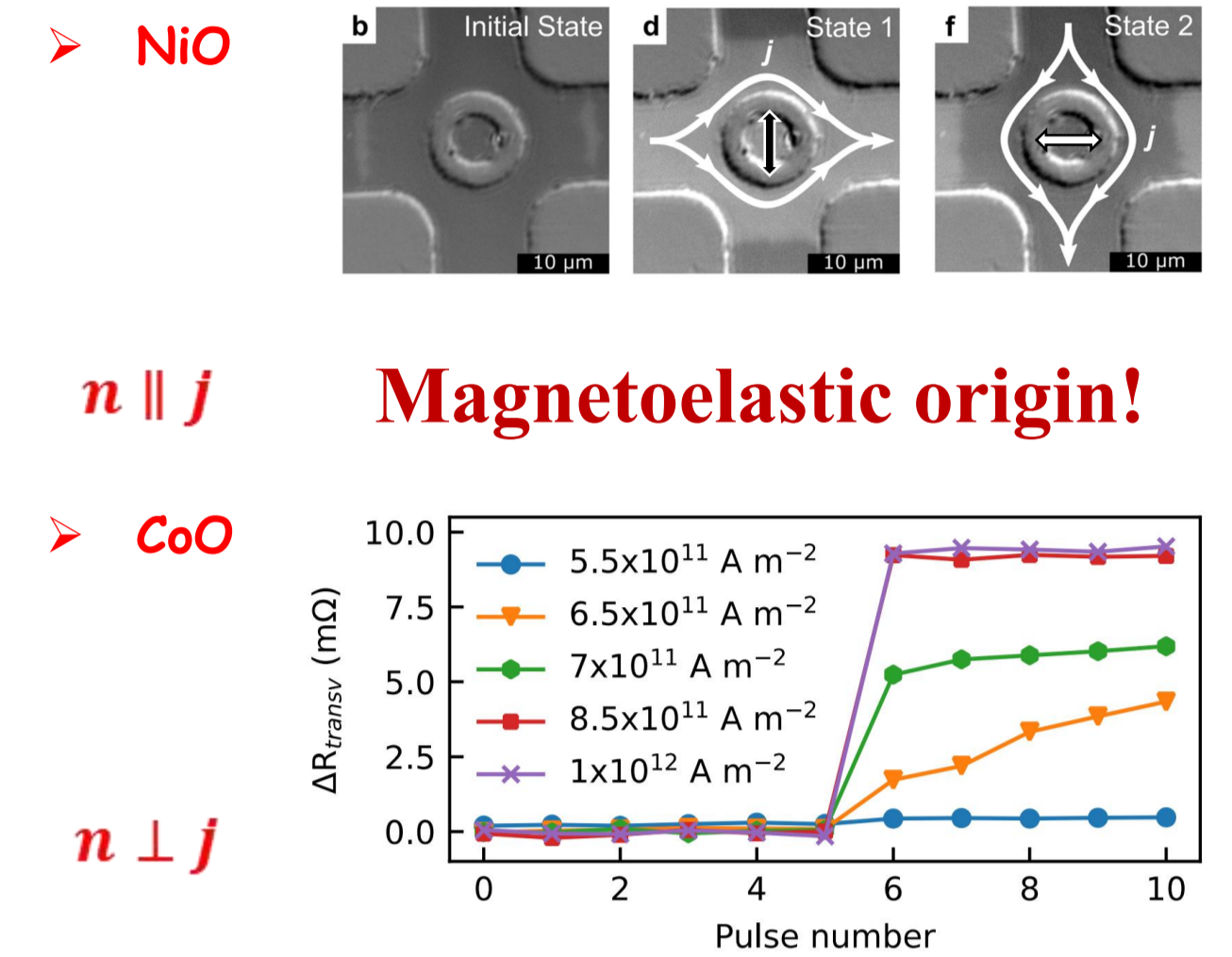
J. Xu, et al. Phys. Rev. B (2019)

F. Schreiber, et al. APL (2020)

J. Xu, et al. New J. Phys. (2020)

➤ Real domain switching!

Current switching mechanism



➤ NiO

$n \parallel j$

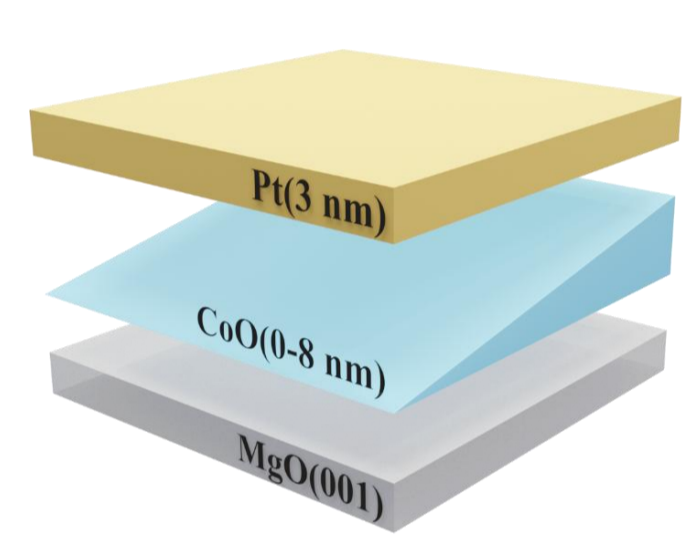
➤ CoO

$n \perp j$

➤ AFM domain switching in CoO?

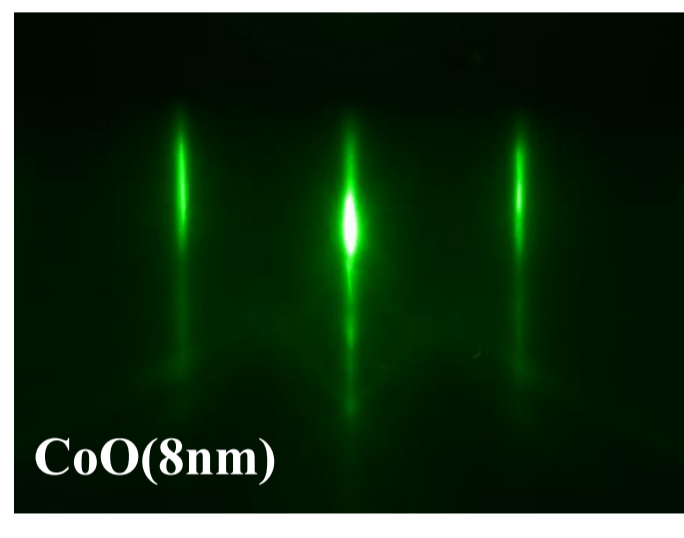
Sample preparation and measurement

Sample structure



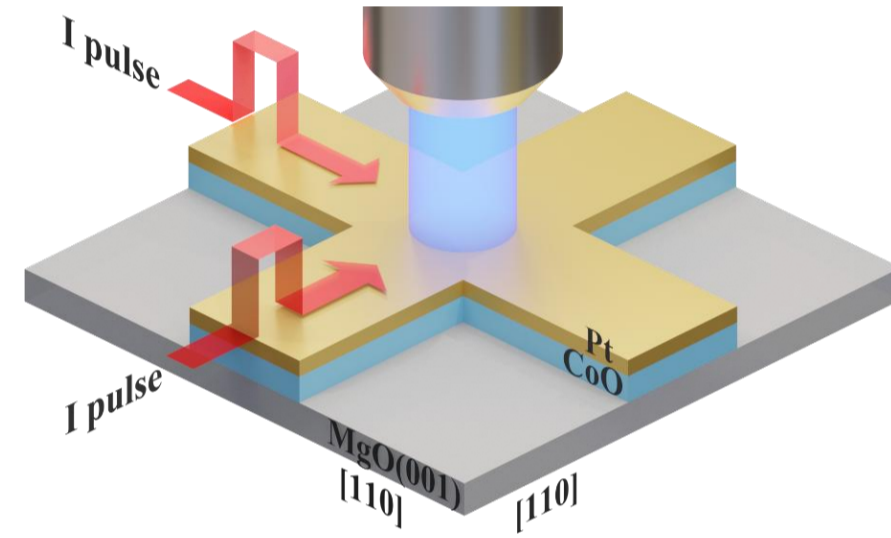
CoO wedge film

RHEED pattern



High quality single crystal film

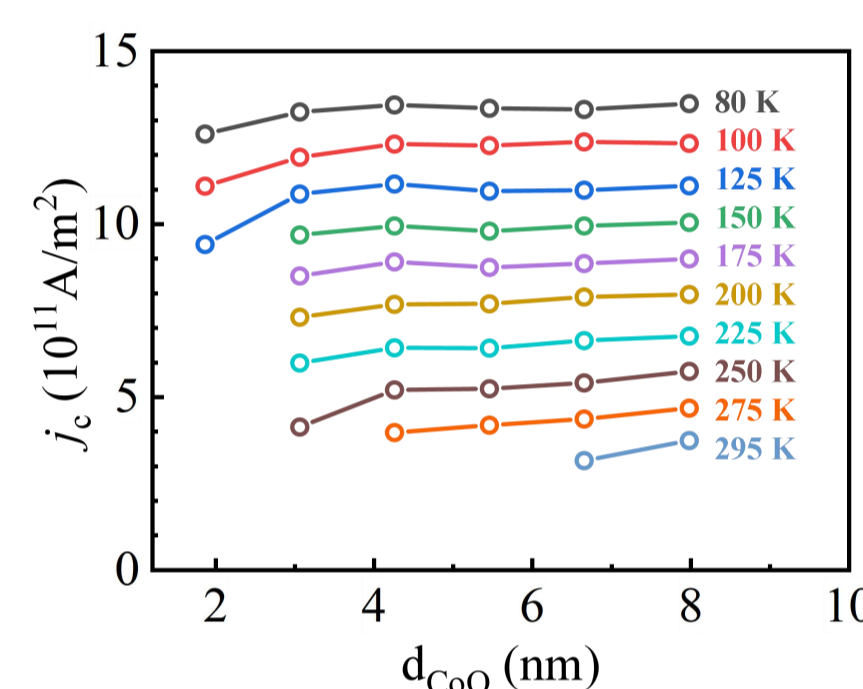
Measurement



Imaging domain switching

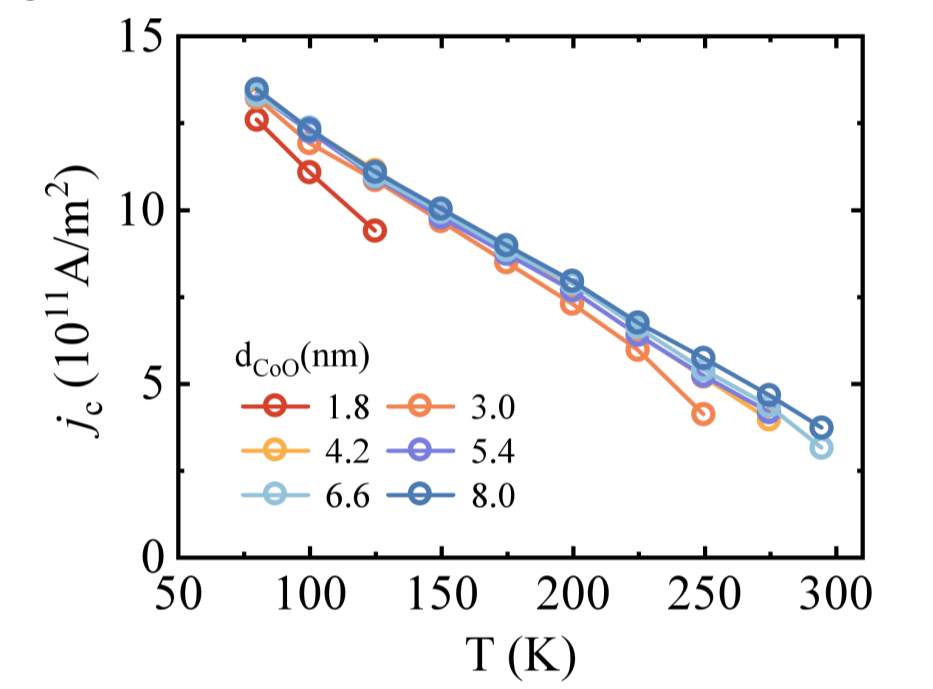
Mechanism for current switching

j_c Vs. d_{CoO}



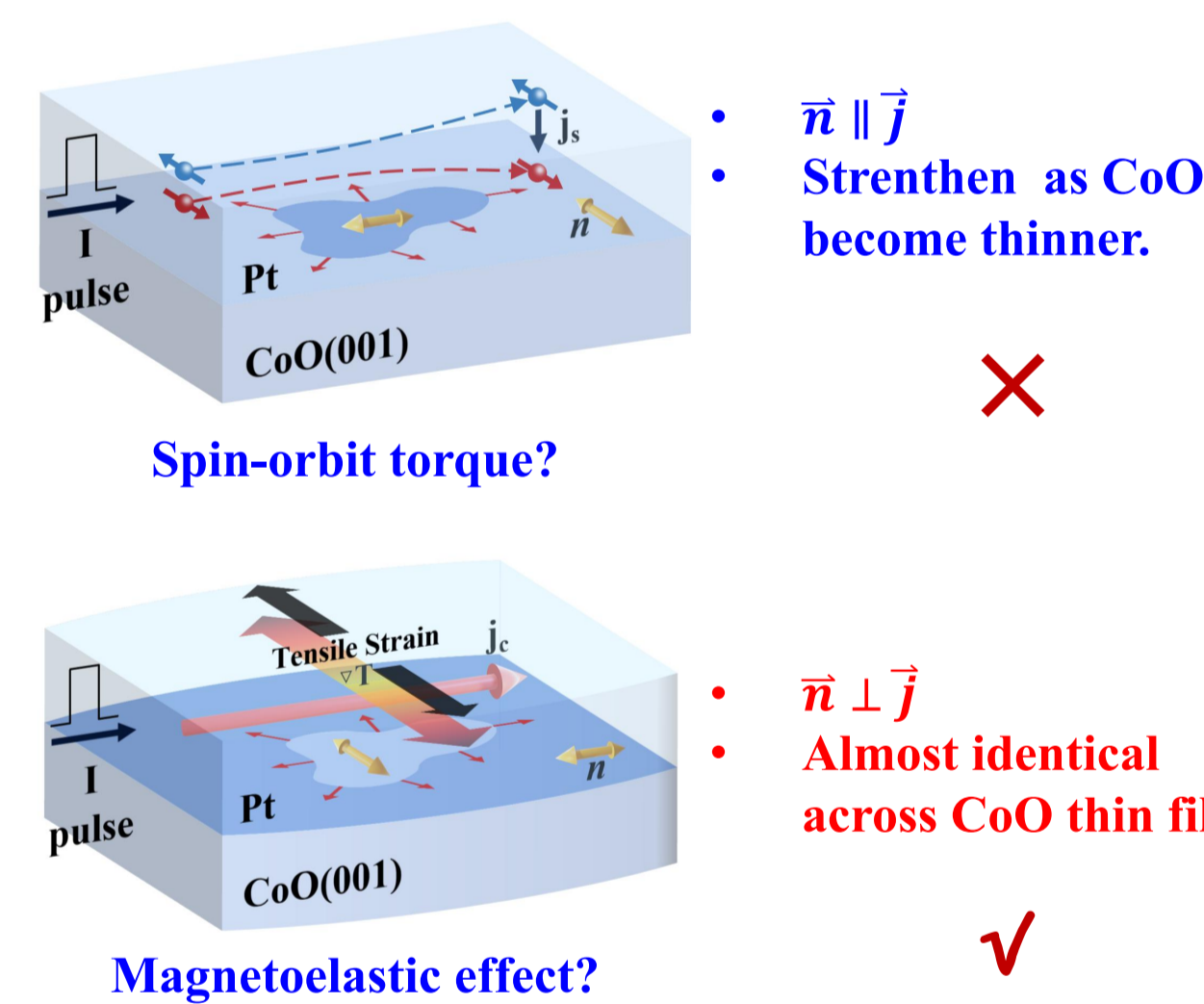
➤ j_c is independent of d_{CoO} with a fixed T

j_c Vs. T



➤ j_c decreases linearly with the T

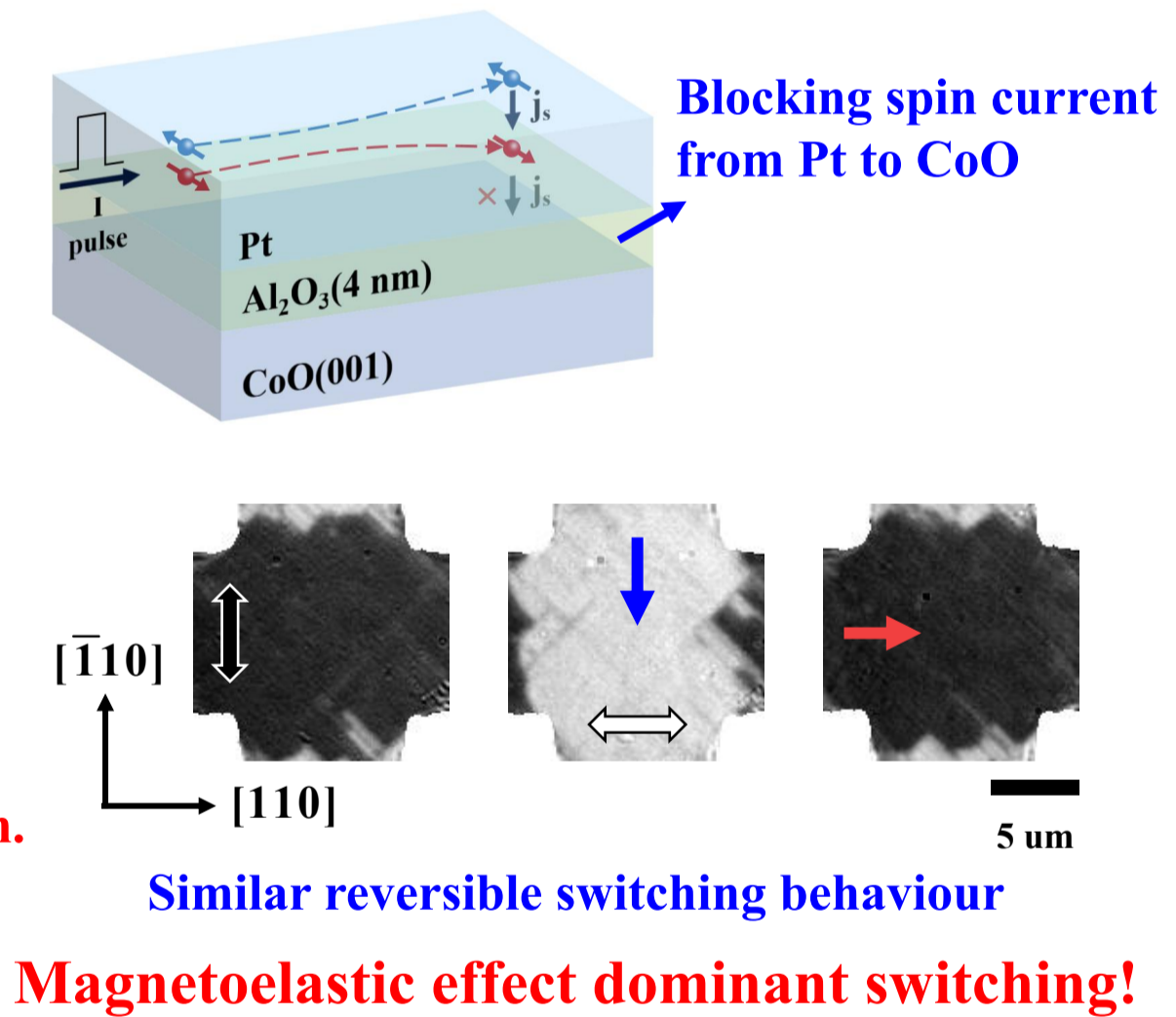
Possible switching mechanisms



- $\vec{n} \parallel \vec{j}$
- Strengthen as CoO become thinner.

- $\vec{n} \perp \vec{j}$
- Almost identical across CoO thin film.

Identify switching mechanism

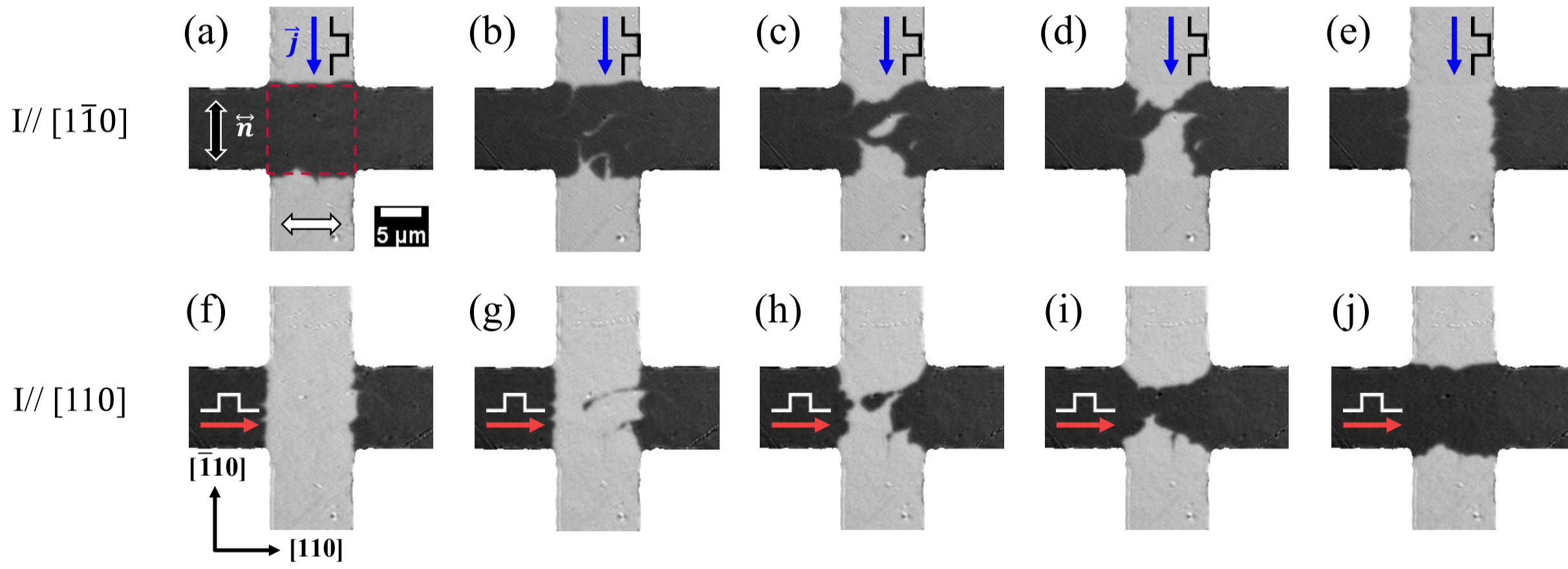


Blocking spin current from Pt to CoO

Similar reversible switching behaviour

➤ Magnetoelastic effect dominant switching!

T dependence switching

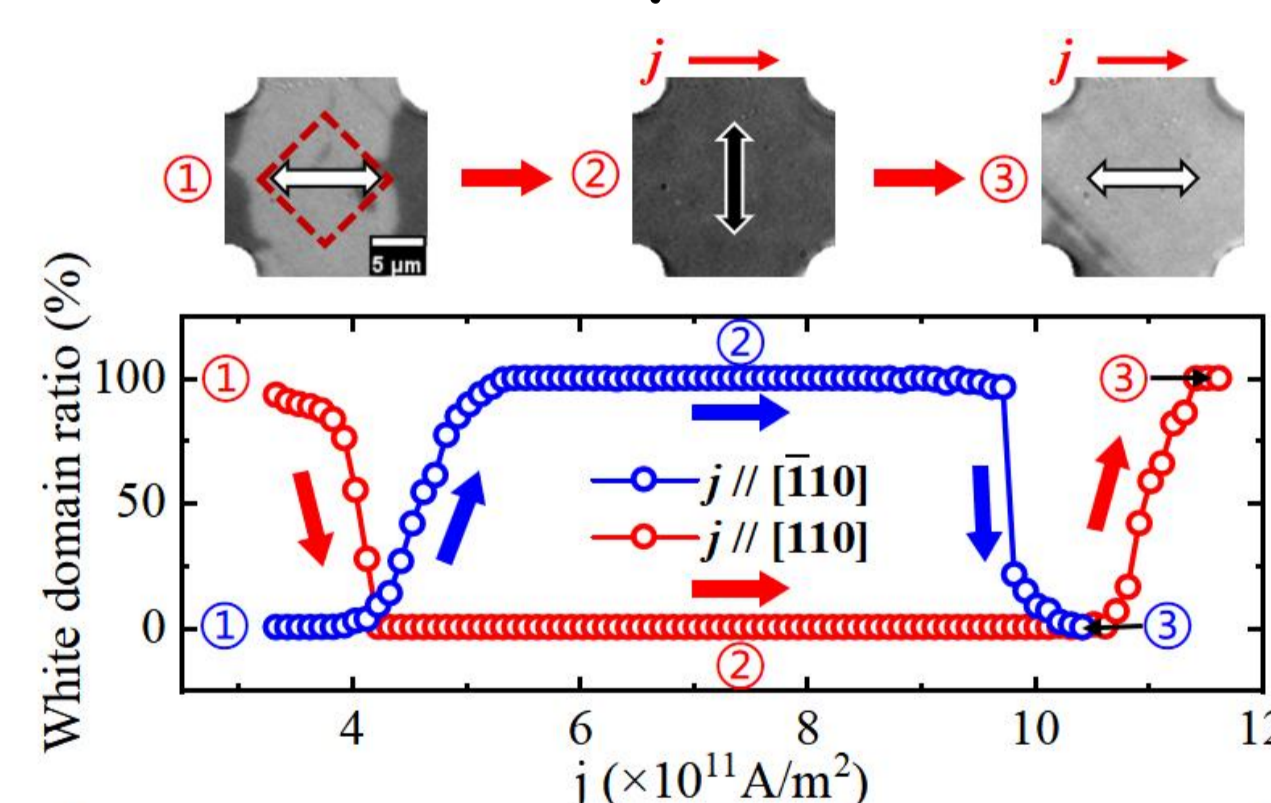


➤ Reversible and clear AFM domain switching.

➤ AFM domain switching could be realized within a wide range of temperature for 8 nm CoO.

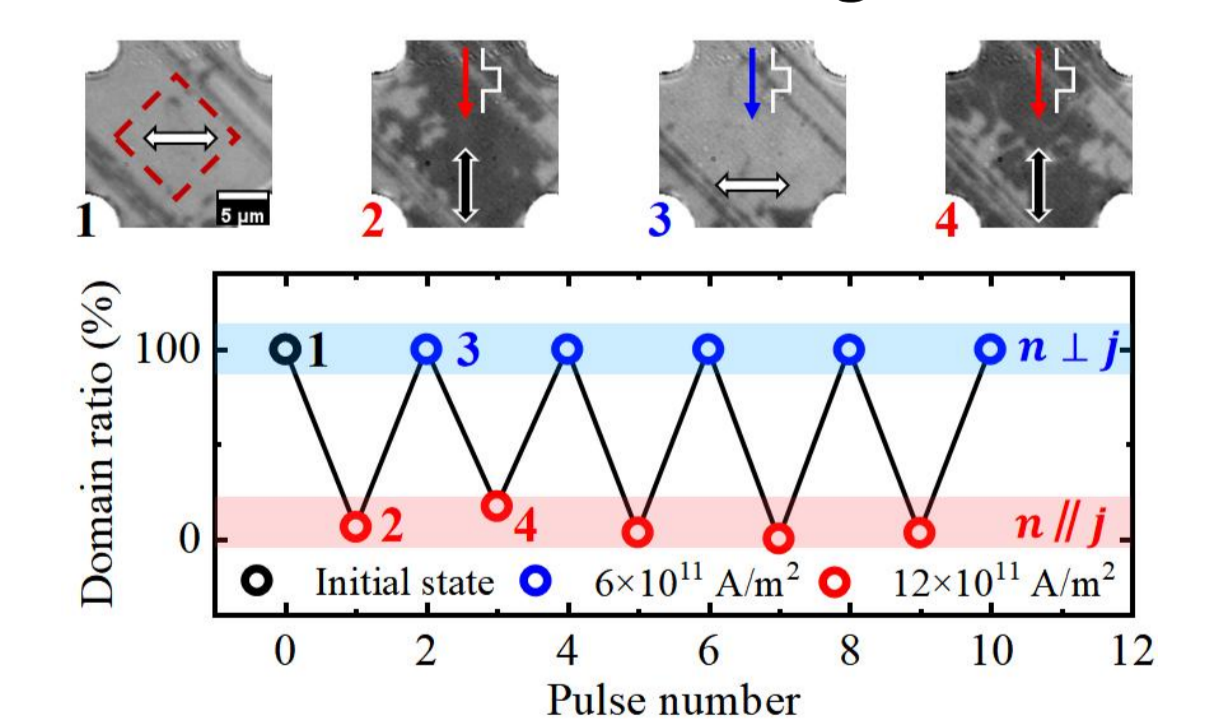
Current-density-modulated switching

Switching curve with increasing current density

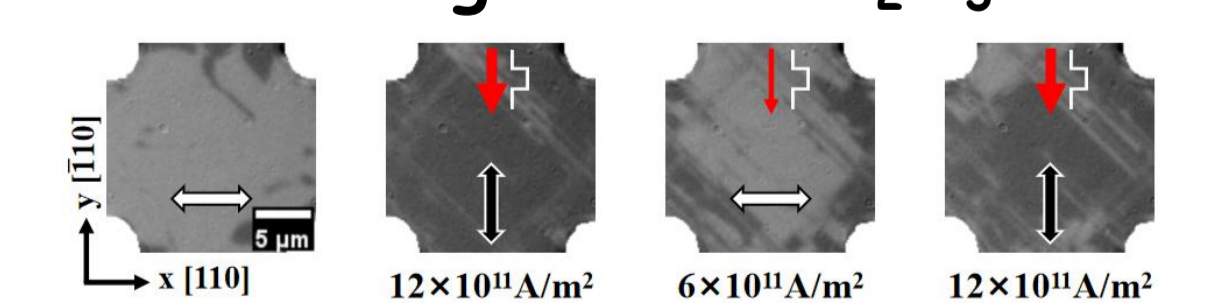


➤ Switching polarity changes at higher j

Reversible switching

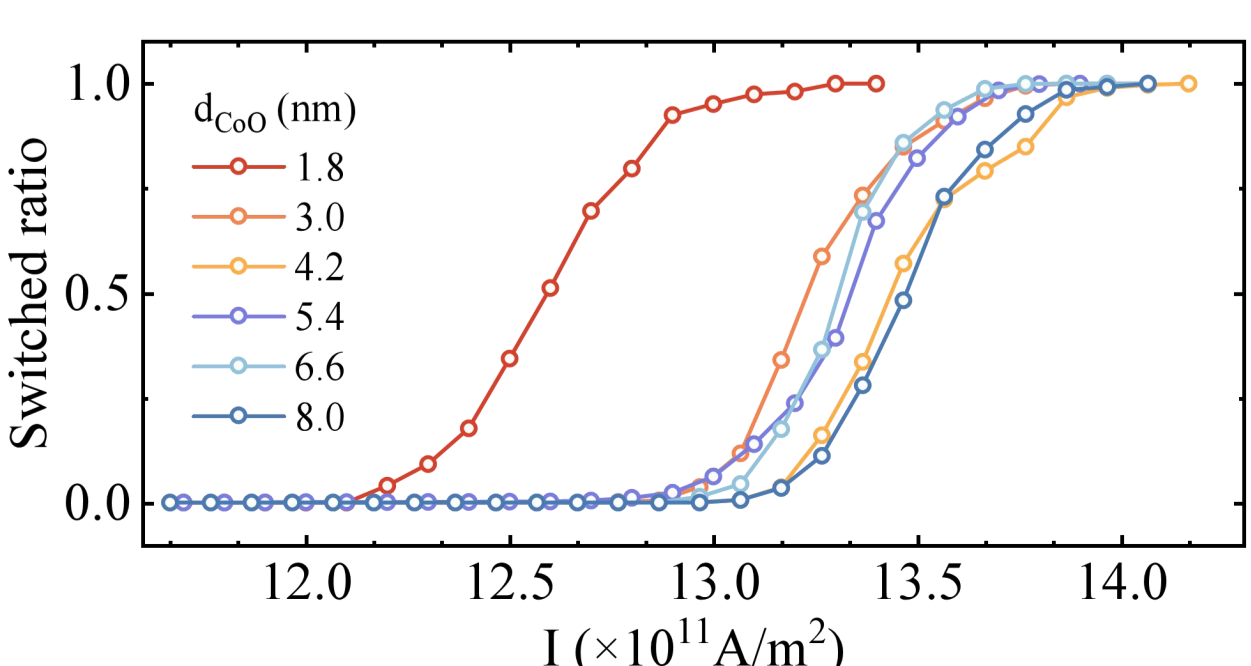
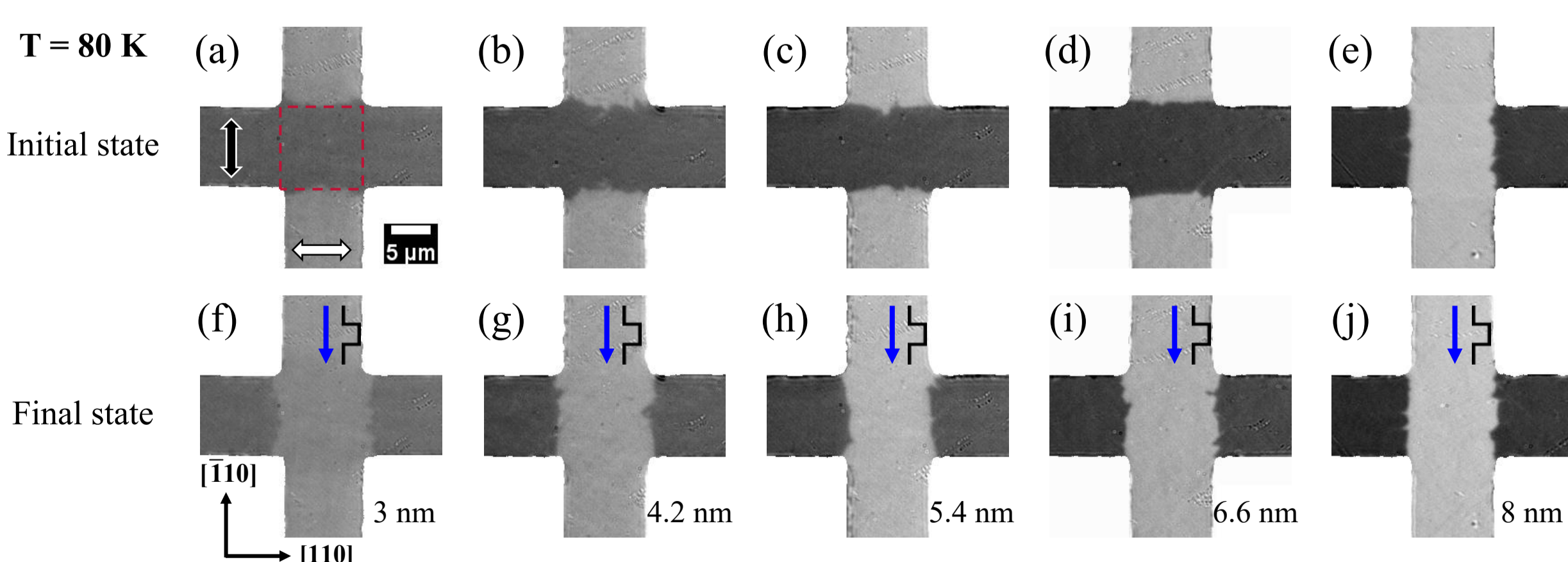


➤ Switching in CoO/Al₂O₃/Pt



- Excluding SOT contribution
- Different strain distribution at higher j

d_{CoO} dependence switching



➤ Switching could be observed in ultra-thin CoO film.

➤ Switching polarity are the same for different CoO thickness.

Summary

Imaging current switching of AFM domains in CoO/Pt

- AFM domain switching was observed with different T d_{CoO} .
- Magnetoelastic effect dominates the domain switching.
- Switching polarity could be modulated by changing current density.

Tong Wu, et al., Phys. Rev. Appl. 21, 044054 (2024)