IDEC Chip Design Contest

An eFlash-Based Computation-in-Memory for AI Edge Computing

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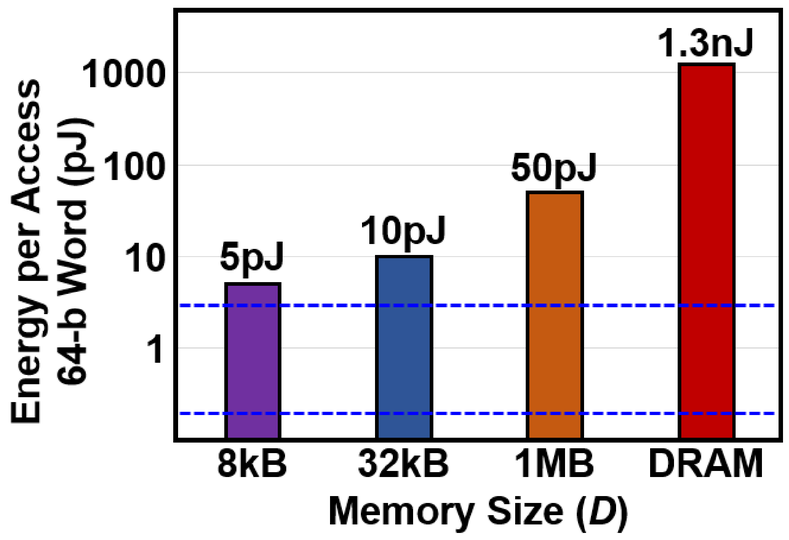
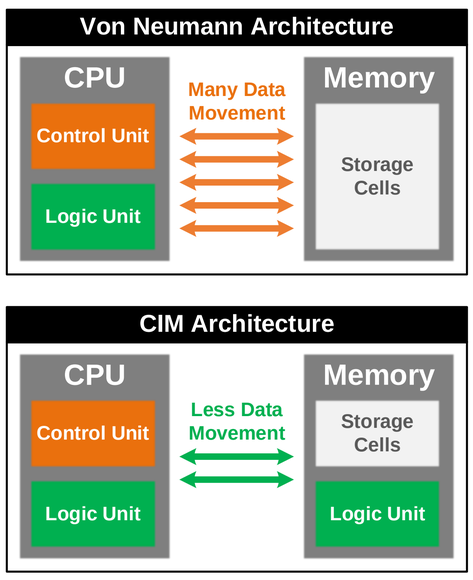
Abstract



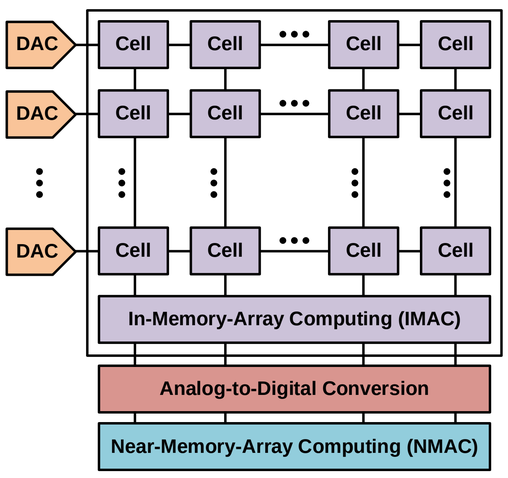
Memory access energy ≫ Computation energy[1]



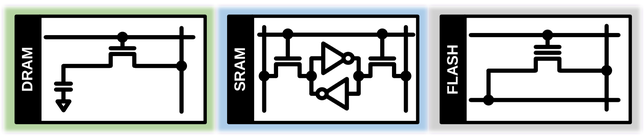
→ **More energy-efficient**

- **To achieve energy-efficient AI computing**
  - ✓ It is crucial to minimize the amount of data movement
- **Memory access energy is greater than computing energy**
  - ✓ Computation-in-Memory(CIM) can drastically reduce data movement and implement a more energy-efficient system
  - ✓ CIM is a memory-centered computing architecture that integrates computing units in memory
- **CIM enables the implementation of energy-efficient systems**
  - ✓ Reduce the movement of data
  - ✓ Effective for parallel processing

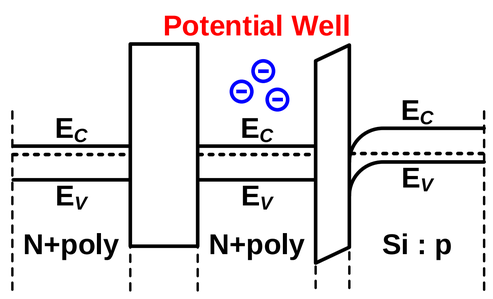
Introduction



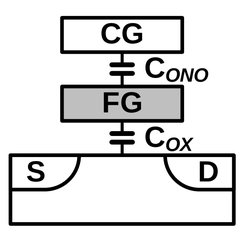
- ✓ **Dynamic data**: Hard to use the stored data to compute
- ✓ **SRAM**: Provide fast read and write speed and low write energy
- ✓ **NVM**: The data does not require power to be maintained



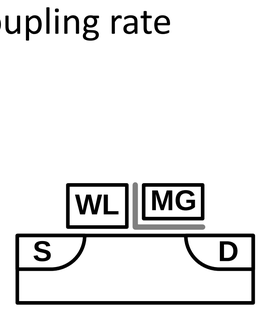
- **Single-poly 3T eFlash cell**
  - ✓ Low PGM voltage (~8V)
  - ✓ Low fabrication cost
  - ✓ High coupling rate



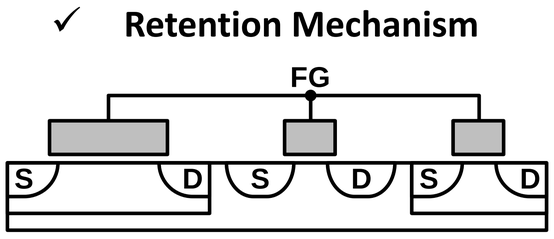
✓ **Retention Mechanism**



✓ **Dual-Poly[2]**



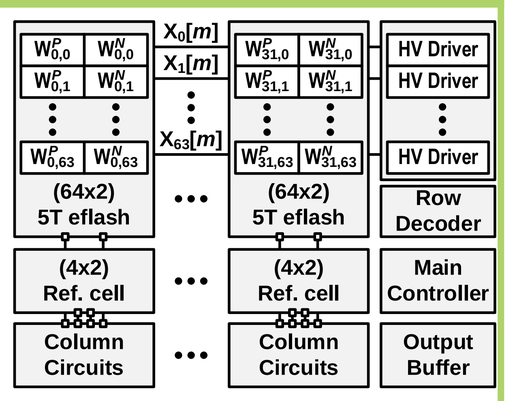
✓ **Split-Gate[3]**

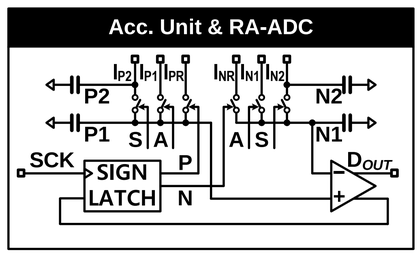


✓ **3T(5T) Single-Poly[4]**

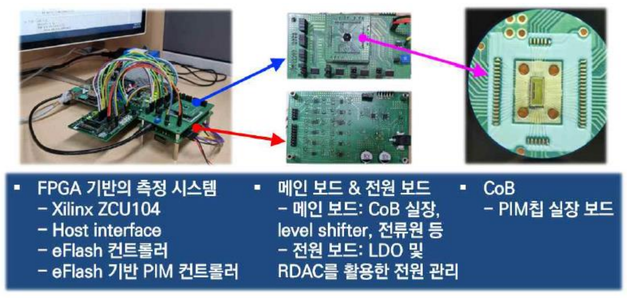
Implementation & Measurement

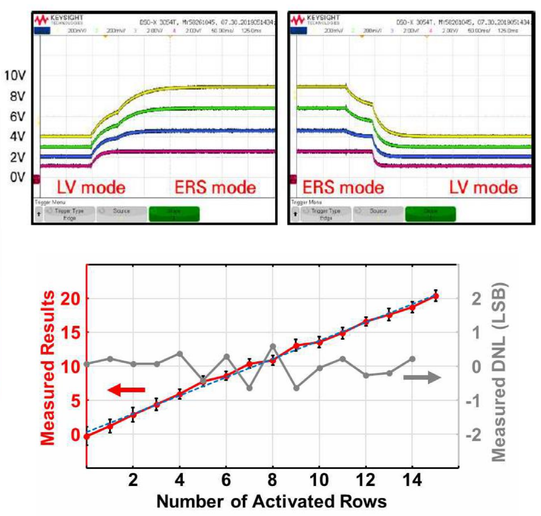
- **High-level block diagram**
  - ✓ Multi-level eflash pair
  - ✓ Biasing for wide-swing BL
  - ✓ Charge domain computing
  - ✓ Resolution-adjustable ADC





- **Measurement results**





Conclusion & Acknowledgement

- **Challenges**
  - ✓ BL Limited dynamic range and nonlinearity issues
  - ✓ ADC and DAC overhead
- **Achievements**
  - ✓ Low-cost charge domain computing circuit and ADC
  - ✓ Analyze MAC values for a sufficient margin

- **References**

[1] M. Horowitz, ISSCC 2014
[2] H. Kojima, IEDM 2007
[3] J. Yater, IMW 2009
[4] S.-H. Song, JSSC 2013

- **Acknowledgement**
  - ✓ The chip fabrication and EDA tool were supported by the IC Design Education Center(IDEC), Korea.