Field-free spin-orbit switching of the Co/Pt multilayer grown on RuO_2

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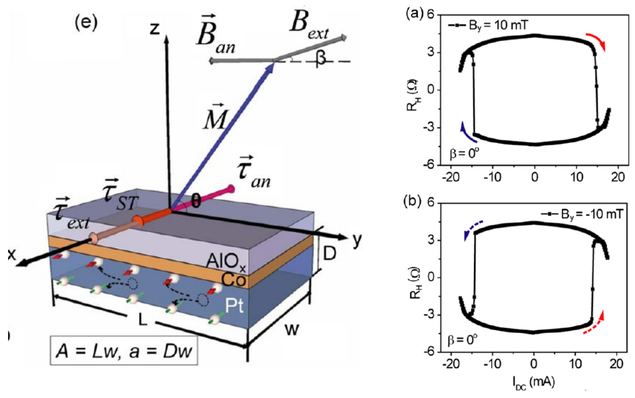
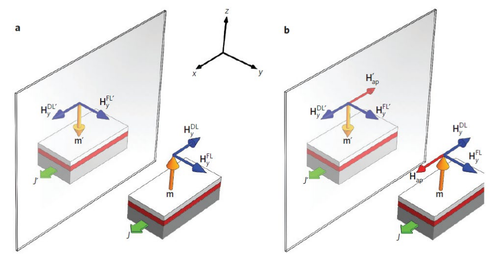
Introduction

- Spin Hall effect induced switching of the magnetization.



Liu *et al.*,Phys. Rev. Lett. 109, 096602 (2012)

- The in-plane magnetic field breaks the symmetry → magnetization switching.



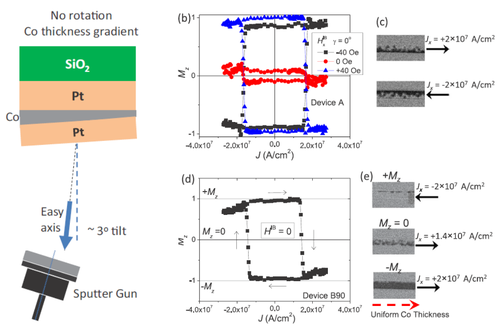
polar vector(I)— Parallel to the mirror → unaltered
Perpendicular to the mirror → reverse

axial vector(m,H_{ext})— Parallel to the mirror → reverse
Perpendicular to the mirror →unaltered

Nat. Nanotechnol. 9, 548–554 (2014)

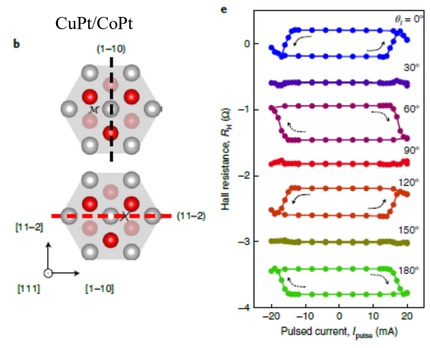
- Method for achieving field free switching.

Tilted easy axis



Vineeth Mohanan P. *et al.*, PRB **96**, 104412 (2017)

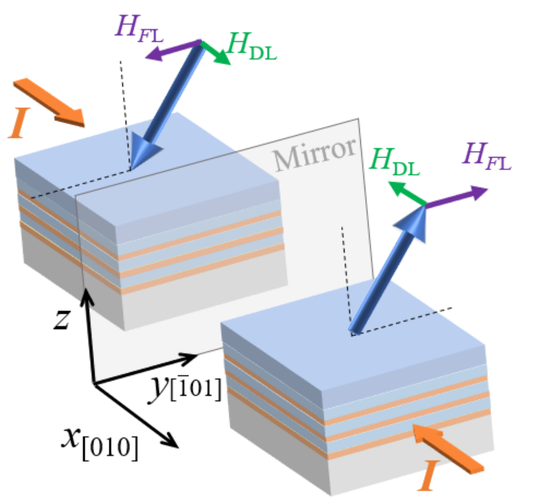
Reduce in-plane symmetry



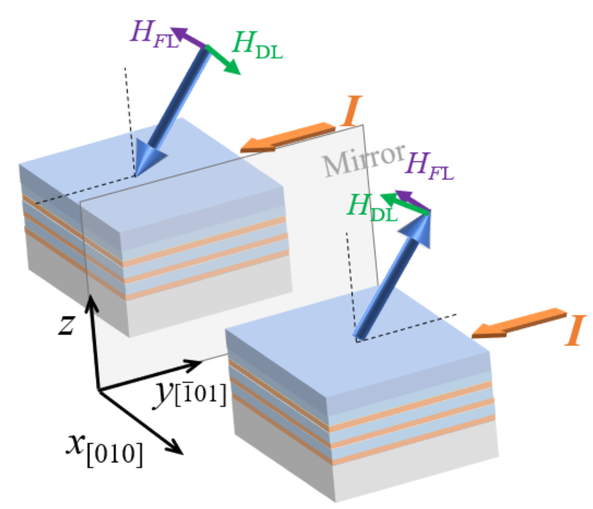
Liang Liu *et al.*, Nat. Nanotech. 16, 277 (2021)

Symmetry analysis

√ Field-free switching

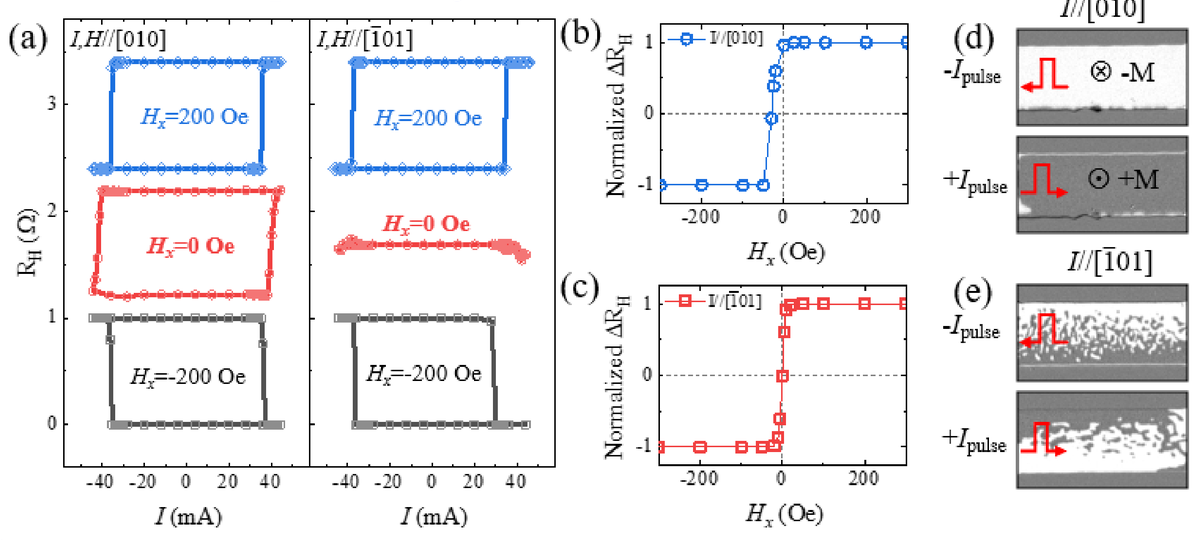


× Field-free switching



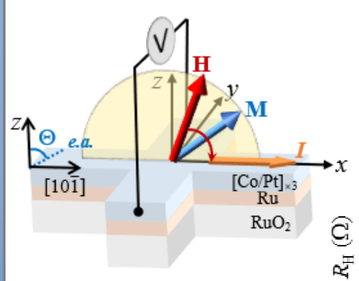
Field-free switching

Sample1:RuO_2/[Co/Pt] $_{\times 3}$/Pt(2)

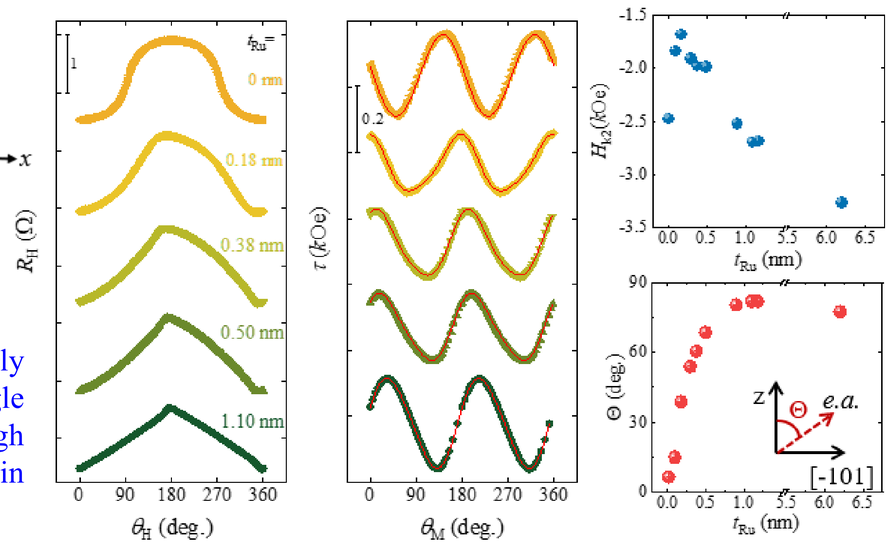


➢ Field-free switching can be achieved when the current is along RuO_2[010]

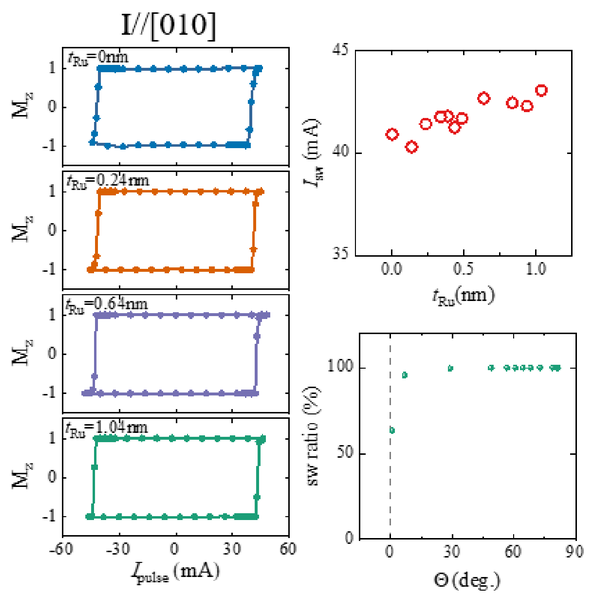
Continuous variation of Θ

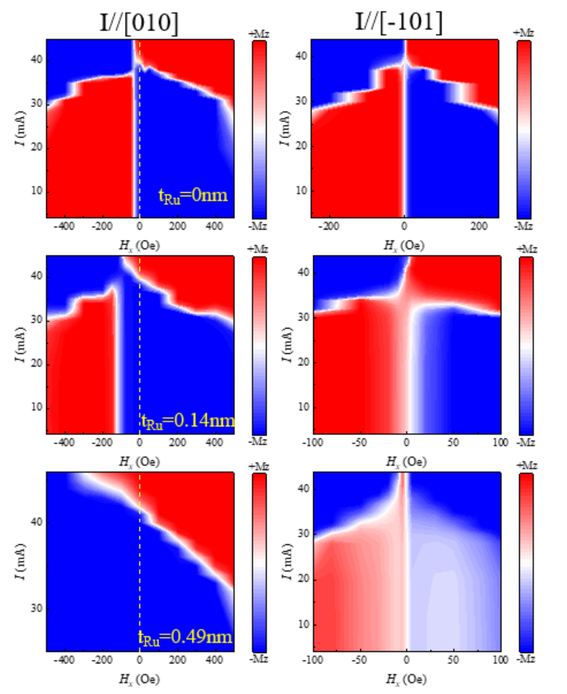


➢ We can quantitatively control the tilt angle of easy axis through inserting an ultra-thin Ru.



Switching with various t_{Ru}

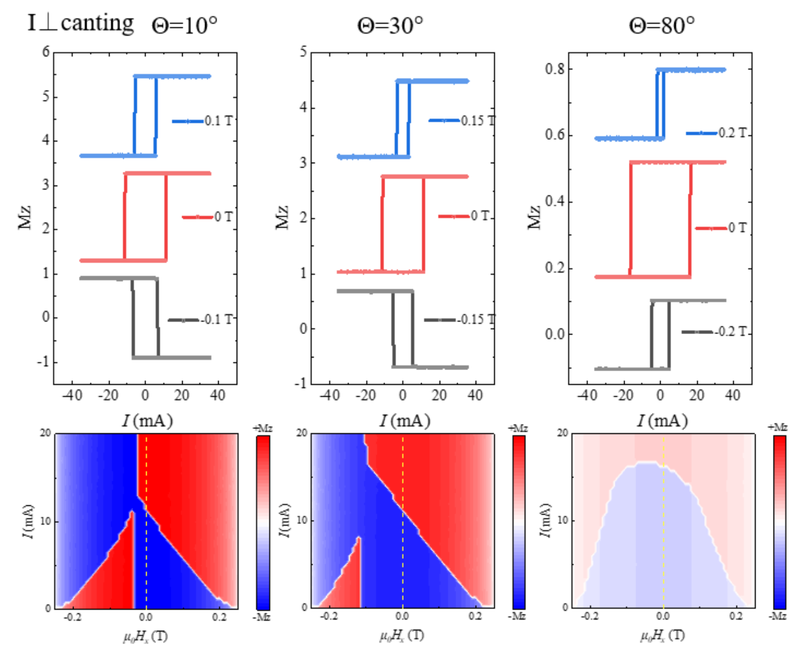




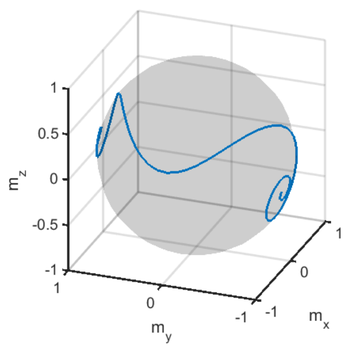
➢ Field-free switching can be observed in all samples;
➢ When the tilt angle reached 6.7°, the field-free switching ratio exceeded 95%.

➢ Higher tilt angle correspond to the greater asymmetry in the RuO_2[010] direction.

Macrospin simulation



➢ When Θ is greater than 60 degrees, mainly type-Y switching mode dominates



Summary

- The field-free switching when the current injecting in the RuO_2[010] direction is realized by the canted magnetization of [Co/Pt]$_{\times 3}$ multilayer.
- We can quantitatively control the tilt angle of easy axis through inserting an ultra-thin Ru.
- Through macrospin simulation analysis, we confirmed that once the tilt angle exceeding 60 degrees, type-Y-dominated switching occurs.