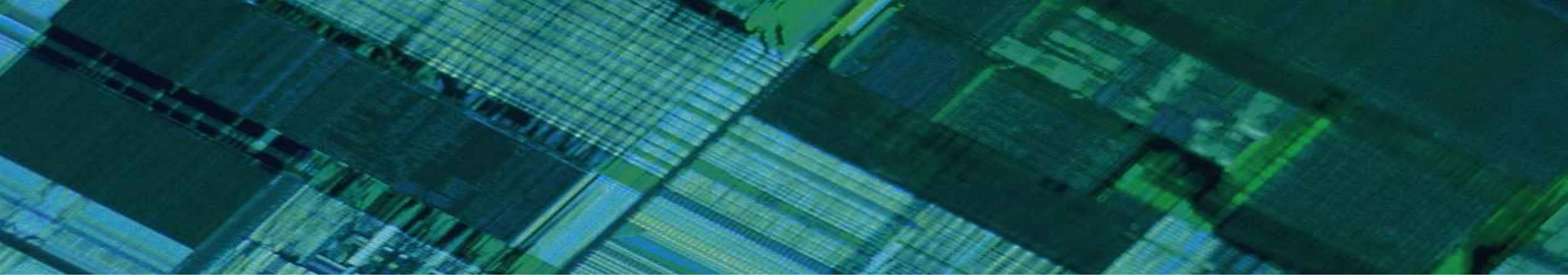


Spin Transfer Technologies

An Allied Minds Company

Orthogonal Spin Transfer (OST)

A Better Approach

Flash Memory Summit
August 2015

Background

History

- Formed in 2007 by Allied Minds and NYU to commercialize Orthogonal Spin Transfer (OST) MRAM research done by Professor Andrew Kent
- In 2012, raised $36 million financing and opened Silicon Valley headquarters
- October, 2014 raised additional $70 million financing

Technology

- OST-MRAM is a disruptive innovation in the field of spin transfer MRAM devices and offers advantages over other MRAM
- Higher speed, lower cost, lower power consumption, higher reliability, and enhanced lithographic scalability

Opportunity

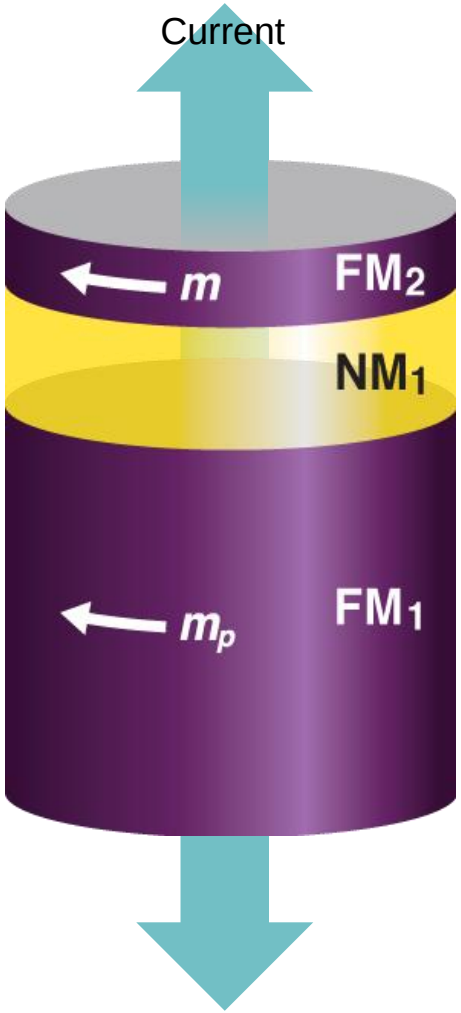
- Served Market Opportunity of $150 Billion in 2015
- Targeted as a replacement for DRAM, SRAM or flash memory
- Markets in storage systems, mobile devices, computing, microcontrollers and SOCs in standalone or embedded configurations

Magnetic Tunnel Junction with Collinear Spin Filter

Magnetic data…'left' or 'right'

Reading - permanent reference direction at low current

Writing - 'collinear spin filter' generates polarization field at high current



"Free" Layer

Tunnel Barrier

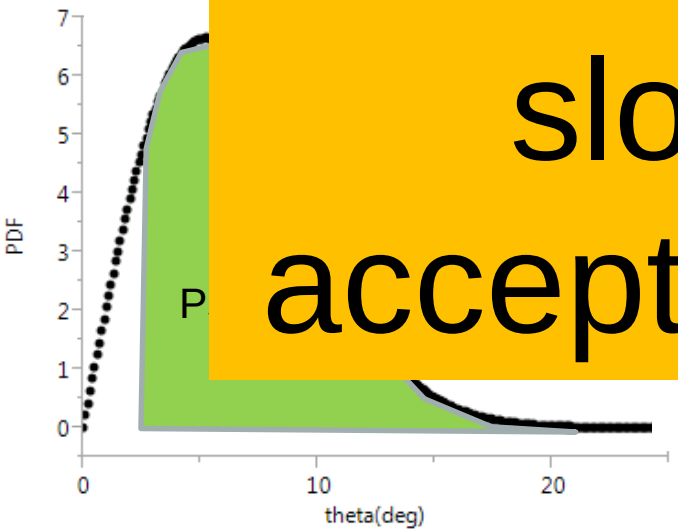
"Reference" Layer

Not to scale

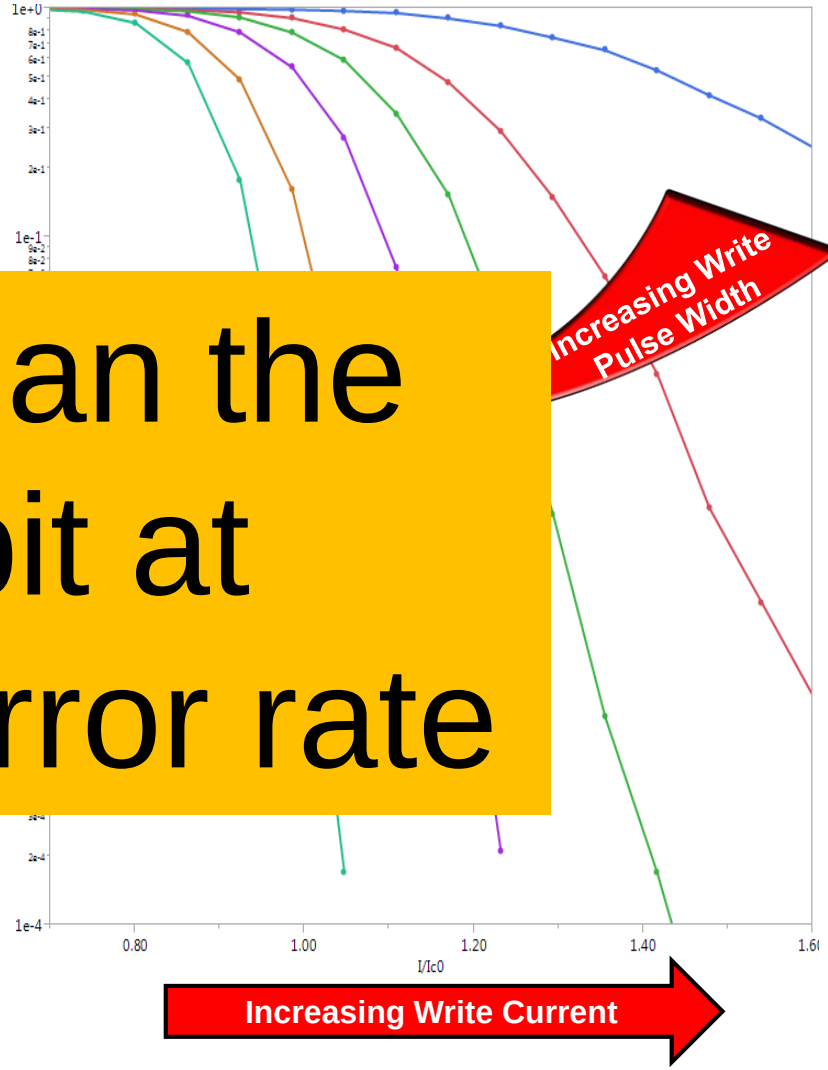
Getting the ‘write’ started in Collinear Spin Torque

- Torque on the magnetic storage requires a perpendicular component – just like a

No faster than the slowest bit at acceptable error rate



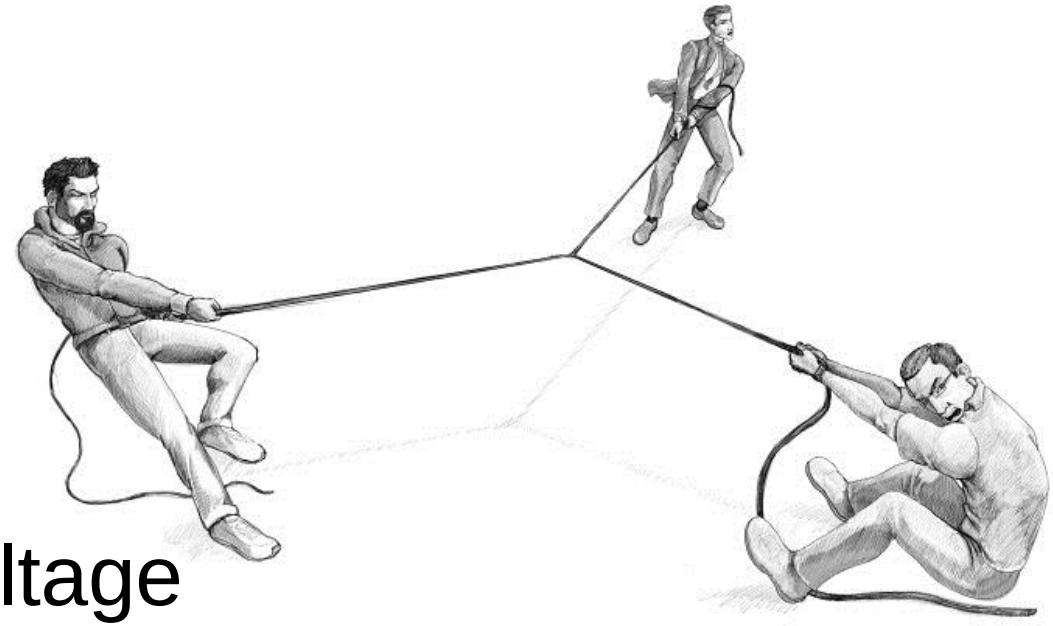
Boltzmann thermal distribution of initial angle



Collinear Spin Transfer – In a Performance Box

Write Error Rate (WER)

→Cost, i.e. ECC



Write Voltage

→Power and Endurance

Write Pulse Width

→Performance and Power

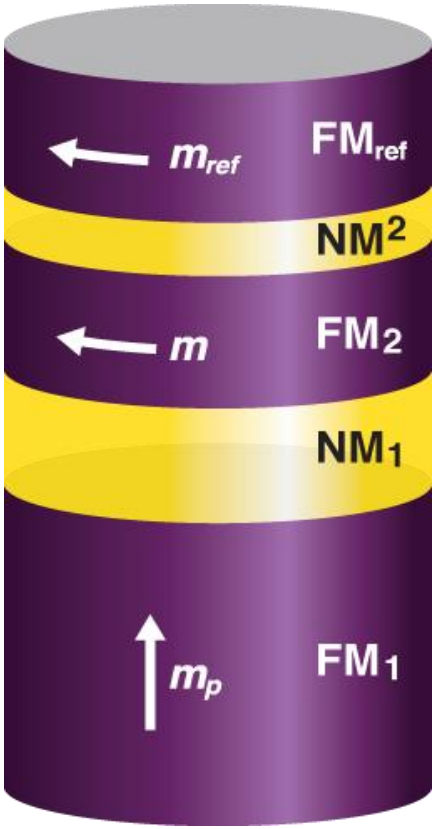
Magnetic Tunnel Junction with Orthogonal Spin Filter

Reading - reference @ low current
Writing - ‘collinear spin filter’ @ high current

Magnetic data…’left’ or ‘right’

Writing - ‘orthogonal spin filter’ @ high current

Strong perpendicular component to ‘spin polarization field’ ***instantaneously*** starts switching of magnetic data in free layer



“Reference” Layer

Tunnel Barrier

“Free” Layer

Orthogonal Spin Polarization Filter

Not to scale

OST Technology
Benefits And Advantages vs. Collinear

Technology	Benefit	Advantage
Deterministic Write Onset & Shorter Write Pulse	Faster Write Cycle	5-10x $T_{WriteCycle}$ reduction <5ns writing High Speed RAM Application
	Lower Write Energy	5-10x power reduction
	Less Oxide Stress	>>10x write endurance advantage
	Less Peak Current to Switch with Low Error Rate	Smaller CMOS cell transistor → Lower cost per bit
	Lower Write Error Rate per Write Time	Scales to smaller lithography with higher speed and lower write energy