MRAM-based Deep In-memory Architectures

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Materials & Integration: Framework for Novel Compute (FRANC)

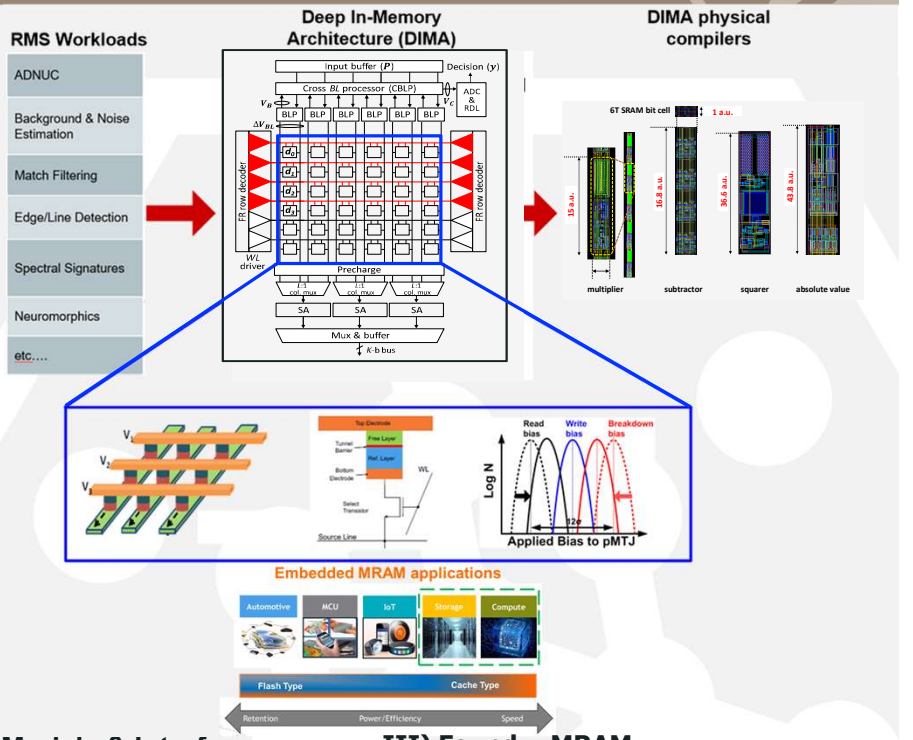
Objective: Integrate PSTT MRAM technology with Deep In-Memory Architectures (DIMAs), simultaneously overcoming memory wall and enabling manufacturability of energy/density-aggressive MRAM.

Technology Approach: Extend DIMA Proof-of-Concept SONIC success to GLOBALFOUNDRIES' platform MRAM. Exploit DIMA statistical compute models to relax MRAM bias margins

- Exploit regularity of DIMA circuits for foundry-platform DIMA compilers
- Demonstrate DIMA prototypes in foundry PSTT MRAM process (22nm FD-SOI)
- Demonstrate DIMA-based systems in RMS defense application

Impacts: > 200X EDP gains in data-centric DoD workloads, 10X gains in SW&P margins

Metrics	SOA	PH1 (sim)	PH2 (bank)	PH3 (syst.)
Energy/MACn (fJ)	6	0.2	0.3	0.4
Throughput (GOPS)	75	500	400	1200
Processing Density (%)	5	25	25	90



Applications and Transition Plan:

- Advanced signal processing capabilities in missile systems
- Benchmarking to RMS SP technologies & Business Cases

Background and Prior Work

I) Advanced SRAM DIMAs

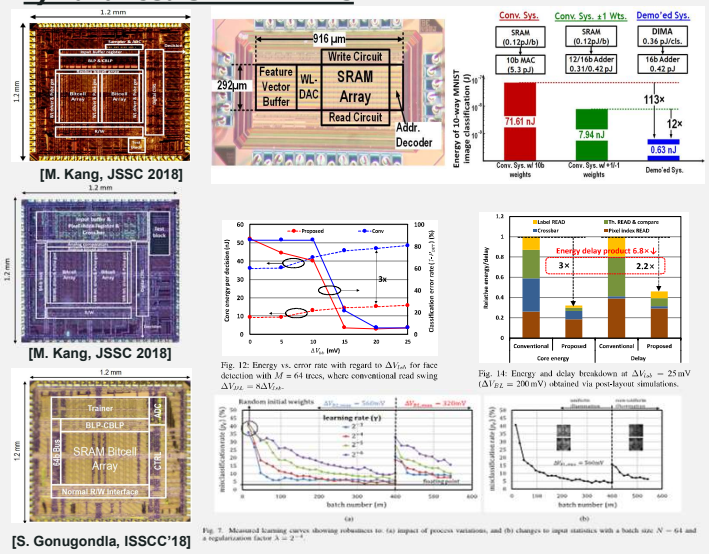
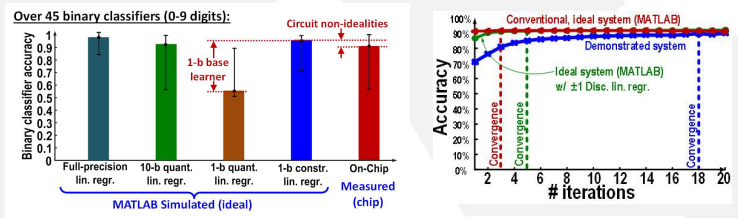


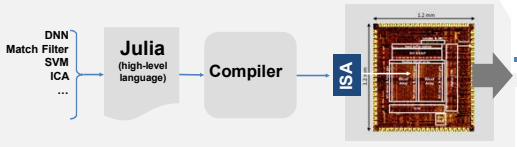
Fig. 12: Energy vs. error rate with regard to ΔV_{LSB} for face detection with $M = 64$ trees, where conventional read swing $\Delta V_{BL} = 8\Delta V_{LSB}$.

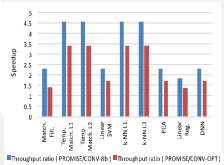
Fig. 14: Energy and delay breakdown at $\Delta V_{LSB} = 25$ mV ($\Delta V_{BL} = 200$ mV) obtained via post-layout simulations.

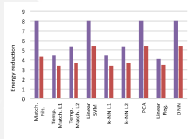
Fig. 7. Measured learning curves showing robustness to: (a) impact of process variations, and (b) changes to input statistics with a batch size $N = 64$ and a regularization factor $\lambda = 2^{-9}$.

II) Statistical Compute Models & Interfaces

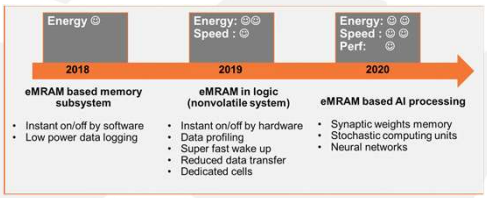








III) Foundry MRAM



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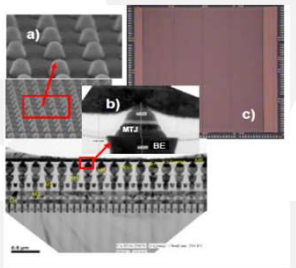

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