



PROGRAMS TAKE OFF AROUND IMMERSION PLATFORM

2nd SPIE Leti litho workshop | Céline Lapeyre | February 28th 2019

LETI IMMERSION CELL PRESENTATION

Coating & Development Track
Sokudo DUO DT3000



Immersion Scanner
NXT:1970Ci



Top view CD-SEM
VeritySEM4i & HCG4000



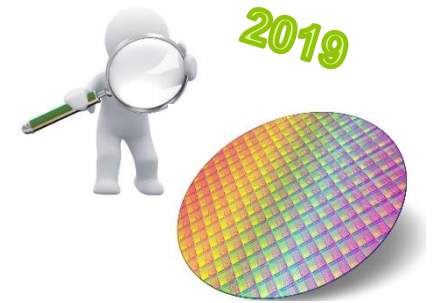
Scanner Monitoring
Yieldstar S375



Overlay
Archer600

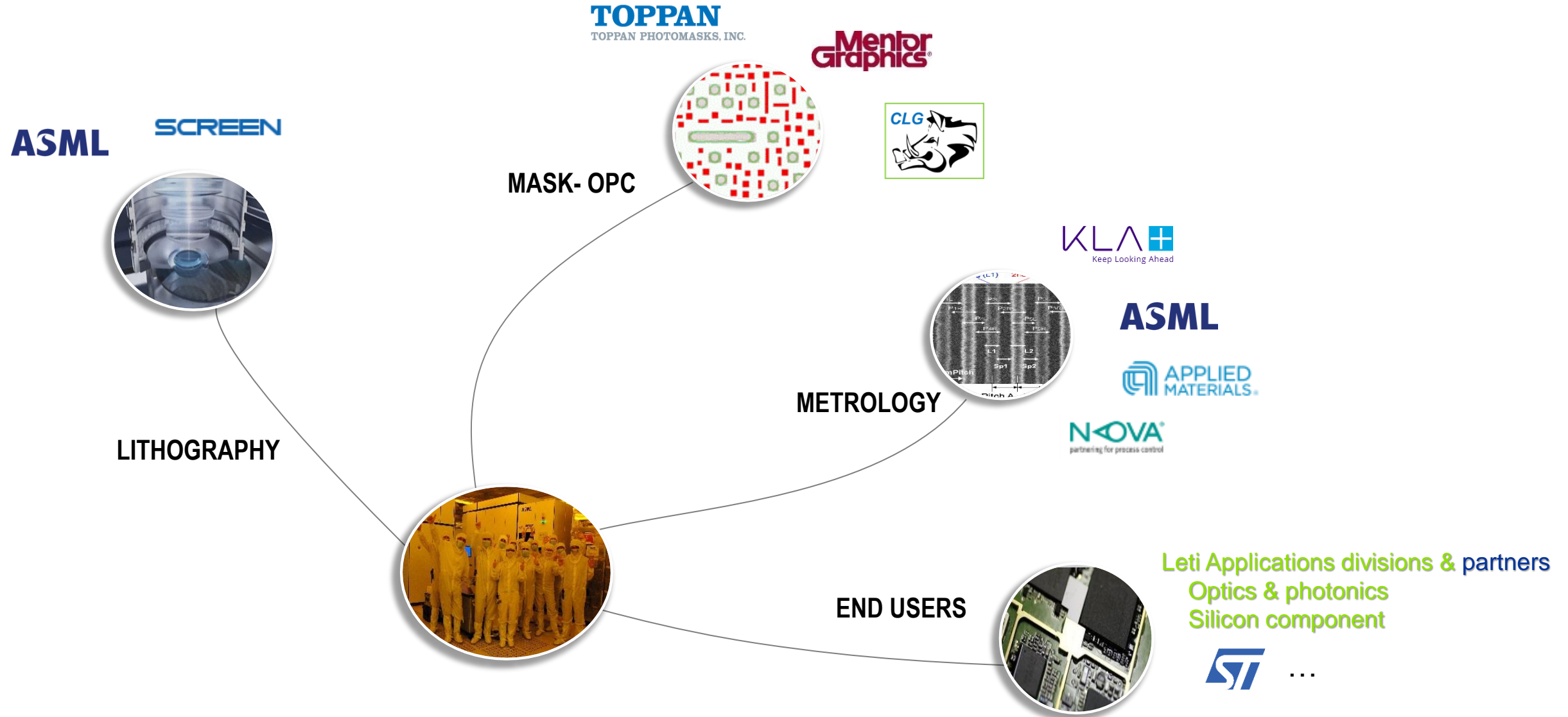


Scatterometer
NOVA T600



Inspection and Defects
Review

Full autonomy to address 300mm advanced LETI programs & support partners with relevant industrial patterning solutions



ADVANCED CMOS

FDSOI

CoolCube™

Stacked nanowires

Quantum

MEMORY

PCM

RRAM

Crossbar

Neuromorphic

PHOTONIC & OPTRONIC

Si advanced designs

Si Wave Guide

2D Grating Coupler

Display, Polarizer

Large dimension network patterns
Work around stitching

DSA

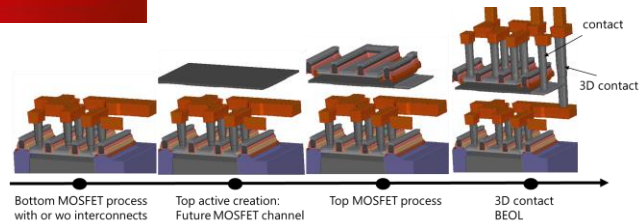
Wafer service

Mastering

LETI Immersion Cell to address advanced LETI programs & support industrial partners

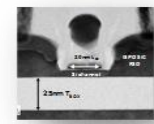
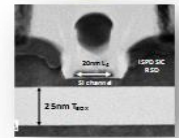
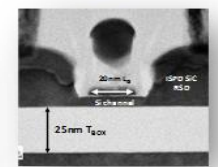
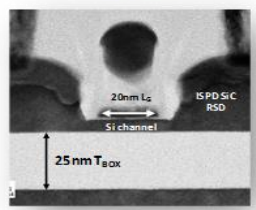
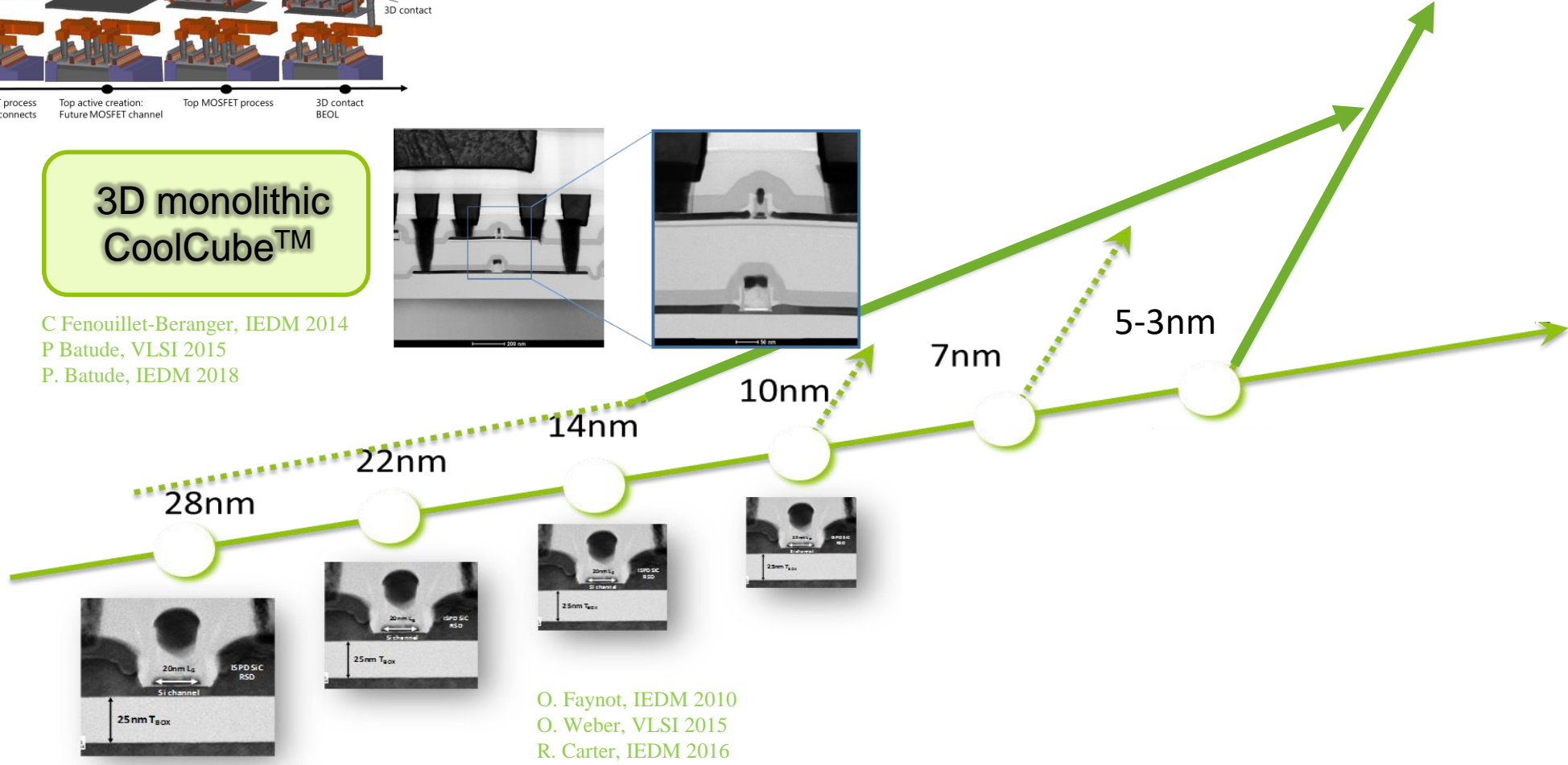
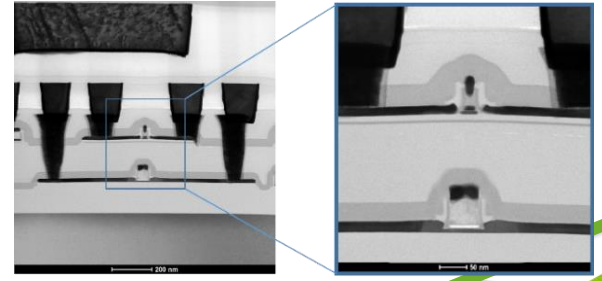
MORE THAN MOORE INNOVATIVE FIELDS & 3D CHALLENGES

ADVANCED CMOS



3D monolithic CoolCube™

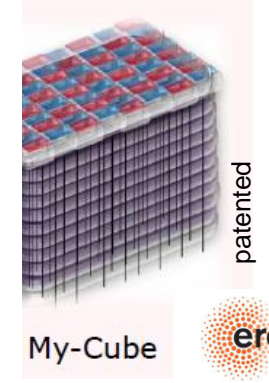
C Fenouillet-Beranger, IEDM 2014
 P Batude, VLSI 2015
 P. Batude, IEDM 2018



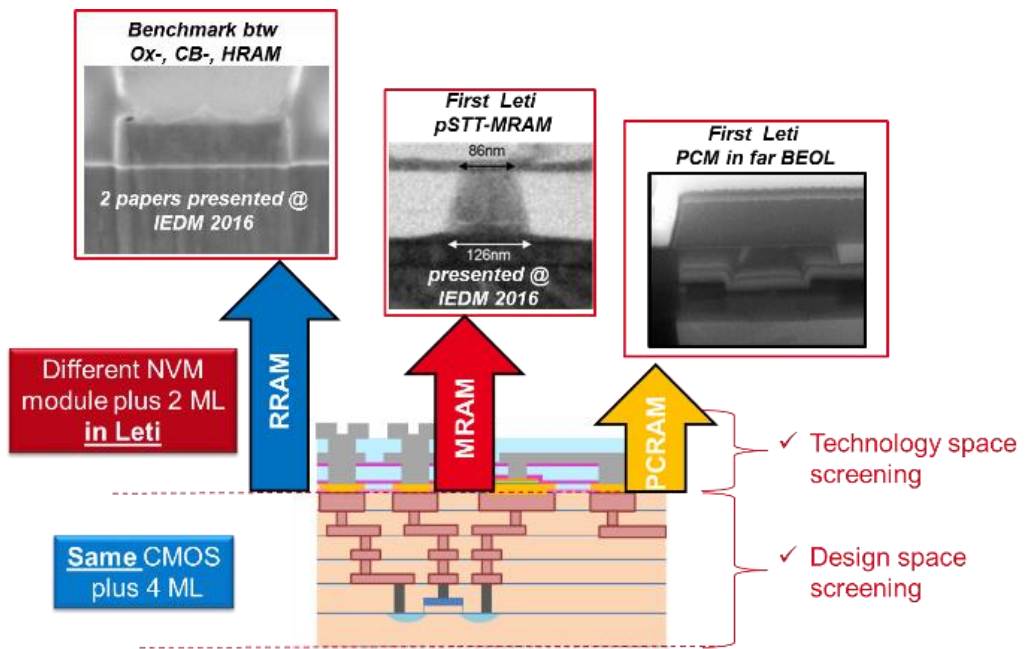
O. Faynot, IEDM 2010
 O. Weber, VLSI 2015
 R. Carter, IEDM 2016

FDSOI

IMC integration ip-scaling



3 BEOL eNVM technologies



Resistive-RAM OxRAM & CBRAM
VLSI 2018
IMW 2018
EDL 2018

PCRAM

FeRAM

TIN PVD
HfO₂+Si
TIN 10nm PVD

IMW 2018
NVMTS 2018
NVMTS 2017
SSDM 2017

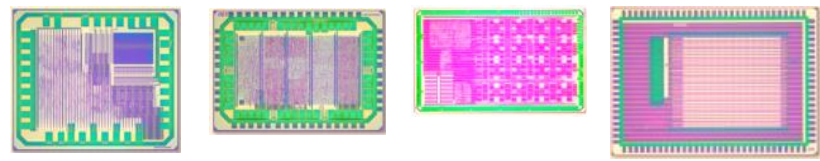
SSDM 2018

Polarization [$\mu\text{C}/\text{cm}^2$]

E [MV/cm]

Material development and exploration

Neuromorphic



IEDM 2018
IEDM 2018
ISSCC 2019



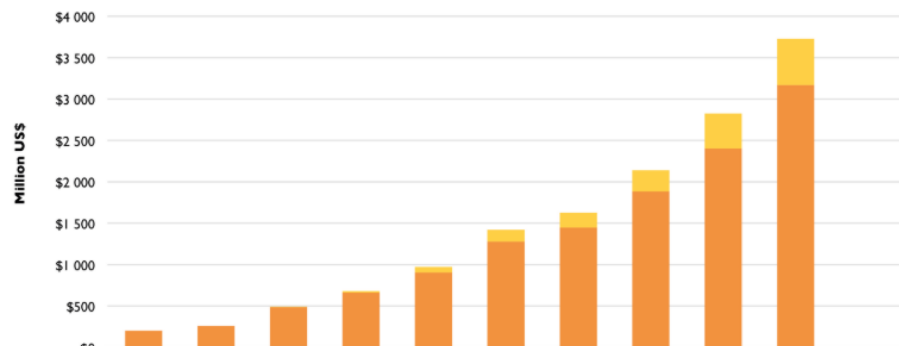
MGH-UCLA Human Connectome Project

LITHO DEVELOPMENT FOR SILICON PHOTONIC



Silicon photonics transceivers market forecast

(Source: Silicon Photonics 2018 report, Yole Développement, January 2018)



| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | CAGR |
|-------------------------------------|--------|--------|--------|--------|--------|----------|----------|----------|----------|----------|-------|
| 200G/400G Si photonics transceivers | \$ 0 | \$ 0 | \$ 5 | \$ 21 | \$ 68 | \$ 142 | \$ 179 | \$ 257 | \$ 424 | \$ 559 | 95,9% |
| 100G Si photonics transceivers | \$ 191 | \$ 251 | \$ 475 | \$ 651 | \$ 900 | \$ 1 278 | \$ 1 448 | \$ 1 884 | \$ 2 401 | \$ 3 169 | 37,3% |
| 40G Si photonics transceivers | \$ 11 | \$ 9 | \$ 12 | \$ 9 | \$ 4 | \$ 0 | \$ 0 | \$ 0 | \$ 0 | \$ 0 | <1% |

Yole Développement are part of Yole Group of Companies

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Advanced photonic developments

High performance devices



193i

RESOLUTION

ROUGHNESS

2D CURVES RET

300mm photonic platform @ LETI

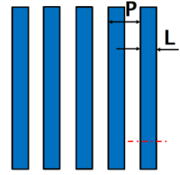


Ecosystem around photonic based on regular MPW shuttle

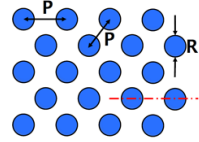


DISPLAY AND LARGE ARRAYS APPLICATIONS

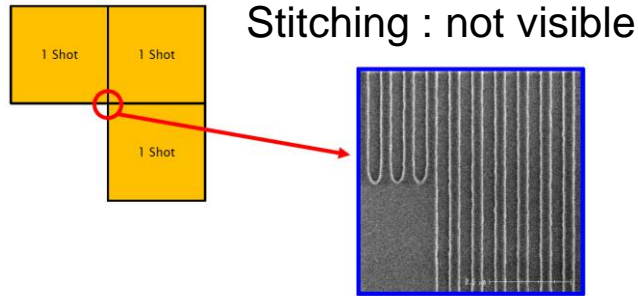
OBJECTIVES



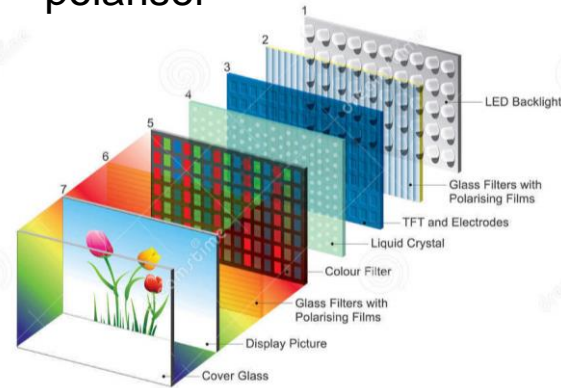
P=80nm,90nm,100nm,140nm
L=40nm,45nm,50nm,70nm



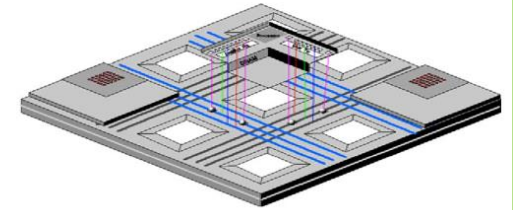
P=180nm
R=90nm



Application example :
Flat panel application
Large surface master for
polariser

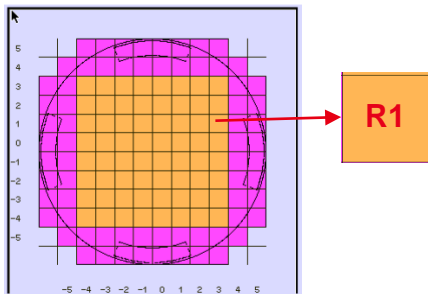


Macrochip Architecture
Photonics bridge chips

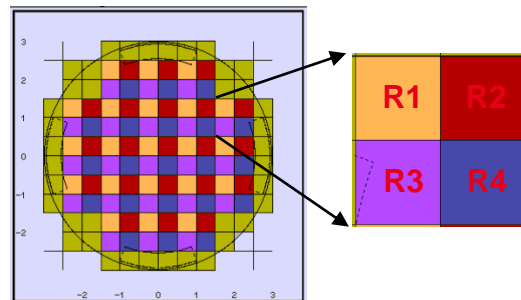


Source: Proceedings of the IEEE 0018-9219
Ashok V. Krishnamoorthy and all

Mapping : full 300mm coverage
or large device: 200X200mm²
exposed with 1 reticle



or large device: 50x50mm²
exposed with 4 reticles

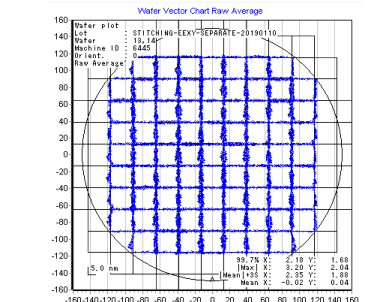
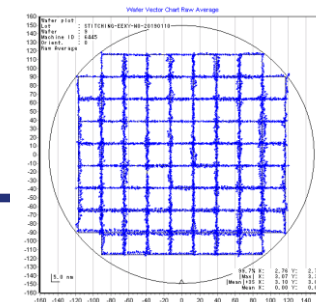


ASML

Overlay performance on NXT1970

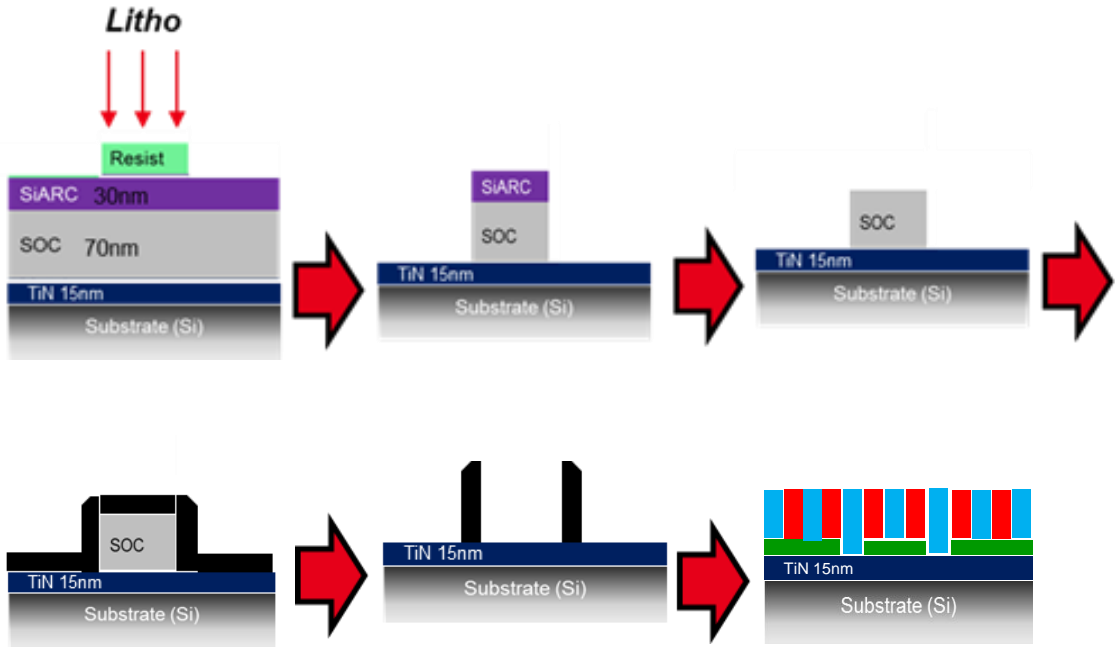
No correction:
X/Y 99.7%: ≤2.8nm

CPE correction:
X/Y 99.7%: ≤2.2nm



DSA CHEMOEPITAXY INTEGRATION

DSA GUIDE : lamellar approach



| <u>L18</u> | x2 | x3 | x4 |
|-------------------------|----|-----|-----|
| CD _{line} (nm) | 27 | 45 | 63 |
| Pitch (nm) | 72 | 108 | 144 |

Spacer flow

Goal: Implement a vehicle test for chemoepitaxy of High- χ BCP ($L_0 < 20$ nm)



IMMERSION CELL ROADMAP

2018

2019

2020

Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug

28FDSOI

3D monolithic CoolCube™ #1

3D monolithic CoolCube™ #2

QBIT Quantum

Stacked nanowires (ERC My-Cube)

PCRAM

GEN1

GEN2

GEN3

PHOTONIQUE

MPWs shuttle

IPH1 Run1

IPH1 Run2

IPH1 Run3

IPH2 Run1

IPH2 Run2

IPH2 Run3

IPH3

DISPLAY

Stitching development

DSA GUIDE

BODHI

AGUA

JDPs

TOOLS SUPPLIERS

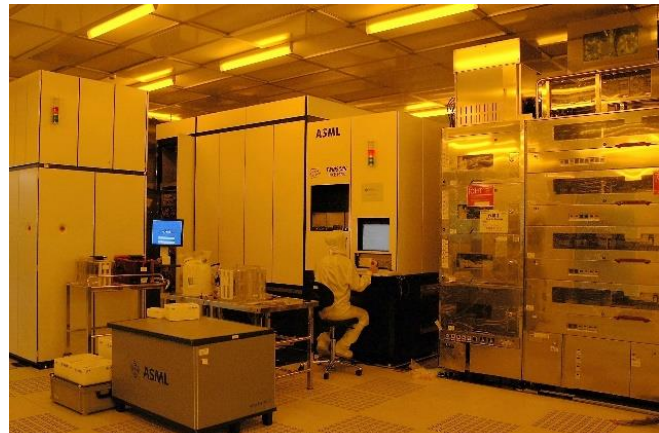
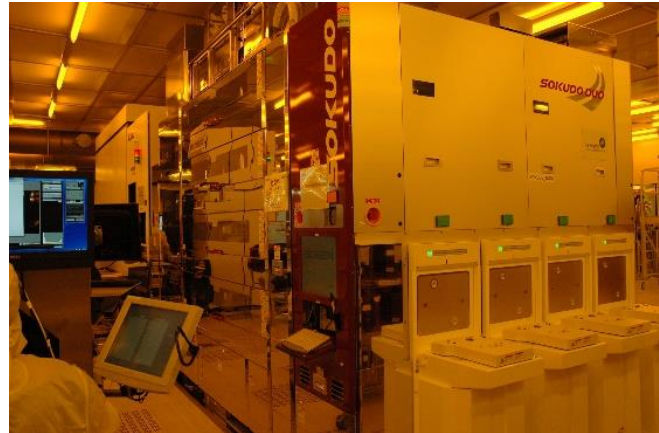
300MM IMMERSION LITHOGRAPHY CELL IMPLEMENTATION AT LETI

END DECEMBER 2017
PO

JANUARY – MAY 2018
DEDICATED CLEANROOM AREA
TOOLS PREPARATION

MAY – OCTOBER 2018
INSTALLATION, TEAM
& PROCESS START

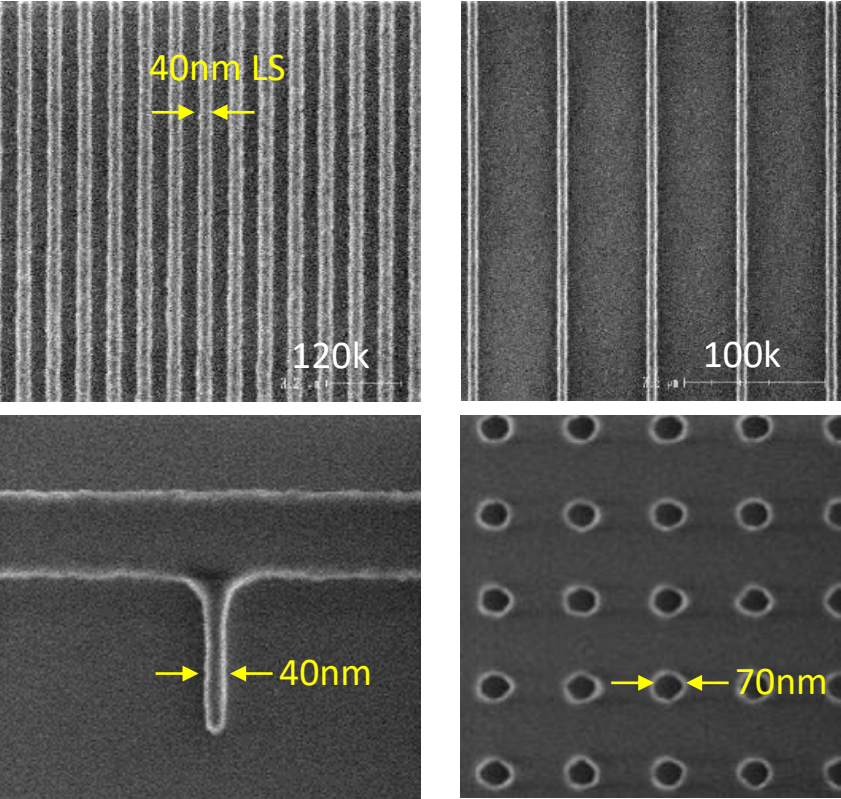
BEGIN OCT. 2018
TOOLS ACCEPTANCE,
ON-LINE WITH SCHEDULE



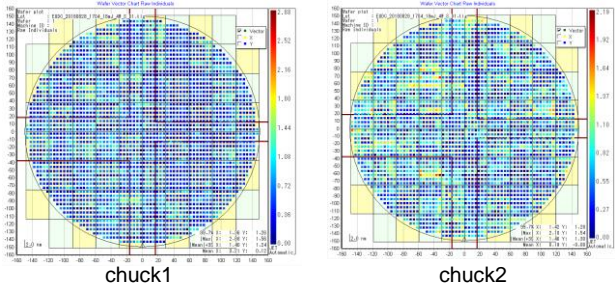
IMMERSION LITHO READY TO SUPPORT LETI STAKES

SEPTEMBER 2018 : 1st lithographies made on immersion cluster meeting expectations

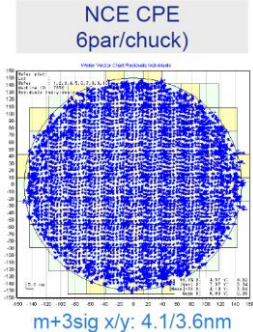
Resolution capability



Overlay capability

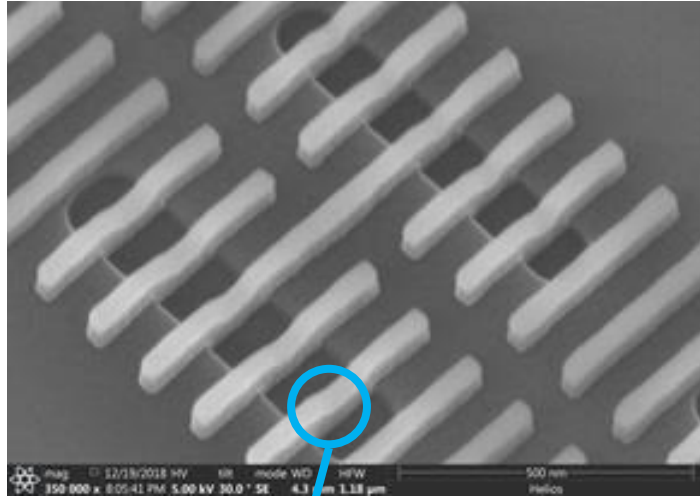


- Dedicated Chuck Overlay : $(99.7\%) \leq 1.7\text{nm}$
- Matched Machine Overlay NXT1970 to NXT1950 : $m+3\text{sig} \leq 4.1\text{nm}$



FULL- LETI 28FDSOI INTEGRATION DEVELOPMENT START

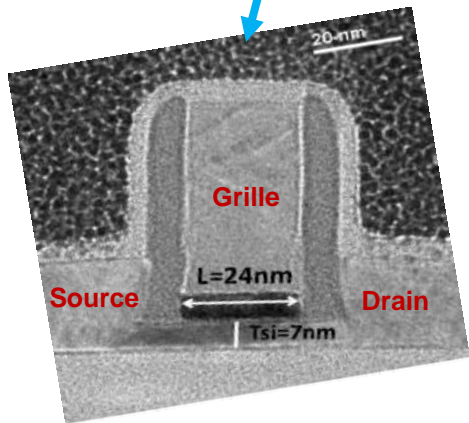
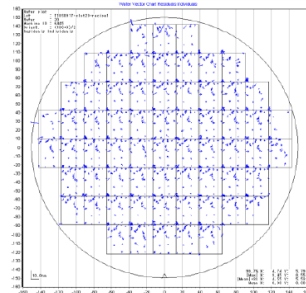
NOVEMBER 2018 : 28FDSOI process development start in 300mm



GATE on 28FD-SOI

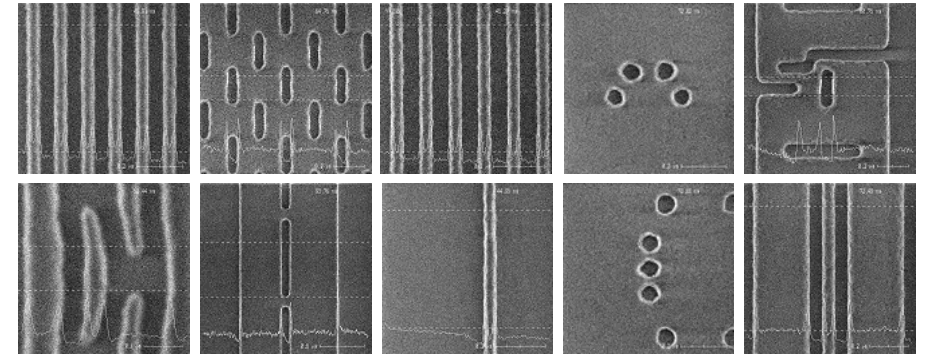
45nm CD litho
 Ovl ($M+3\sigma$) $\leq 5.5\text{nm}$
 alignment to ACTI
 (partner)

30 intrafield locations
 NCE CPE 6par



28nm FDSOI transistor

Lithographies under tuning



...300mm complete 28FDSOI flow patterning under development

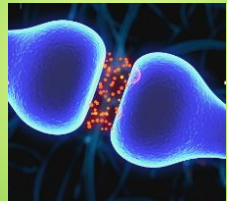
Next : 28 FDSOI technology to be used as base wafers for 3D integration (3D monolithic, Memories, Qbit,...)

CONCLUSION

- Immersion Cell is part of large 300mm investments @LETI (2018-2020)
- Strong start-up of Immersion Cell since October 2018 with challenging projects
- First results are aligned with roadmap expectations

Our objective :
Support the next wave of innovations with best-in-class lithography option

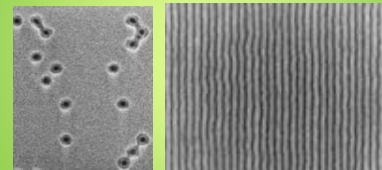
Non-Volatile Memory



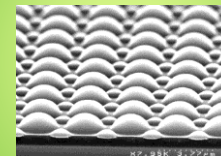
Neuromorphic



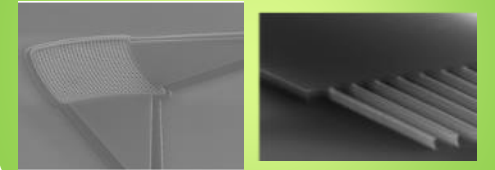
DSA



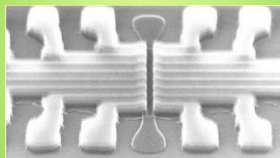
Imager



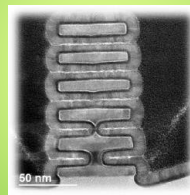
Photonic



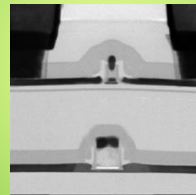
Quantum



Stacked Nanowires



3D monolithic



Cybersecurity



Other

Biochips
Mastering



Thank you for your attention !

Acknowledgements

CEA and LETI employees acknowledge « Auvergne Rhône Alpes Region » for major investments that have been made in LETI microelectronic 300mm line under NANO2022-IPCEI program.

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