leti
cea tech

ADVANCED COMPUTING

Meeting tomorrow's computing challenges in a connected world

Leti, technology research institute

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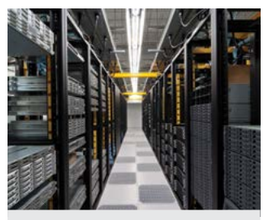
Advanced computing **to energy-efficient computing**

Advanced computing is undergoing a radical change from numerical simulation to new consumer services dedicated to analyzing large data volumes using Big Data and Data Analytics.
Exponential growth of information for fine-grain simulations or generated by humans and objects has led to a digital data explosion. Tomorrow's data volumes will require rapid processing and analysis within a constant energy envelope and under low-cost ownership.
This will cause a paradigm shift for computing infrastructures (supercomputers and data centers) in a move from tightly focused performance to energy-efficiency and total ownership cost.

APPLICATIONS

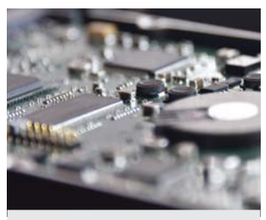
Leti's energy-efficient computing solutions address every computing application from microserver-scale to data center-scale massive data computing.



Advanced Computing:
Compute-intensive processor with memories and dedicated interconnects

Big data, data analytics:
Large-scale storage systems for data analysis

Cloud computing:
Data center-scale virtualization of computing resources



Microserver:
Socket-scale virtualization of computing resources

PRIME CHALLENGES

Performance

Computing technology progress has been fueled by the Moore's Law. Processor performance has generally doubled at every technology node; this trend continues since application demand remains strong.

10^{18} FLOP
exascale computing around 2020

Energy per operation

Based on a targeted 20MW power consumption for advanced computing, the energy per double-precision operation (approximately 200 PJ today) demands a tenfold reduction in relation to exascale machines. Energy per operation needs to be divided by four every two years.

÷ 4
every 2 years

× 2 every technology node

× 2
every 2 years

Cost

A prime challenge is to control both the cost of advanced processor production and the cost of new design development. The all-in cost of developing new circuitry is skyrocketing due to increasingly complex design steps involving heavy functional and physical verification. The cost of ramping up new technology almost doubles at each node.

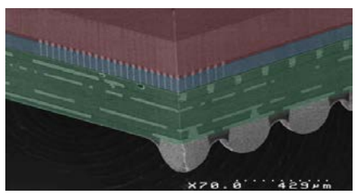
Data traffic

Data traffic is growing fast, complementing computing performance needs and energy challenges, on account of not only the data volume required for accurate application, but also the huge number of connected things and people producing and using information.
This represents another source of energy waste since we need to move data between production, storage and processing locations.

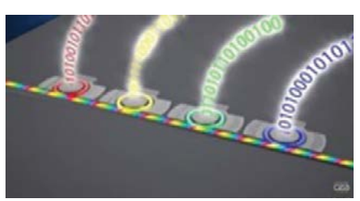
LETI'S SOLUTIONS FOR NEXT GENERATION COMPUTING

TECHNOLOGY AND ARCHITECTURE SOLUTIONS **FOR TRANSITIONING TO DISRUPTIVE ARCHITECTURES**

Leti capitalizes on its silicon **technologies (FDSOI, 3D)**, **architecture (many-cores)** and **middleware** to improve energy efficiency and facilitate compute node scaling. Design and manufacturing performance are thereby enhanced at minimum cost. By 2020, Leti technologies will have further raised compute node energy efficiency by introducing optical transmission and **non-volatile memories** close to the computer.
CoolCube™ 3D sequential technology and high-density integration will also increase compute density and system-on-chip neural networks will be developed for accelerating specific applications.



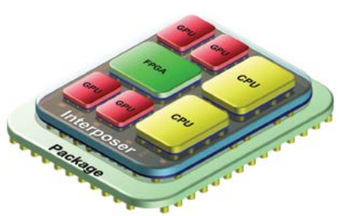
High-density 3D



Integrated photonic links

INTEGRATION SHIFT

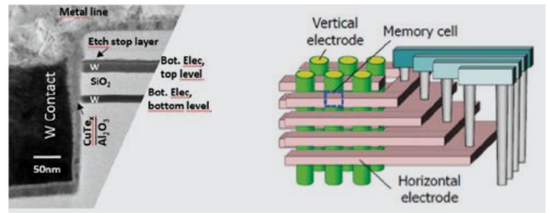
- 3D integrated many-core circuits
- Interposer integrated chiplets
- Integrated photonic links
- Middleware software (OS, hypervisor, RDMA, etc.)



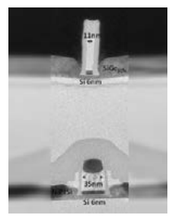
Interposer integrated chiplets

TECHNOLOGICAL SHIFT

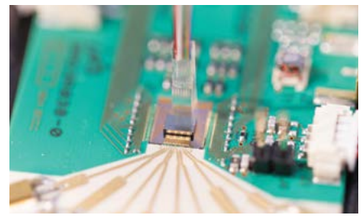
- New memory materials and architectures
- Advanced CMOS
- 3D VLSI (CoolCube™) and high-density 3D
- Integrated silicon-photonic dies
- Software tools, benchmarks and design methodologies



Resistive memories



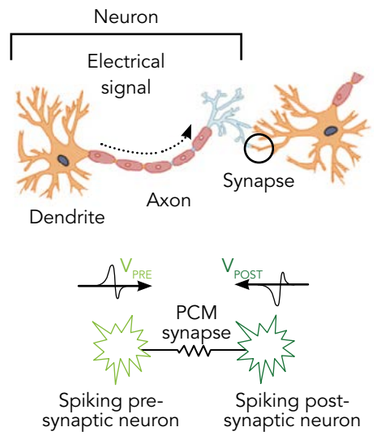
CoolCube™



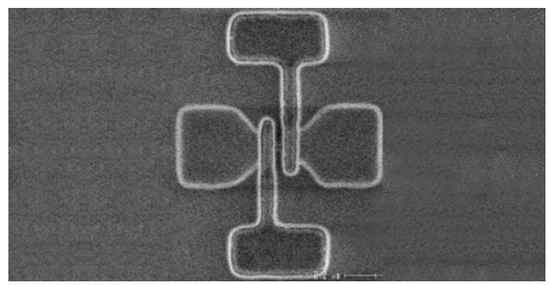
Photonic die

COMPUTER ARCHITECTURE PARADIGM SHIFT

Neuromorphic architectures
- Spike-coding for deep networks
- Fast and accurate neural network exploration
- Optimized DSP for neural network
- Non-volatile memory synapses implementation



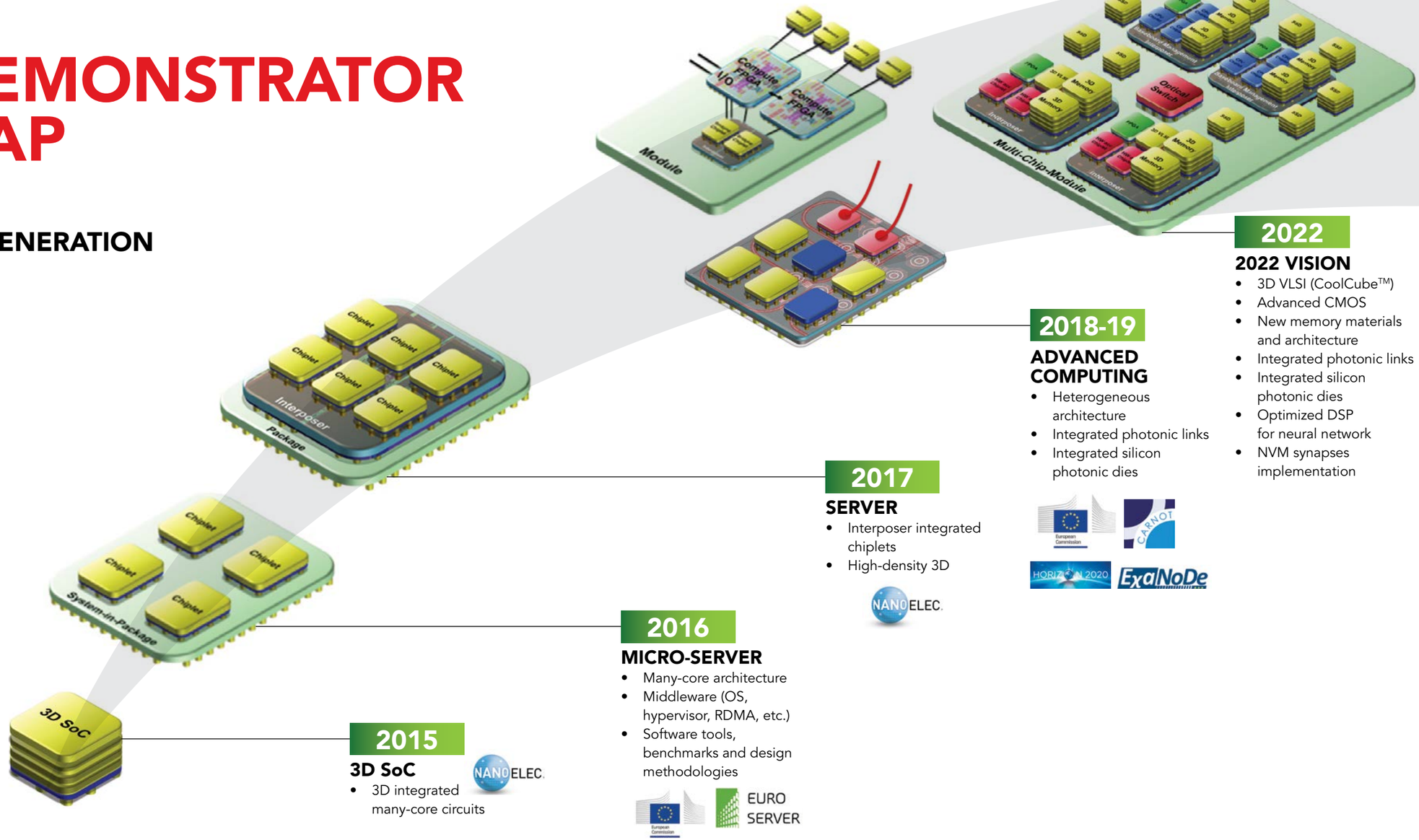
Quantum computing
Semiconductor qubit device exploration:
- SiGe is a suitable material for creating qubits
- Quantum device fabrication benefits from nanowire technology developed at Leti



Qubit silicon device

LETI'S DEMONSTRATOR ROADMAP

TOWARDS NEXT GENERATION COMPUTING



CHIPLET DEVELOPMENT AXIS

INTERPOSER DEVELOPMENT AXIS

2022

2022 VISION

- 3D VLSI (CoolCube™)
- Advanced CMOS
- New memory materials and architecture
- Integrated photonic links
- Integrated silicon photonic dies
- Optimized DSP for neural network
- NVM synapses implementation

2018-19

ADVANCED COMPUTING

- Heterogeneous architecture
- Integrated photonic links
- Integrated silicon photonic dies

2017

SERVER

- Interposer integrated chiplets
- High-density 3D

2016

MICRO-SERVER

- Many-core architecture
- Middleware (OS, hypervisor, RDMA, etc.)
- Software tools, benchmarks and design methodologies

2015

3D SoC

- 3D integrated many-core circuits

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 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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