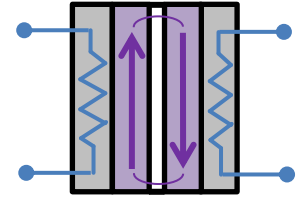


Theme 4: Nanomagnetism



Co-PIs: Jeff Bokor, Sayeef Salahuddin (UCB), Sakhrat Khizroev (FIU), Shan Wang (Stanford)

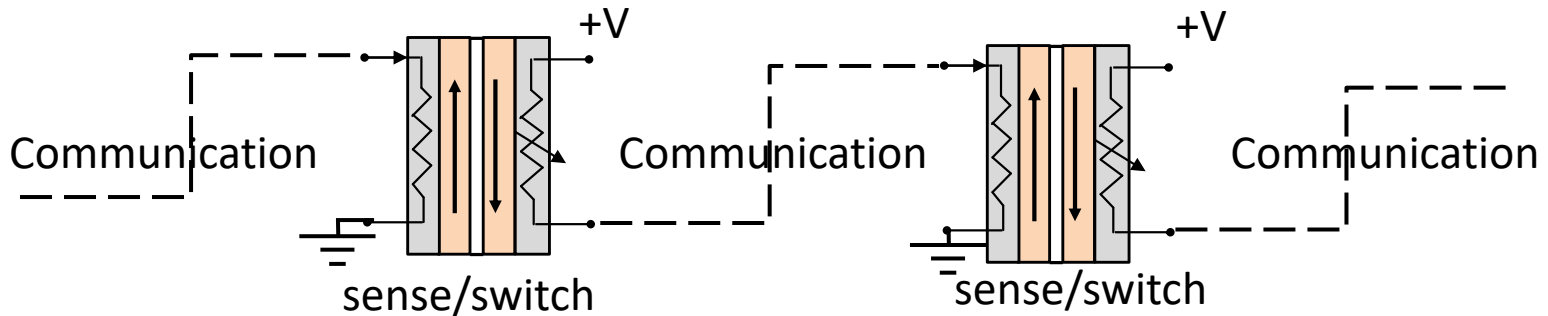
System Integration: Vladimir Stojanovich (UCB),

Graduate Students/Postdocs: Jyotirmoy Chatterjee, (UCB), Amal El-Ghazaly (UCB), Hyejin Jang (UCB), Xiang Li (Stanford), Rawan Naous (UCB), Brayan Navarette (FIU), Yoonhwan Kang (UCB), Akshay Pattabi (UCB), Marc Stone (FIU), Ingrid Torres (FIU)



Theme Overview

**Main Goal: Realize a Magnetic Switch to Meet E³S Device Specs
(Theme Leader: Jeff Bokor)**



**Low operating voltage
Fast switching speed**

Electrical interconnect

On/off ratio

Understand circuit/system applications



1/14/16

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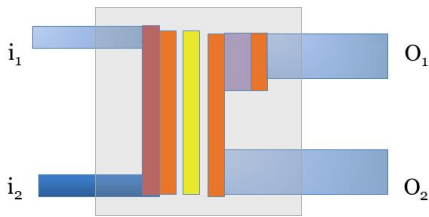
NSF 2016 Site Visit

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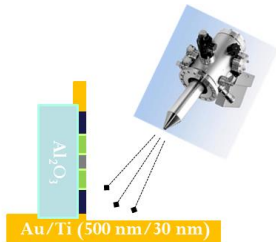
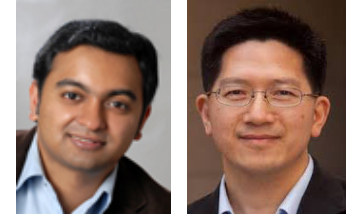


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Current Theme Projects & PI's



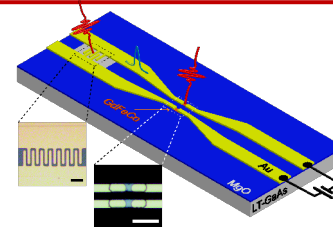
- High-gain spin-orbit torque switch
[Salahuddin, Wang]



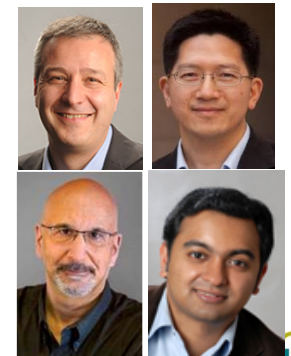
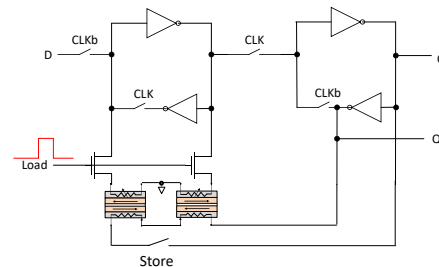
- Ultra-low switching current in sub-10 nm MTJs [Khizroev, Bokor]



- High-speed nonequilibrium magnetic switching [Bokor, Salahuddin]
 - Non-precessional, sub-10 psec switching time

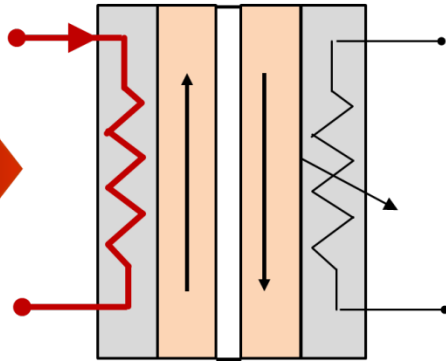


- Circuit/systems design and integration [Stojanovic, Wang, Bokor, Salahuddin]
 - Use non-volatility to overcome leakage



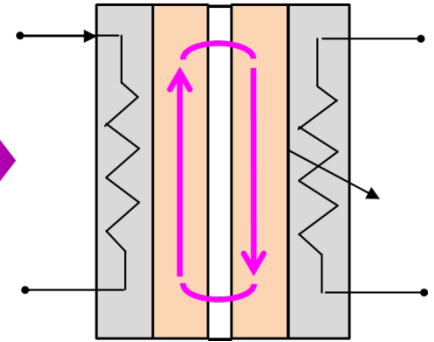
Goal 1

Low Switching Energy (aJ range)



Goal 2

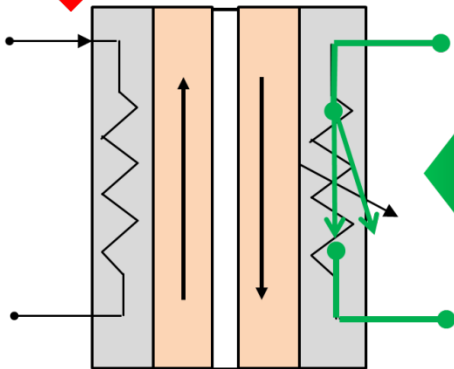
Fast Switching Speed (< 10 ps)



Goal 3

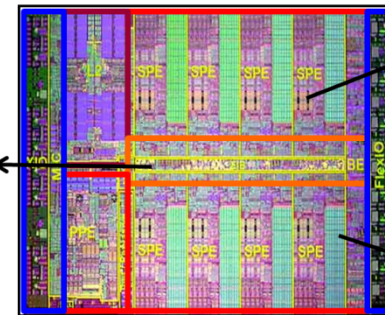


High on/off ratio (>1000)



Goal 4: Full System Analysis

Crossbar (communication)



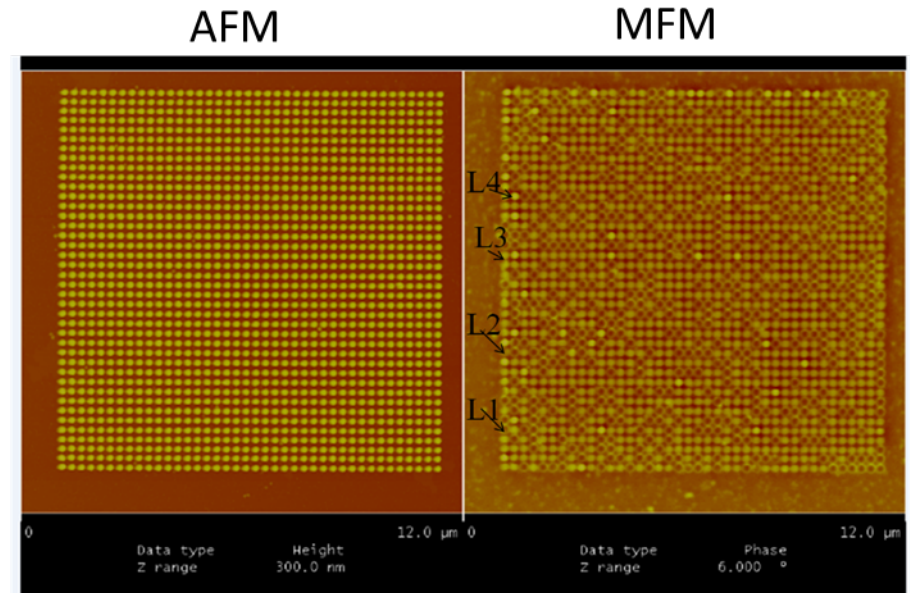
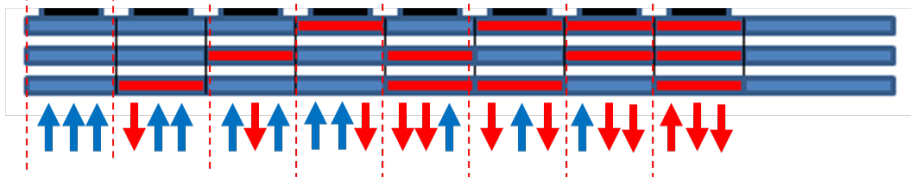
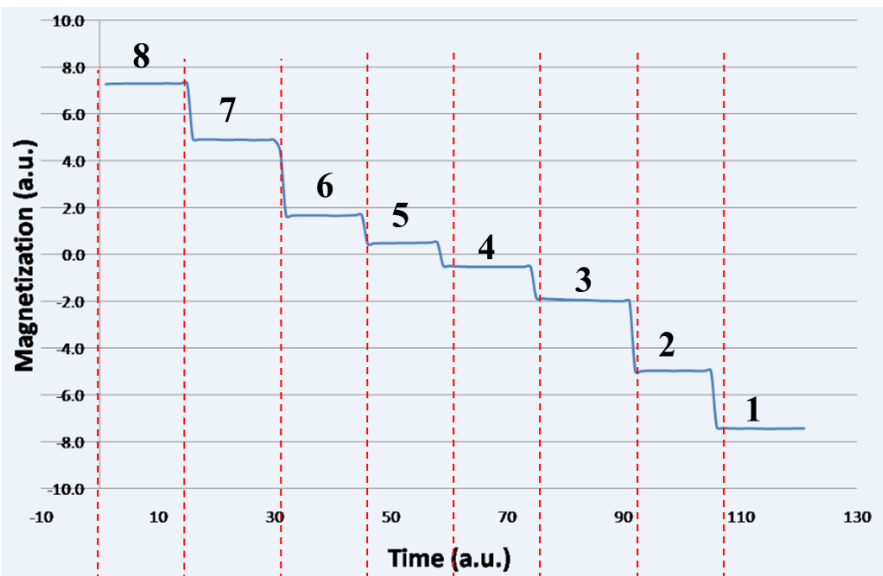
Floating Point (computation)

On-chip cache (data storage)



Multilevel 3D Magnetic Tunneling Junctions for In-Memory Computing

F-MOKE Measurements from Densely Patterned 4-Layer Junction Demonstrate 3-D Information Storage



Khizroev Group



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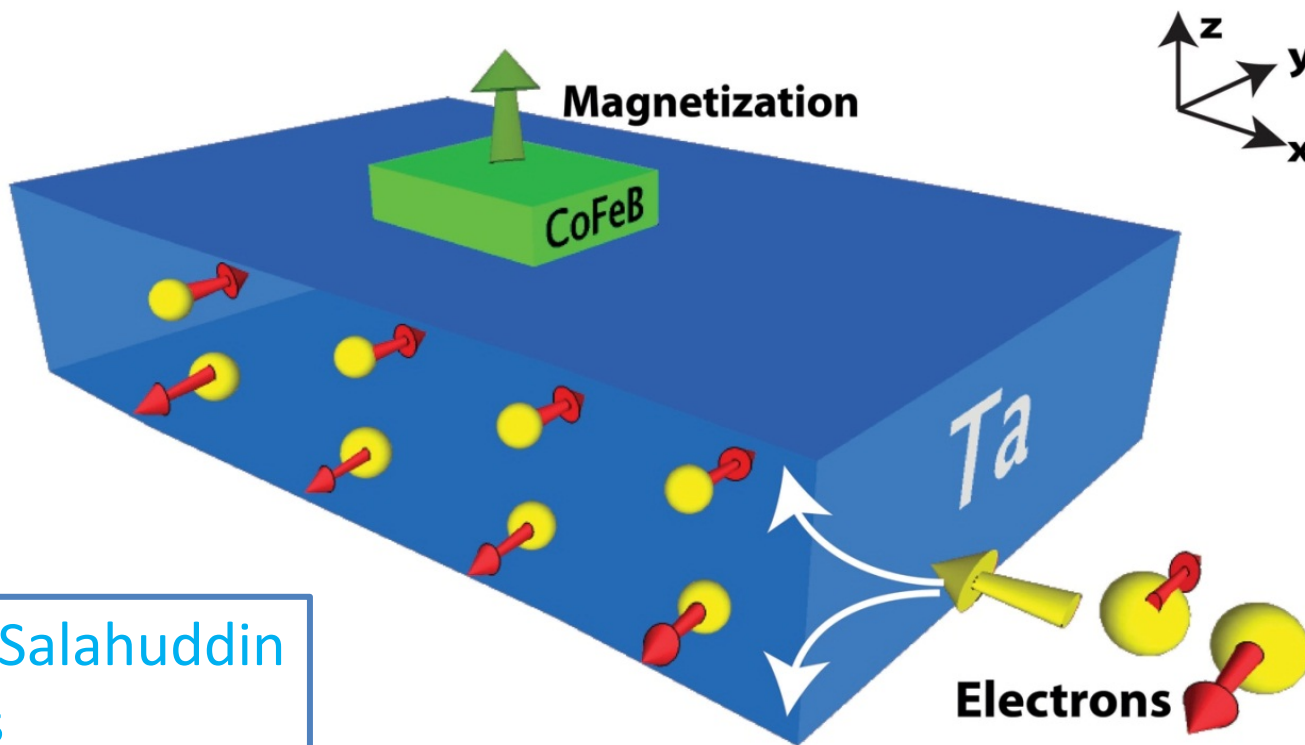
E3S Retreat, Berkeley

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Spin Orbit Torque Switching



Wang, Salahuddin
Groups



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E3S Retreat, Berkeley



Center for Energy Efficient
Electronics Science

Bokor Group Members

- Amal El-Ghazaly → Cornell EE Faculty! 😊
- Hyejin Jang, Postdoc joined from UIUC
- Ingrid Torres, Summer 2019 from FIU
- Jyotirmoy Chatterjee
- Akshay Pattabi
- Brandon Tran, UCB undergrad, now UCB Ph.D. student

