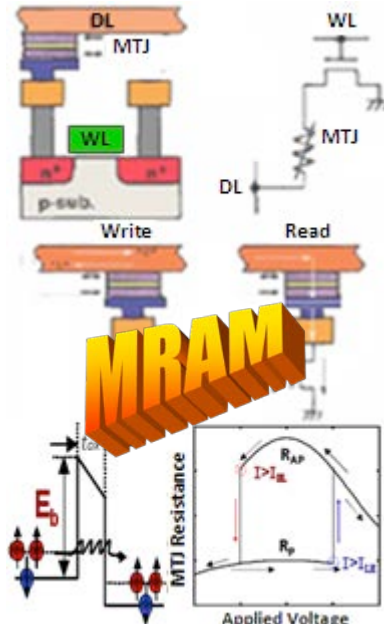




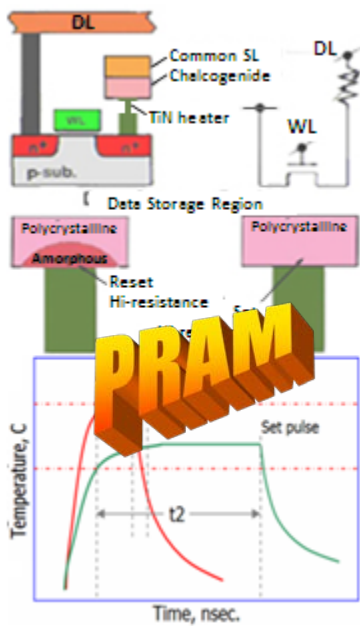
# Life Beyond Flash: New Non-Volatile Memory Technologies

Chung H. Lam  
IBM Research

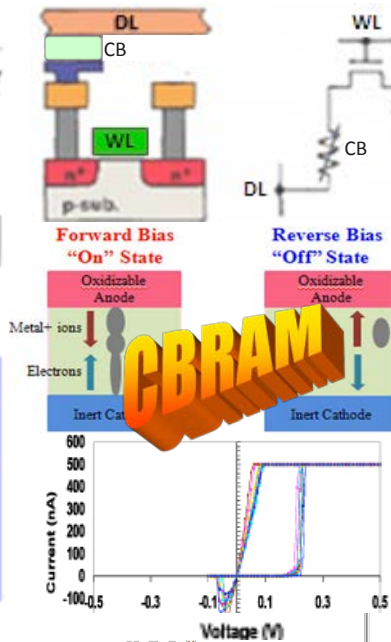
# Probable Candidates



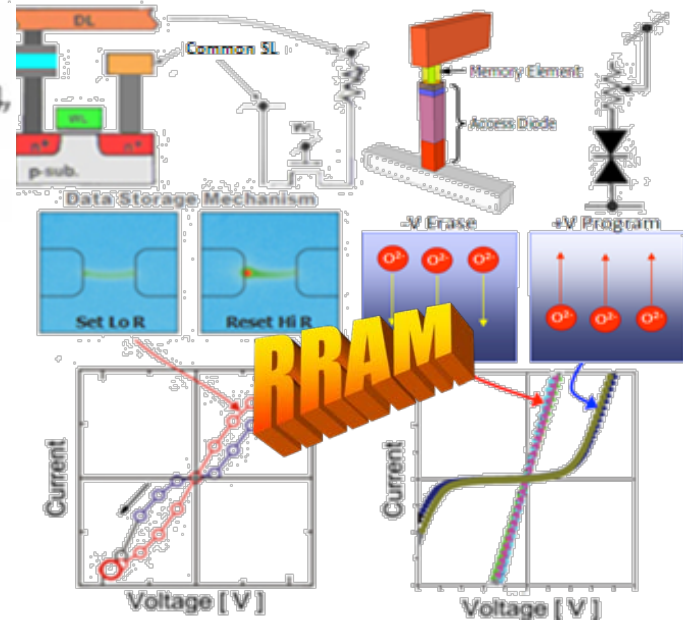
**MRAM**



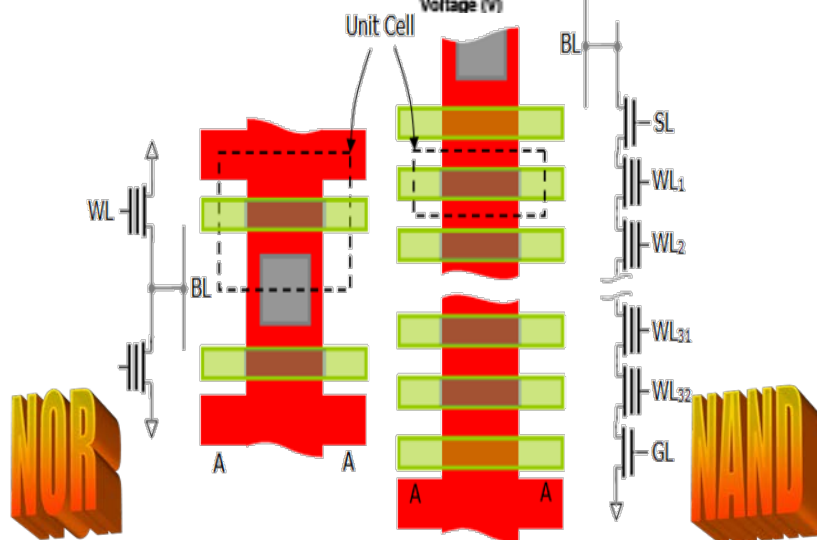
**PRAM**



**CBRAM**



**RRAM**



**NOR**

**NAND**

# Current Consensus

**MRAM**

**PRAM**

**CBRAM**

**RRAM**

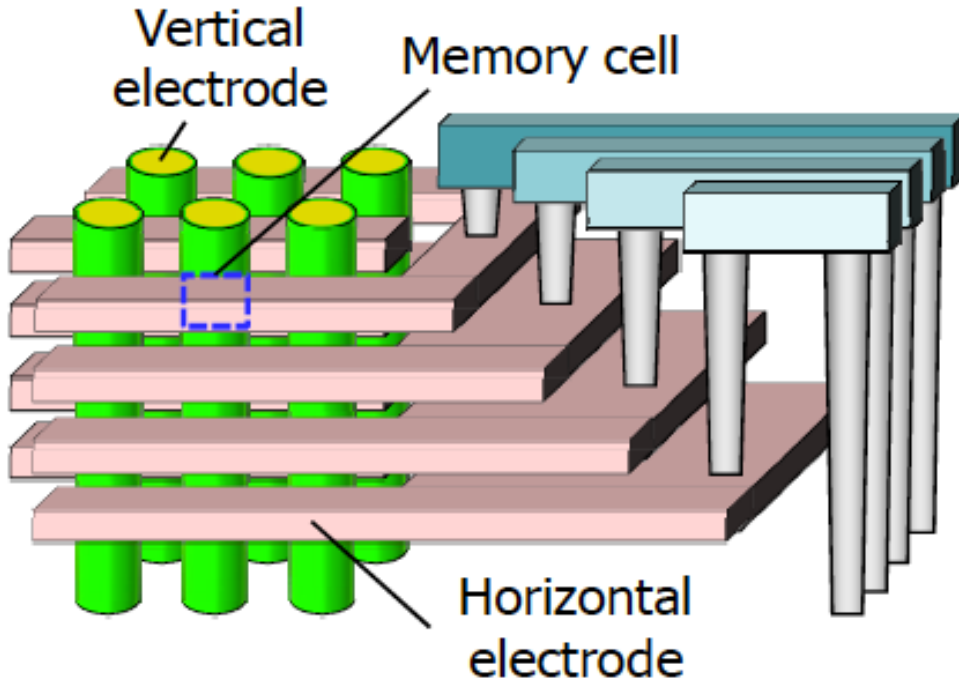
**DRAM**

**NOR**

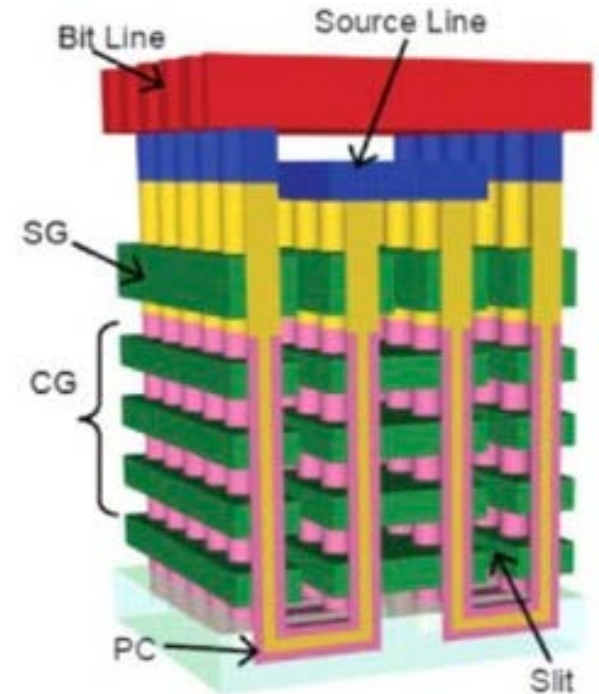
**NAND**

DL, WL, MTJ, p-sub., Write, Read, Common SL, Chalcogenide, TiN heater, Data Storage Region, Polycrystalline, Amorphous, Reset, Hi-resistance, Forward Bias "On" State, Reverse Bias "Off" State, Oxidizable Anode, Inert Cathode, Metal ions, Electrons, Unit Cell, BL, SL, WL<sub>1</sub>, WL<sub>2</sub>, WL<sub>31</sub>, WL<sub>32</sub>, GL, A, A, Memory Element, Access Diode, Data Storage Mechanism, Set Lo R, Reset Hi R, -V Erase, +V Program, Current, Voltage [V], Applied Voltage, Temperature, C, Time, nsec., Current (nA), Voltage (V)

# NAND in 3D is a tough competitor



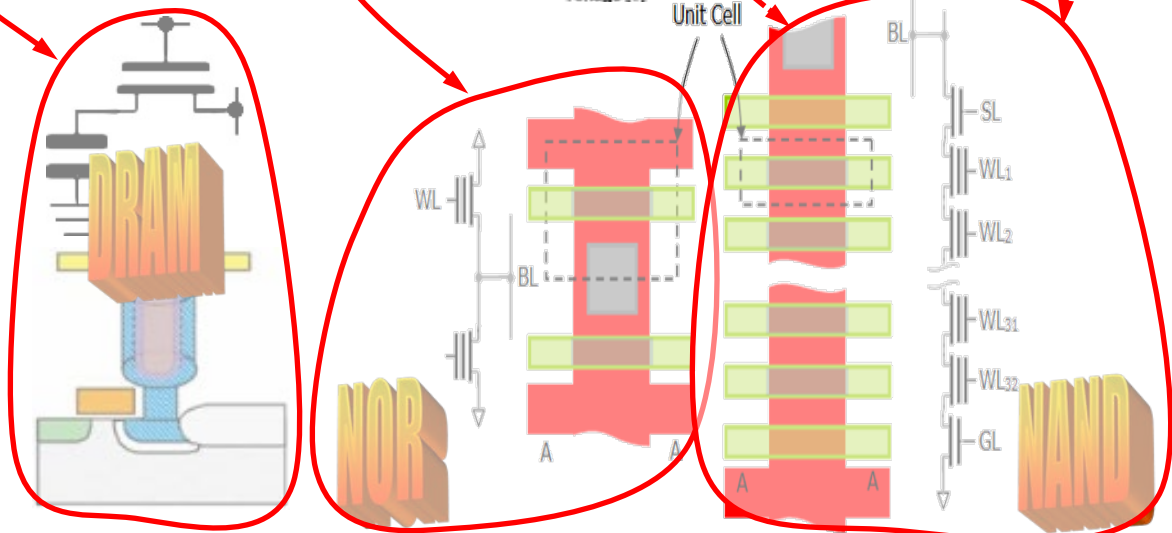
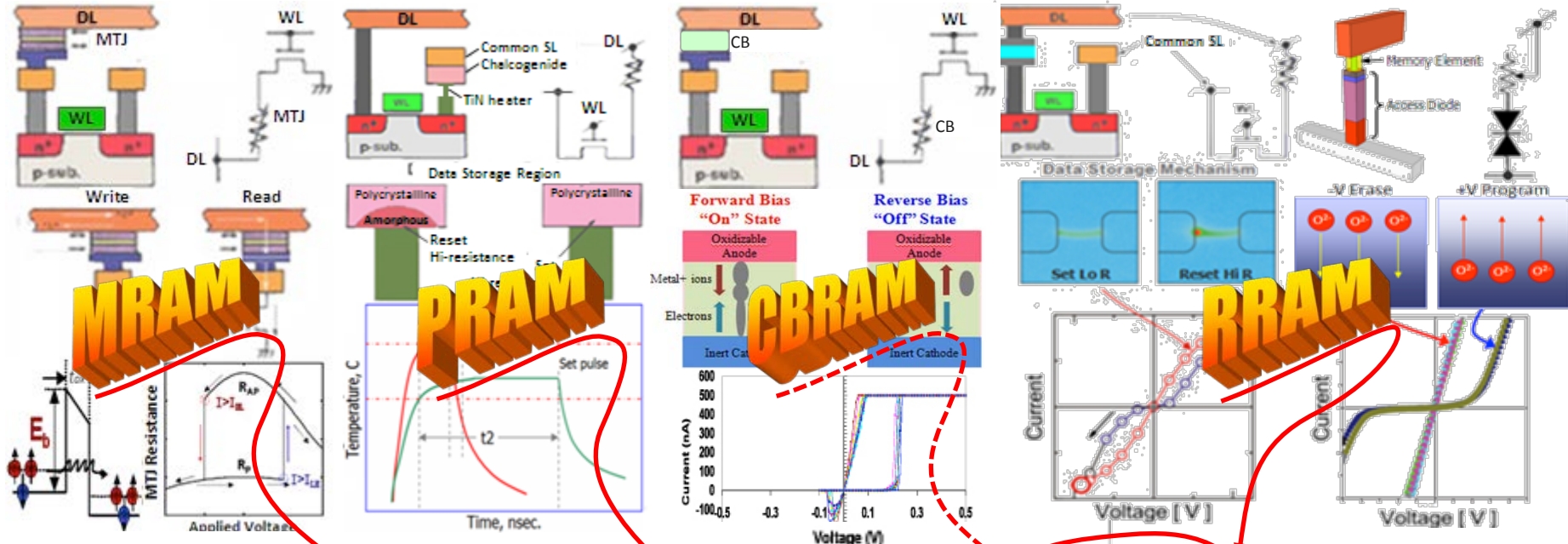
Source: I.G. Baek et al, IEDM 2011



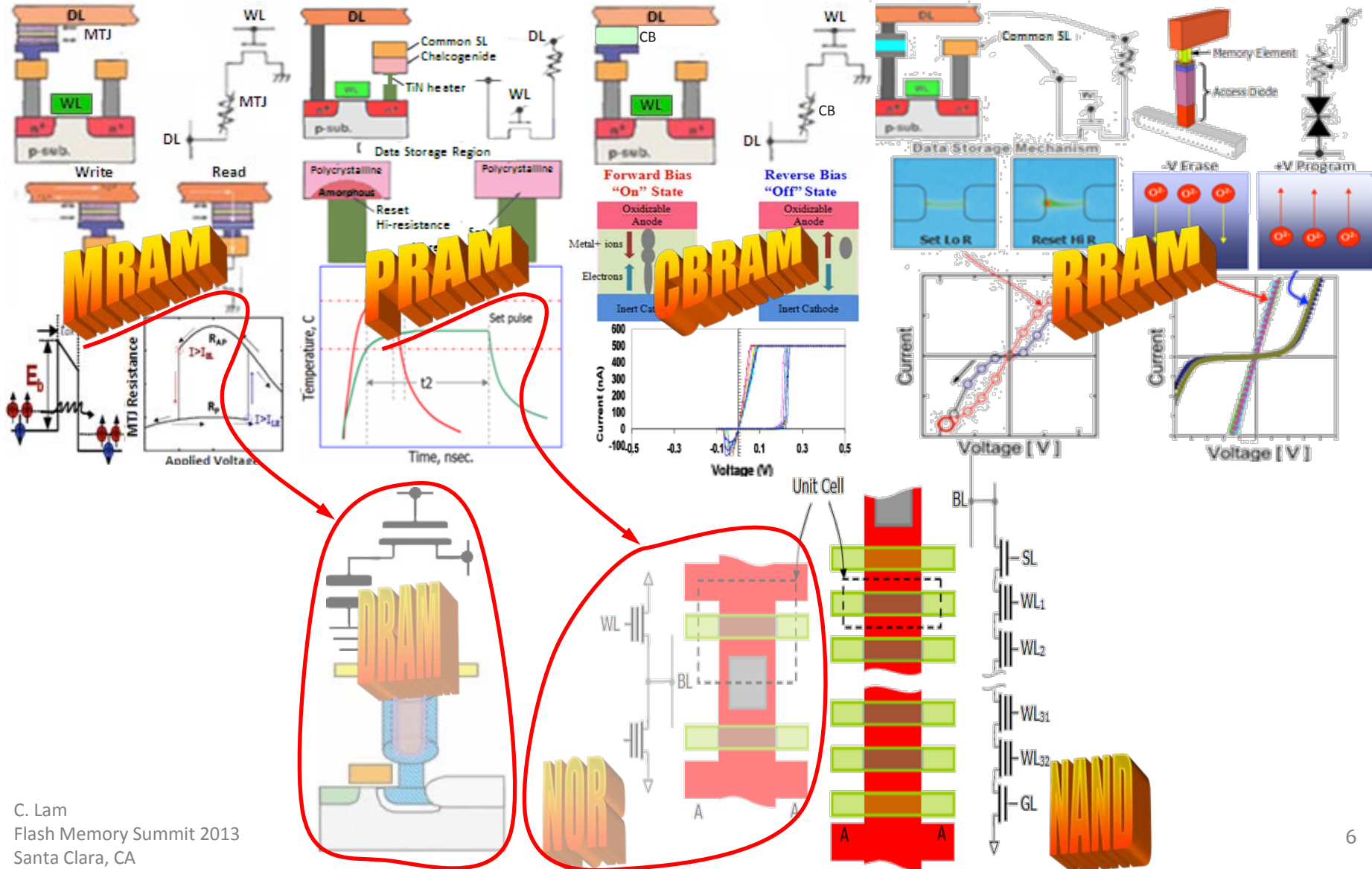
Source: R. Katsumata et al, VLSI 2009

- ❑ A vertical integration scheme similar to BiCS integration which minimizes the number of process steps and critical masking levels without double patterning processing for Resistive RAM has the potential to compete with NAND.
- ❑ While it is still early to tell, the current consensus is ...

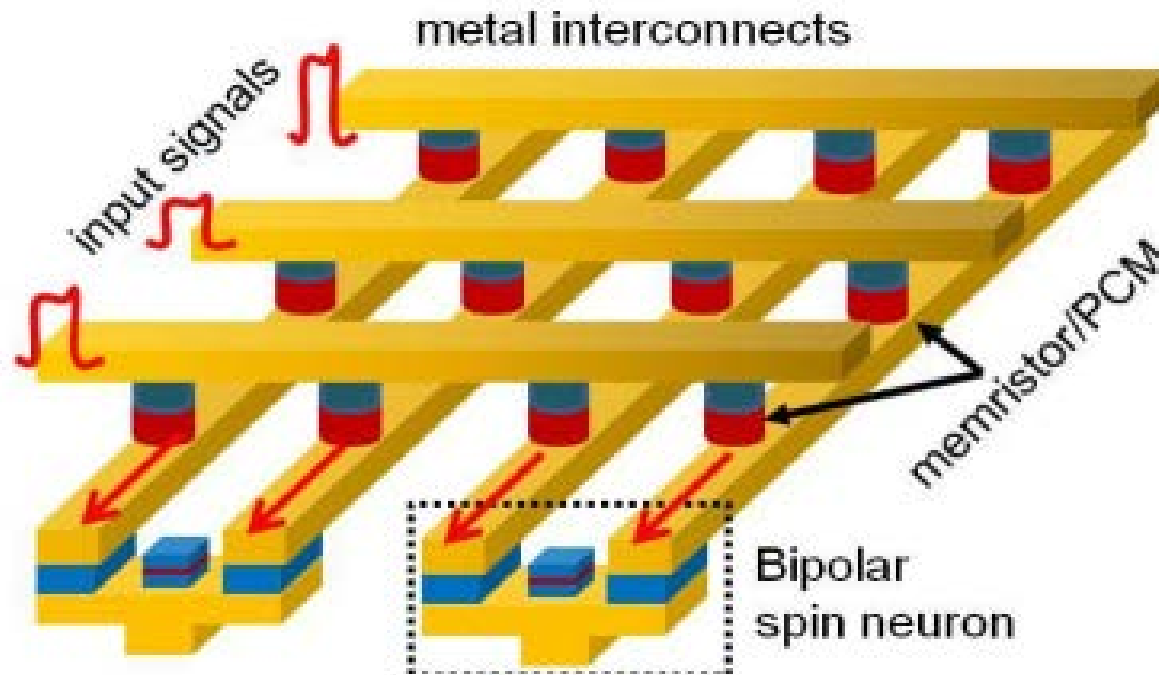
# Current Consensus



# Probably not going to happen!



# Then, What's life beyond Flash?



Source: [arxiv.org/abs/1206.3227](https://arxiv.org/abs/1206.3227): *Proposal For Neuromorphic Hardware Using Spin Devices*



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