ADDRESSING FUTURE COMPUTING ARCHITECTURE WITH SILICON PHOTONICS

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ADDRESSING FUTURE COMPUTING ARCHITECTURE WITH SILICON PHOTONICS

Hughes METRAS _ Leti Workshop @ Semicon West | July 10, 2018

SI-PHOTONICS – MARKET DRIVERS

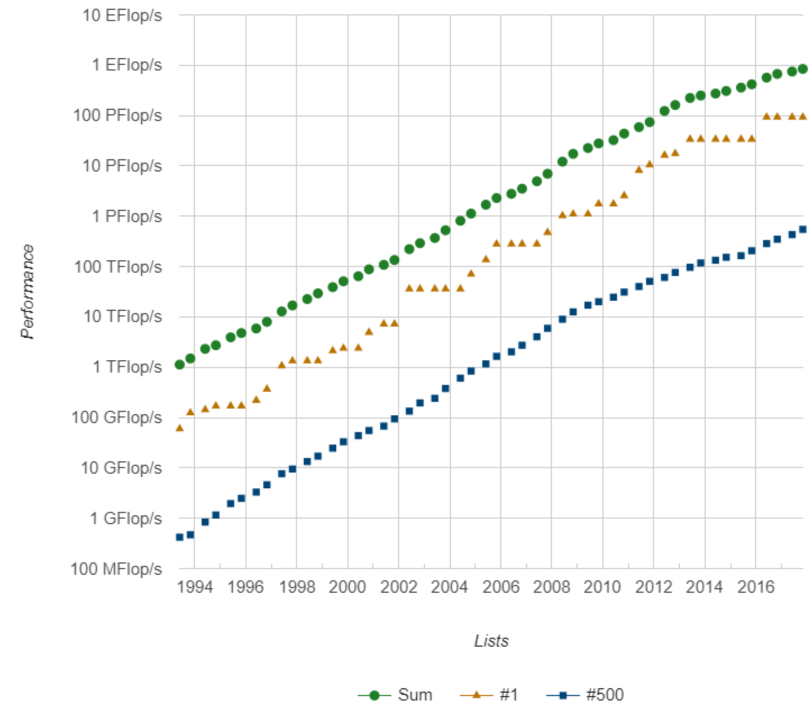
HPC and Datacenters

EXASCALE ERA REQUIREMENTS

Power

Interconnects (Bandwidth)

Cost



➔ High Data Rate, Low Power, Low-Cost Interconnects

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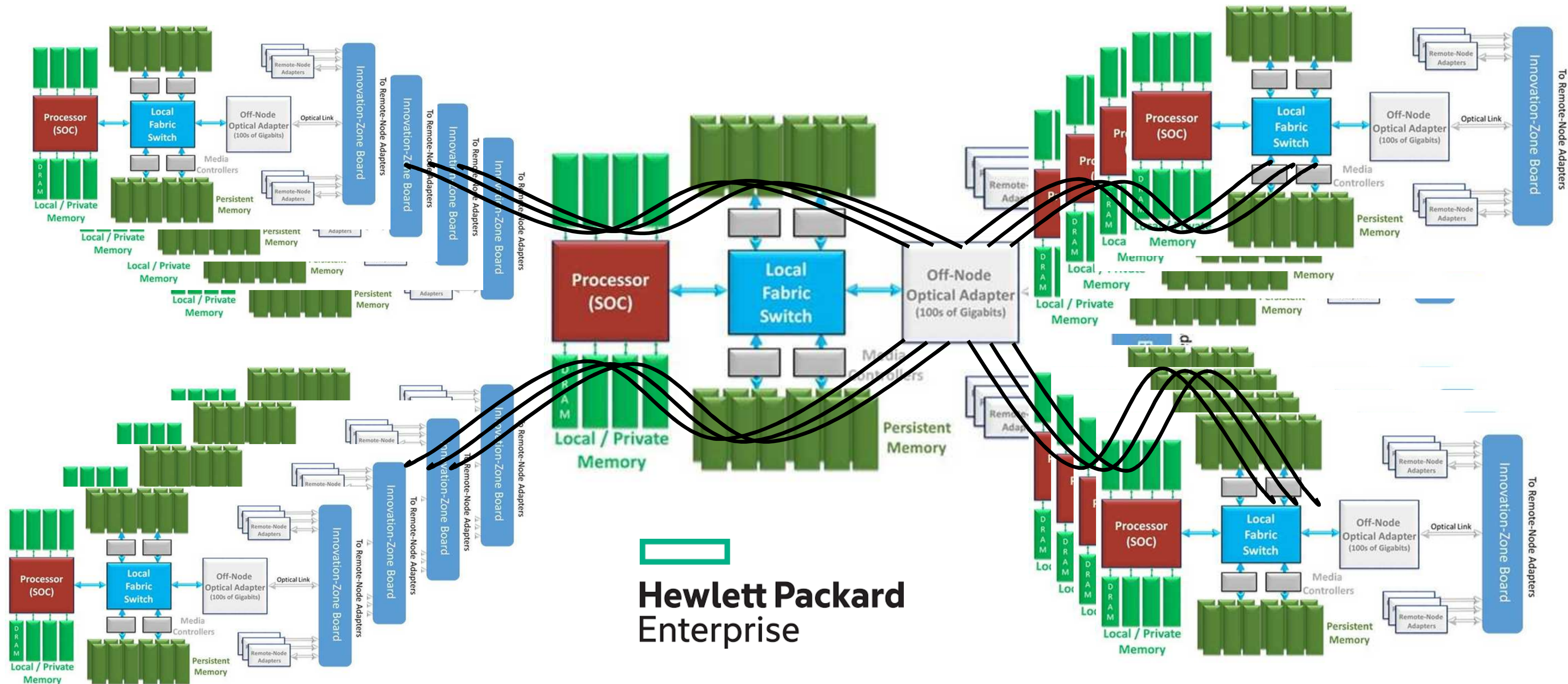
NEW COMPUTING ARCHITECTURES

Component interfacing **with >100 single mode fibers** each of them carrying **>10 wavelengths** modulated at **10-25 Gbits/s.** This would provide a performance of **>20 Tbits/s** at less than **500 fJ/bit**.



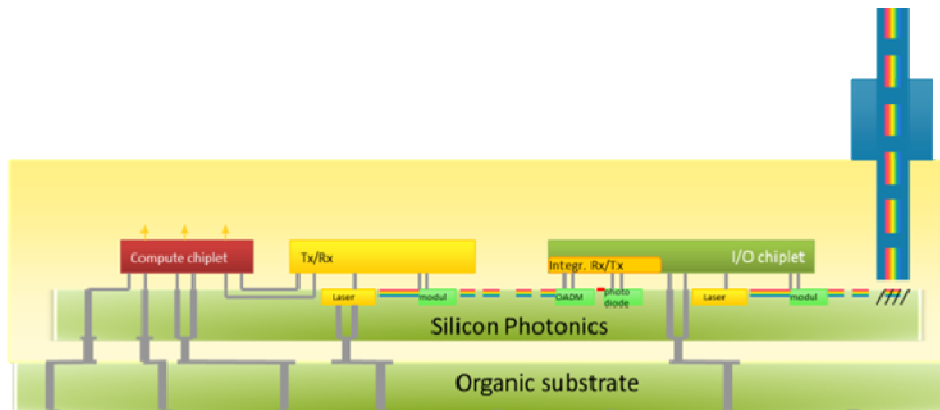
➔ High Data Rate, Low Power, Low-Cost Interconnects

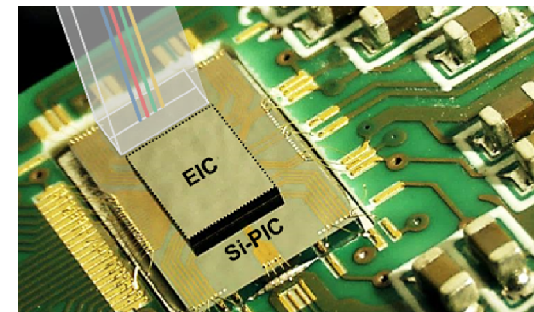
3D SI-PHOTONICS CONVERGENCE – REQUIREMENTS FOR TECHNOLOGY

- Aim at heterogeneous integration: lasers, silicon photonics platform, fibers, electronic drivers, PCB
- Optimize performance of individual components
- Use a platform compatible with mass manufacturing

→ Find an integration platform combining performance, cost and form factor

- 3D TSV technologies enable high-speed interconnect between photonic chips and electronic drivers + interface to the PCB host
- High-density Cu pillar and die-to-wafer hybrid bonding will enable high-quality RF interconnects, high reliability and ultimately a high number of interconnects.





Silicon Photonics Interposer

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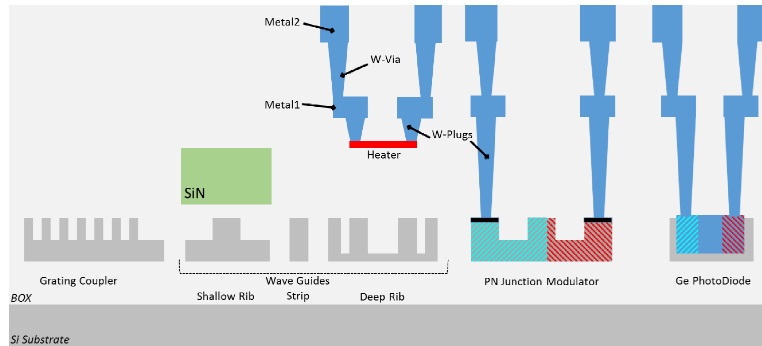
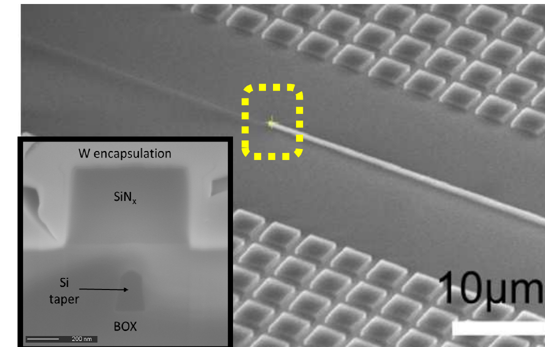
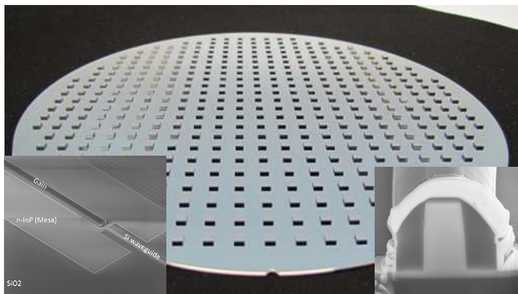
SI-PHOTONICS DEVELOPMENTS

- Integration of SiN layer on top of the Si → t

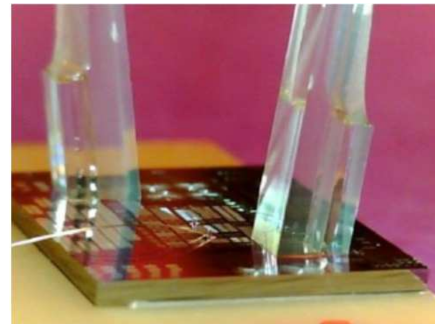


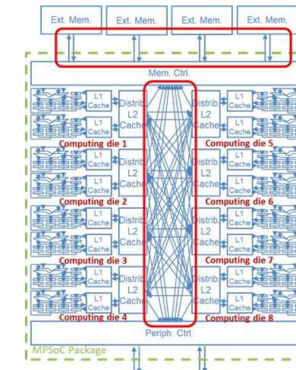




- 3-5 die bonding on Silicon
- CMOS compatible Hybrid Laser

- Single Mode Fiber Alignment





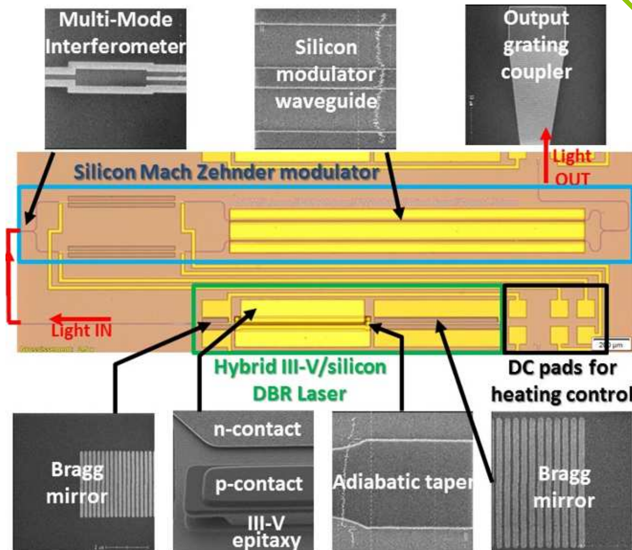
Multi-cores bottlenecks

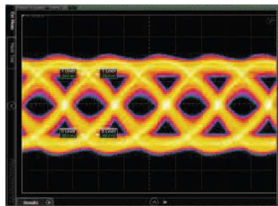
- Optical Network On Chip

Increasing the diversity of solutions to optimize performance and integration

INTEGRATED HYBRID III/V ON SILICON LASER RESULTS

25Gb/s laser + MZM transmitter

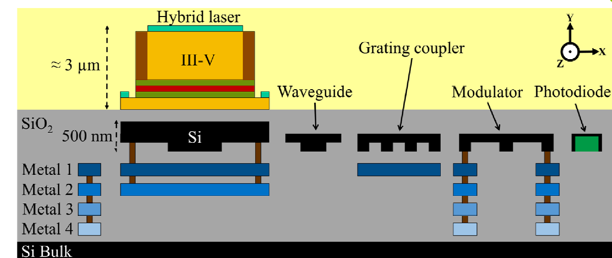


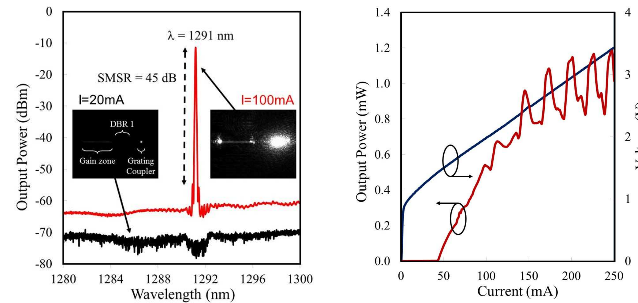


- Co-integration hybrid IIIV/Silicon DBR laser + silicon Mach-Zehnder modulator.
- 25Gb/s transmission at 1.3µm up to 10km.

T. Ferrotti et al. ,1.3µm hybrid III-V on Silicon Transmitter Operating at 25Gb/s SSDM, (2016)

Back-Side Integrated Hybrid laser

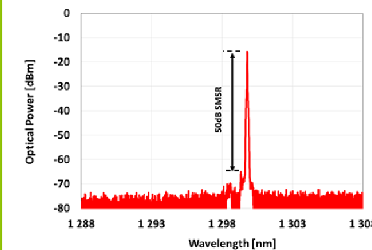




- Demonstration of a new back side integration of a hybrid laser compatible with CMOS based photonic platform.
- Single wavelength behavior demonstrated with SMSR higher than 35dB.
- Lasing threshold around 45 mA with an output power > 1.15mW at 200mA

J.Durel et al., First Demonstration of a Back-Side Integrated Heterogeneous Hybrid III-V/Si DBR Lasers for Si-Photonics Applications, IEDM (2016)

CMOS-compatible Hybrid laser

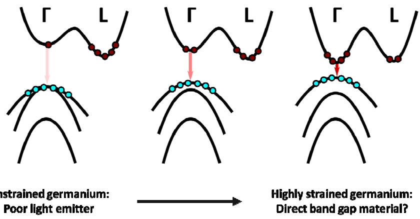


- Front side integration of a hybrid III-V/Si laser in a fully CMOS compatible 200mm technology.
- CMOS compatible metallization (no noble metals) and patterning (no lift-off) processes.
- Single wavelength behavior demonstrated with SMSR higher than 50dB.
- Lasing threshold around 60 mA with a 3mW output power at 190mA

B. Szelag et al., Hybrid III-V/Si DFB laser integration on a 200 mm fully CMOS-compatible silicon photonics platform

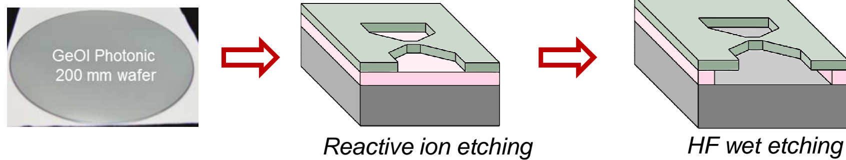
GROUP IV DIRECT BAND-GAP MATERIALS

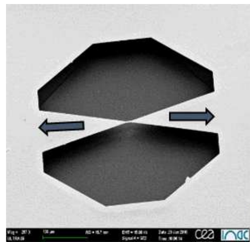
Tensile strained Ge approach

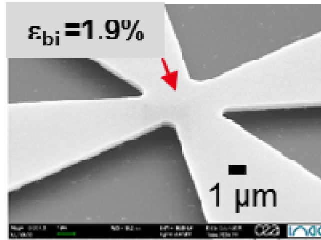


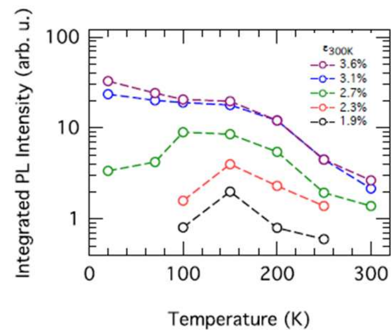
- Record of uniaxial stress in Ge: 4.9 %
- Record of biaxial stress in Ge: 1.9 %
- Direct bandgap behavior demonstrated
- No lasing effect yet

- Residual strain amplification of GeOI substrates



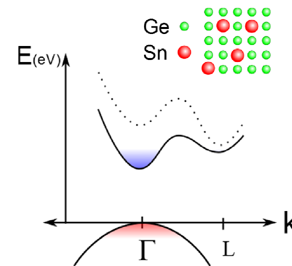






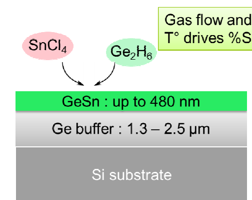
V.Reboud et al., Progress in Crystal Growth and Characterization of Materials, 63, 2, 2017, 1-24

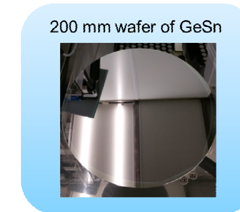
GeSn alloys approach

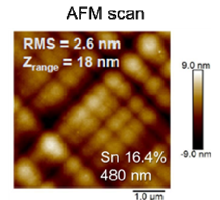


- Low temperature GeSn growth on 8" wafer
- Step-graded GeSn buffers approach
- GeSn layers with Sn content up to 16%
- Lasing effect in GeSn micro-disks up to 180K

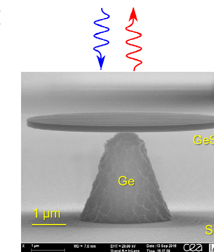
- Out of equilibrium growth of GeSn at low temperature

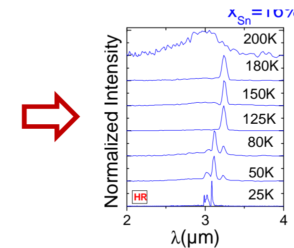






- Lasing effect





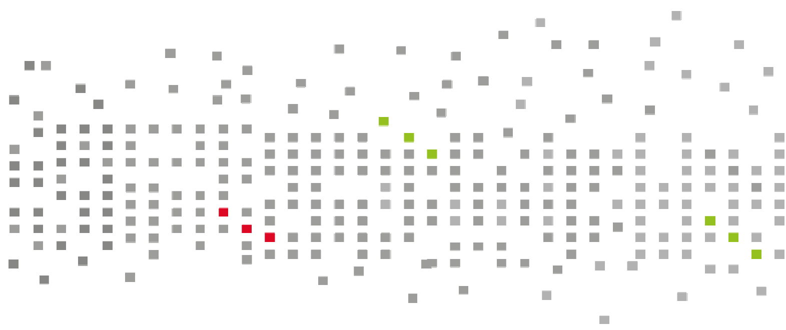
V. Reboud et al., Appl. Phys. Lett. 111, 092101 (2017).

CONCLUSIONS

- Silicon photonics: a mature solution supported by industrial foundries
- CEA-Leti has developed a mature Si-platform, CMOS compatible, supported by standard EDA tools and **available through MPW shuttles or tailored projects**.
- On going transition from **200mm → 300mm** wafers
- Leti is working on **new options** to increase the level of integration and complexity of the silicon photonics circuits

NEW FUNCTIONS AND OPPORTUNITIES BROUGHT BY OUR RECENT INVESTMENTS IN 300 mm TECHNOLOGIES

Thank you for your attention!



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