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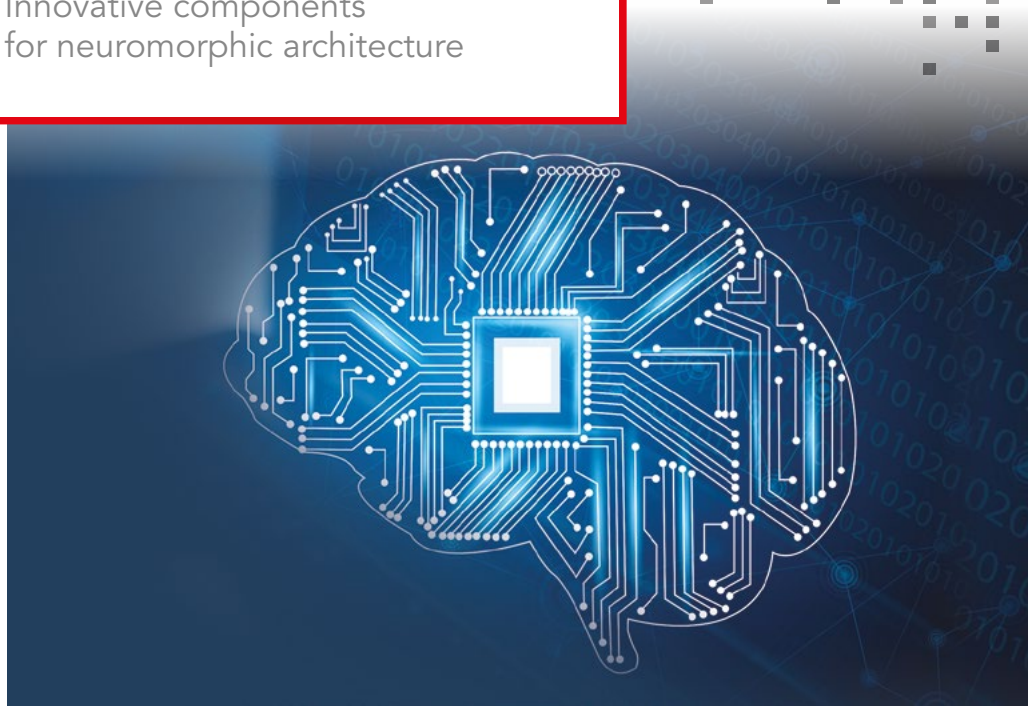
EMERGING NON VOLATILE MEMORY

Innovative components
for neuromorphic architecture



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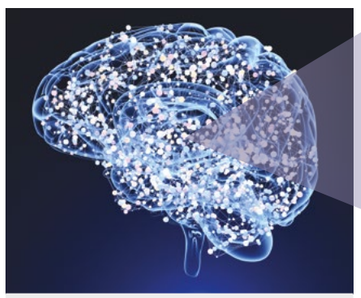
Neuromorphic architecture…

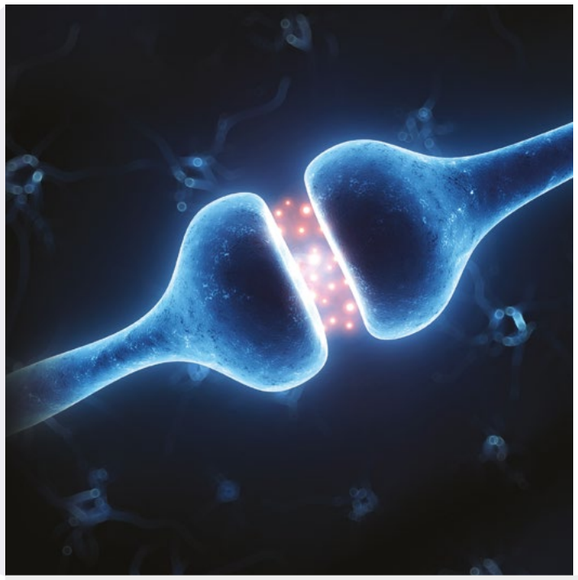
Brain-inspired computing has been regarded as an alternative to conventional computational paradigms since the late 1950s. Today's omnipresence of "big data" and worldwide social interactions calls for technologies capable of analyzing complex objects—such as sounds, images, or videos—in real time and ensuring cognitive human interaction. Conventional solutions cannot meet increasing demand for computing efficiency and "intelligent" features. Moreover, the advent of the Internet-of-Things has also introduced a new decentralized and hierarchical communication architecture requiring edge analytics that take data processing from the Cloud to the edges of networks and end-devices.

Neuromorphic architectures offer opportunities for implementing robust, energy efficient accelerators and are increasingly popular among designers.
Use of innovative components, such as **emerging resistive memories,** has been explored to allow implementation of cognitive tasks in neural networks.
These novel components bring memory closer to the processing unit and offer extraordinary potential for implementing "intelligent" features, thereby approaching the way knowledge is created and processed by the human brain.



CORTICAL COLUMN

NEURAL NETWORK



SYNAPSE

…and opportunities *for novel Non Volatile Memory technologies*

Resistive RAMs will provide solutions to enable new functions and new products based on neuromorphic architectures.

BEOL NVMs technologies include oxide-based resistive memories (OxRAM), conductive bridge memories (CBRAM), phase-change memories (PCM), and magnetic memoires (MRAM). They can integrate a wide range of functional materials.

BEOL NVMs offer key advantages:

- Directly CMOS compatible
- Compatibility with high density integration
- Good endurance
- Stackable (crossbar architecture) and provide low-power consumption
- Providing non volatility very similar to logic circuits, even within logic elements

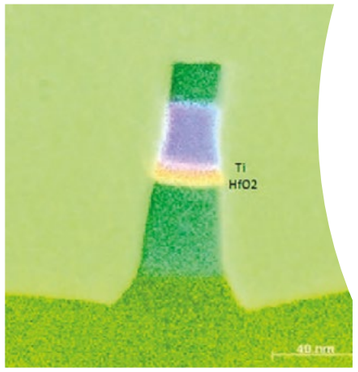
RESISTANCES AS SYNAPSES: RRAM

TOWARDS NEXT MEMORIES GENERATIONS

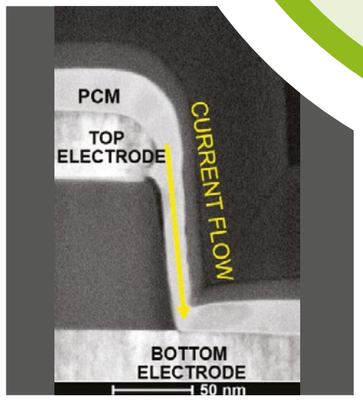
LETI CAPITALIZES ON ITS MEMORY TECHNOLOGIES,
DESIGN AND ARCHITECTURE EXPERTISE
TO IMPROVE ENERGY EFFICIENCY SYSTEMS

TECHNOLOGY

- New materials exploration for back-end of line non-volatile memory technology
- Over 10 years' experience in metal insulator and chalcogenides materials for memory application
- Selector technology assessment and co-integration with resistive memory
- Prototyping and manufacturing of test structures from single point memories to Mb arrays using a MPW shuttle service
- 8" and 12" prototyping capabilities with various lithographic tools available
- Silicon electrical characterization and cross-validation through extensive modelling



OxRAM



PCM

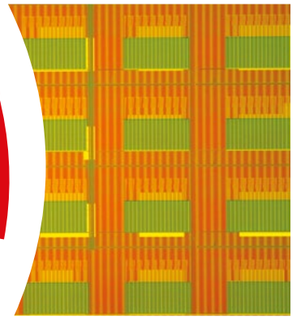
LETI'S SOLUTIONS

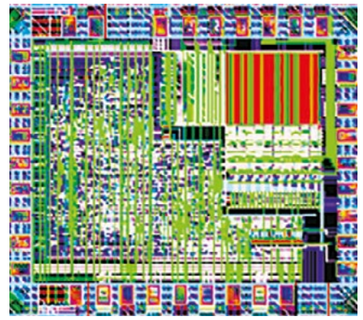
DESIGN

Advanced memory design:
- Ultra-low power and ultra-low voltage memory design
- Study and design of crossbar memories Crossbar design

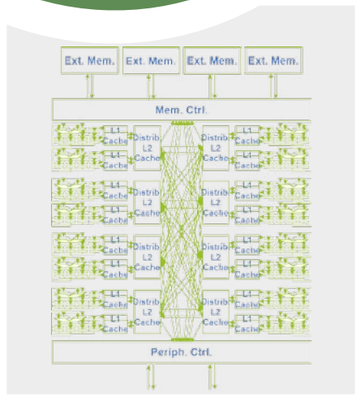
Low power solutions for data communication:
- 3D interconnect design kit
- Asynchronous network-on-chip
- Remote DMA over interposer
- New data format for higher energy efficiency

In-Memory-Computing:
- Demonstrator design
- Extended from SRAM to NVM
- Software support





Dedicated NVM design



ARCHITECTURE

Neuro-inspired architecture:
- Spiking Neurons with OxRAM
- Spiking Neurons for 3D future imagers
- Cortical Column architecture

Data-centric architectures with NVM and high density 3D integration:
- New cache hierarchy
- Neuro-inspired architecture
- In-memory computing

New data format for higher energy efficiency:
- UNUM
- Integer representation for probabilistic computation

Low power communication infrastructures:
- Smart DMA
- Smart Controllers

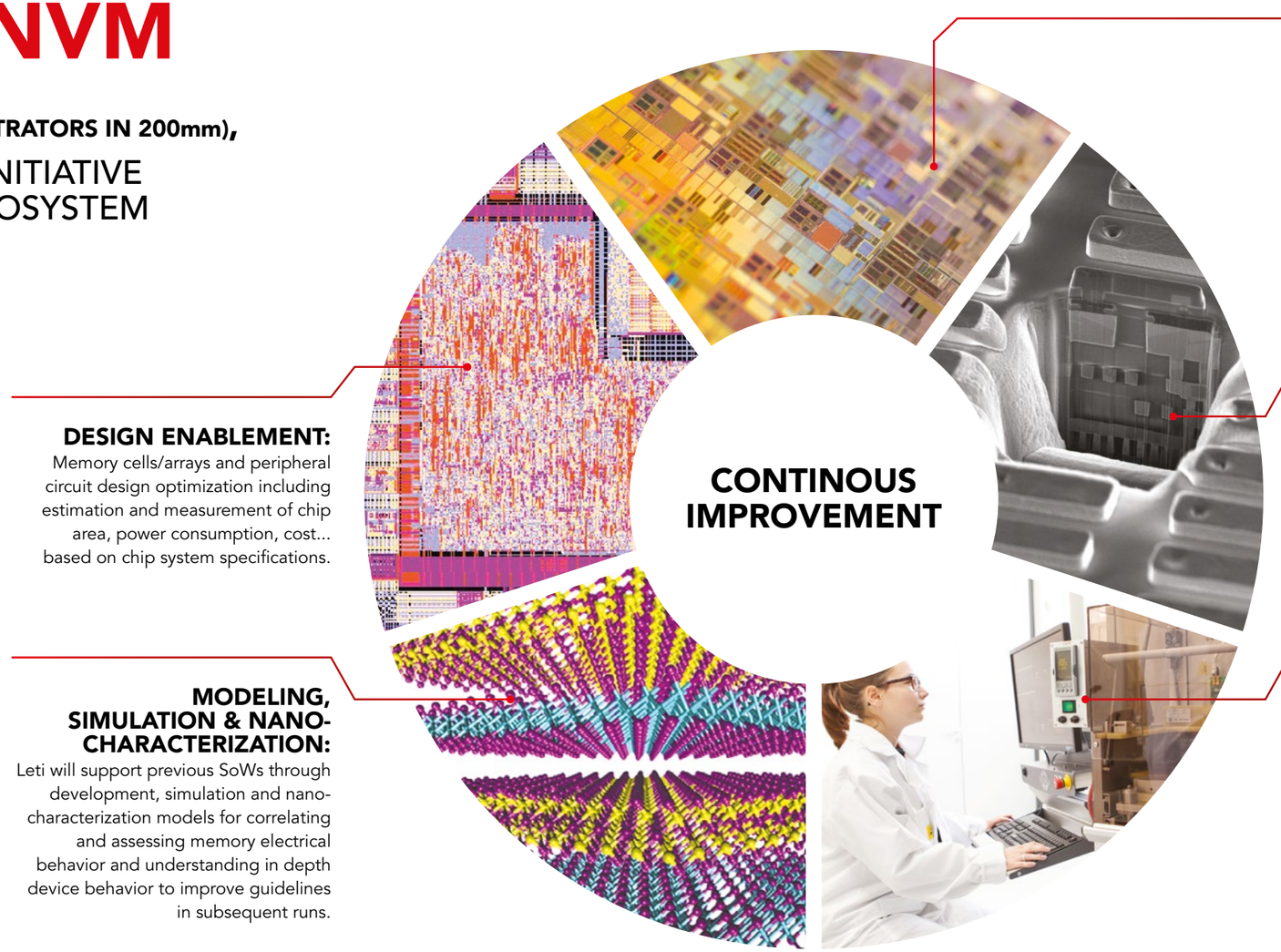
LETI, A STRATEGIC PARTNER FOR CUSTOMIZED DISRUPTIVE NVM

MAD (MEMORY ADVANCED DEMONSTRATORS IN 200mm),
1ST WORLDWIDE PLATFORM INITIATIVE ENABLER OF A NEW NVM ECOSYSTEM

Leti has two 300mm and 200mm lines dedicated to many advanced technological developments including screening and characterization of new RRAM, PCM and MRAM material and device architectures.
The MAD test vehicle, based on 8"-130nm CMOS technology, opens the way to disruptive BEOL technology assessment, offering versatility (materials, stacks, dimensions, memory structures, etc.) and robustness (industrial tools, metrology, secured processes, etc.).

A 300nm test vehicle on an advanced FD-SOI platform is being developed and is planned to be available in 2019. The tools are already available at Leti for specific developments, such as fine tuning of advanced materials.

DEFINITION OF TECHNOLOGY SPECIFICATIONS:
Specifications/constraints helps define the best intergation plan into BEOL NVM test vehicle: CMOS technology node to be considered, materials to be screened, test structures definition, characterization protocols, foundry partners, etc.



DESIGN ENABLEMENT:
Memory cells/arrays and peripheral circuit design optimization including estimation and measurement of chip area, power consumption, cost... based on chip system specifications.

MODULE DEVELOPMENT:
Process test vehicle to include critical memory module (electrodes and active material) with simplified back-end on top.

MODELING, SIMULATION & NANO-CHARACTERIZATION:
Leti will support previous SoWs through development, simulation and nano-characterization models for correlating and assessing memory electrical behavior and understanding in depth device behavior to improve guidelines in subsequent runs.

TEST & CHARACTERIZATION:
Testing and characterization devices at memory cell/array level. Extraction of relevant figures of merit including reliability and cyclability. Enhanced material optimization and device architecture in subsequent runs.

AN EXTENSIVE TOOLBOX FOR CUSTOMIZED RESEARCH AND BENCHMARKING BETWEEN DIFFERENT BEOL NVM TECHNOLOGIES

ABOUT LETI

Leti is a technology research institute at CEA Tech and a recognized global leader in miniaturization technologies enabling smart, energy-efficient and secure solutions. Committed to innovation, its teams create differentiating solutions for Leti's industrial partners.

By pioneering new technologies, Leti enables innovative applicative solutions that ensure competitiveness in a wide range of markets. Leti tackles critical, current global issues such as the future of industry, clean and safe energies, health and wellness, safety & security…

Leti's multidisciplinary teams deliver solid micro and nano technologies expertise, leveraging world-class pre-industrialization facilities.

For more than 50 years, the institute has been building long-term relationships with its industrial partners providing tailor-made solutions and a clear intellectual property policy.

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