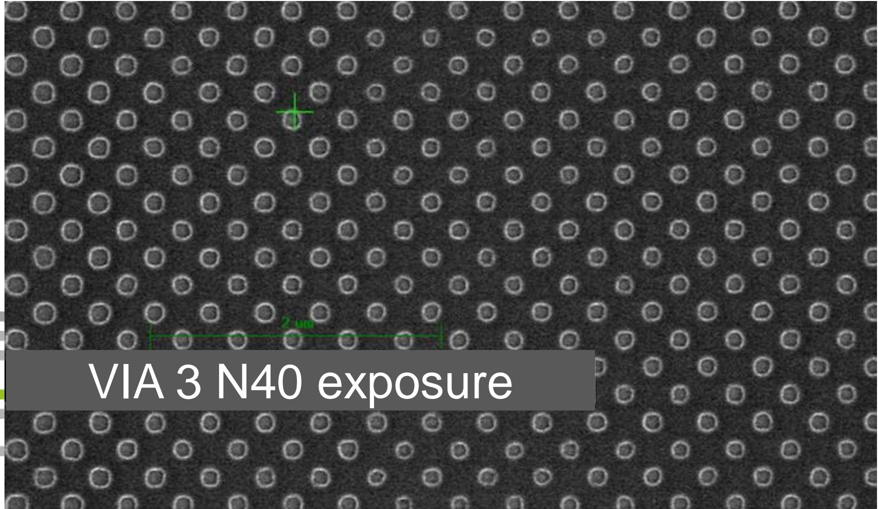


DYNAMIC BLANKER INTEGRATION INTO THE MAPPER TOOL : THE DYNAMICS OF AN ANNOUNCED SUCCESS

LETI Lithography | Workshop SPIE 2018 MuliBeam Session

WHAT PROBLEMS COULD BE ADDRESSED

- Lithography Solution for:
  - Prototyping in R&D and Pilot Line for technology evaluation
  - Fab capability extension to address resolution below 100 nm and/or small scale production
  - Truly unique chips, individual design
- Need to have access to:
  - Versatile lithography technology
  - Maskless approach preferred (save $$$ w.r.t. mask cost)
  - High resolution (not ultra high) compatible with N40 and above
  - Reasonable throughput
- Solutions available:

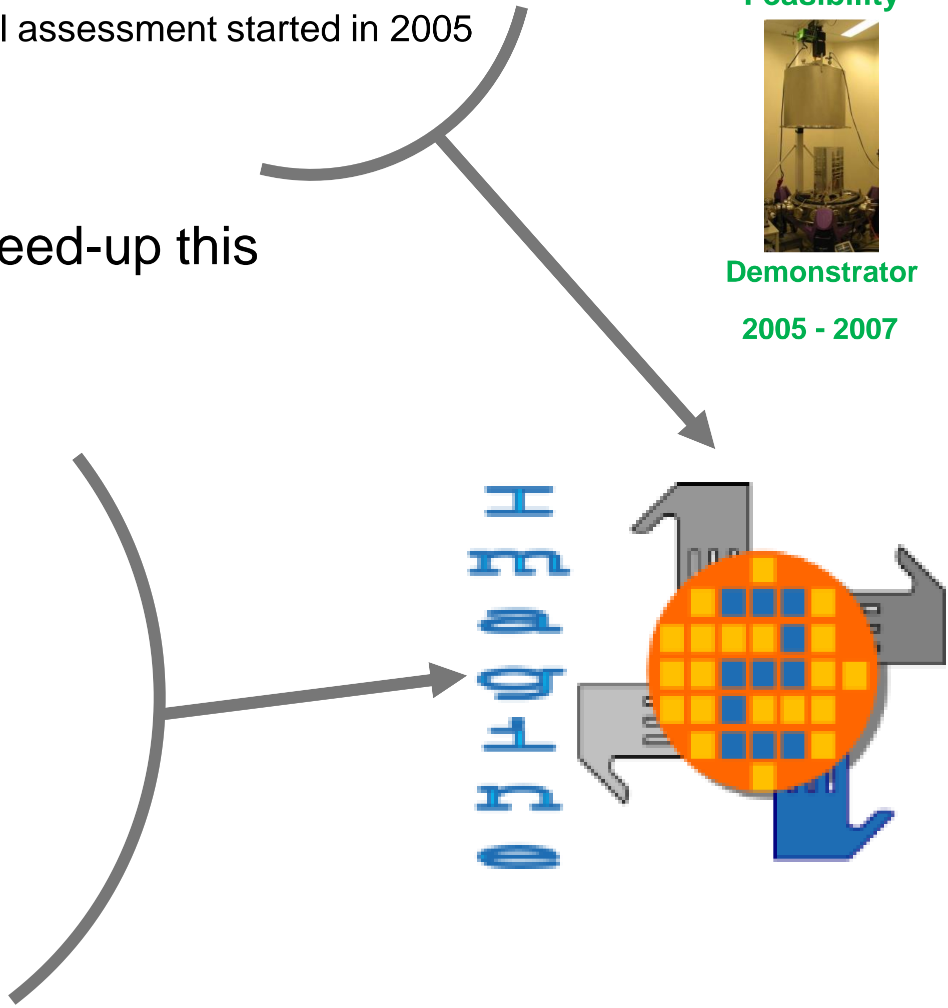
Key Parameters	Throughout (Wph)	Resolution	Productivity	Need for masks	Manufacturing Solution ?
Optical Step & Scan Lithography	High (> 100)	~ 40 nm	Volume manufacturing compatible	YES ($$$$)	YES
Conventional Ebeam	Limited by total current in 1 beam. Pattern dependent	~ 10 nm	<< 1 wph, lab only	NO	NO
Mapper Platform	Current in 1 beam multiplied by number of beams. (65,000x – 650,000x). Not pattern dependent	~ 30 nm	Volume manufacturing compatible	NO	YES

MAPPER-LETI SOLUTION: IMAGINE PROGRAM

- Starting point
  - A strong collaboration with Mapper Lithography for the tool assessment started in 2005
  - LETI pilot line for technology assessment

➔ Need other partners to strengthen and speed-up this technology development

- Resist Track for Process optimization
- EDA for Data Path, EBPC
- Resist Material
- Metrology
- Defectivity Control
- End Users



Feasibility

Demonstrator

2005 - 2007

Process development

Pre-alpha series

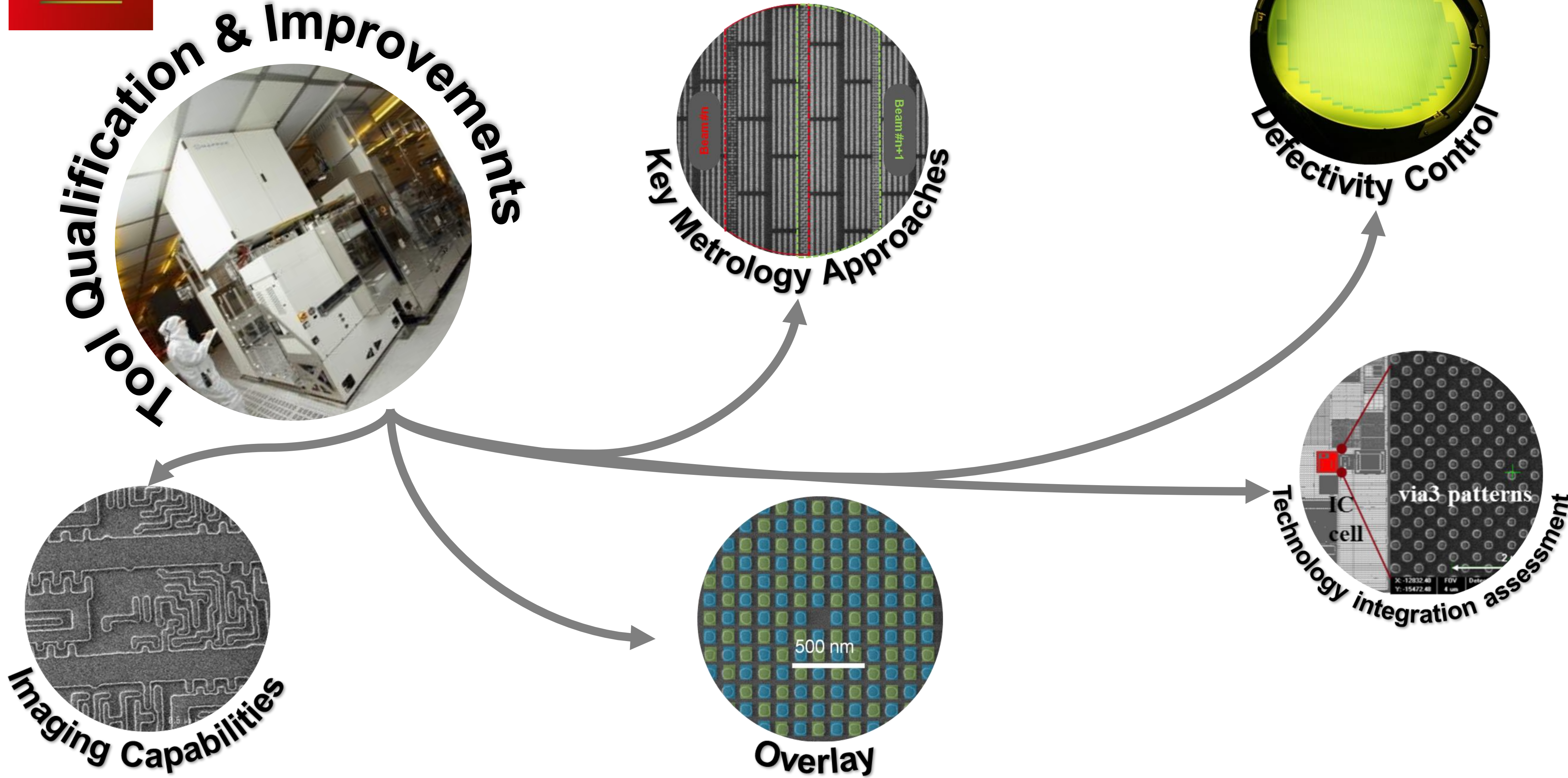
2008 - 2011

Pilot R&D

FLX-1200 series

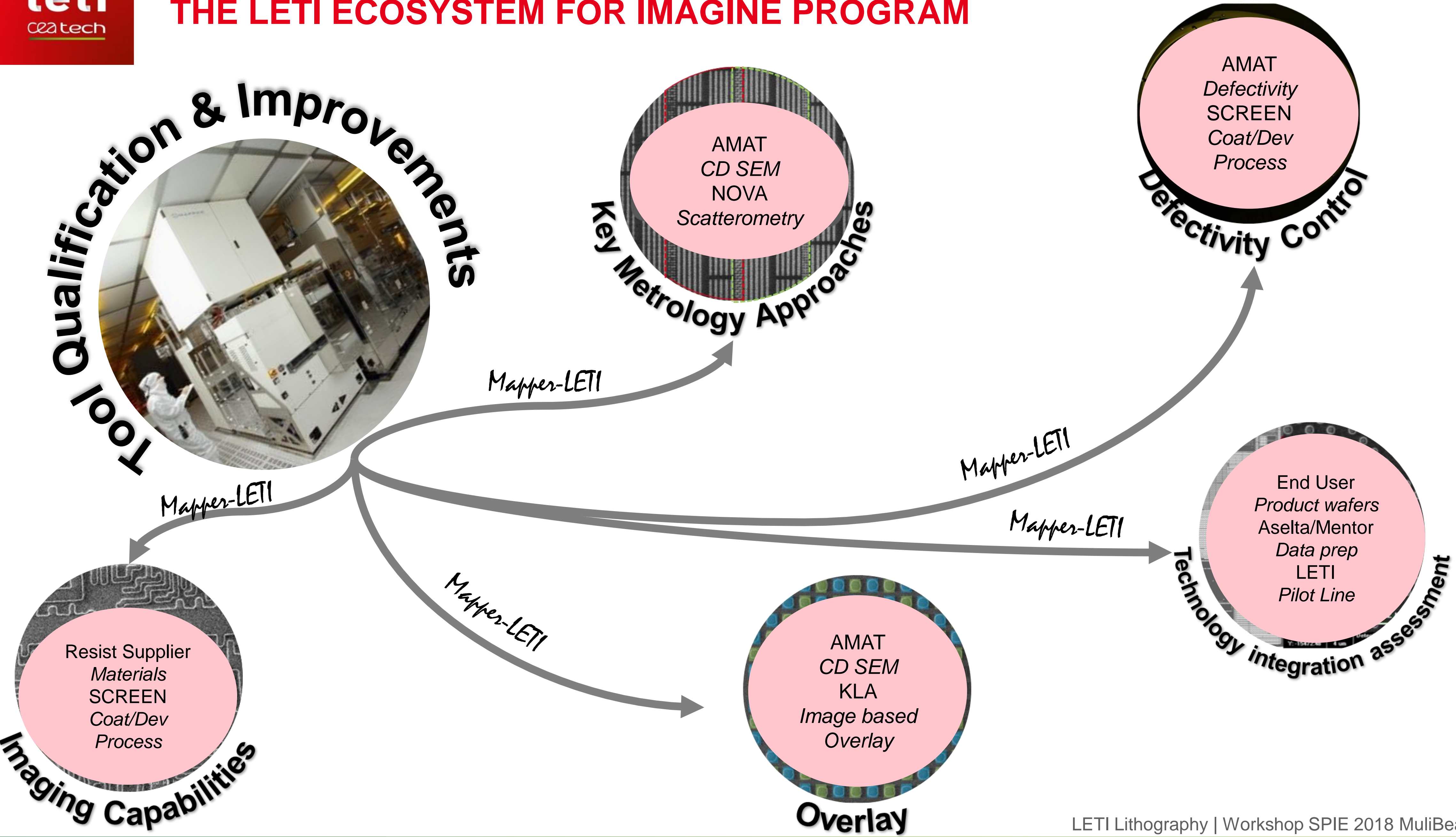
2012 - 2018

THE MAIN IMAGINE PROGRAM OBJECTIVES



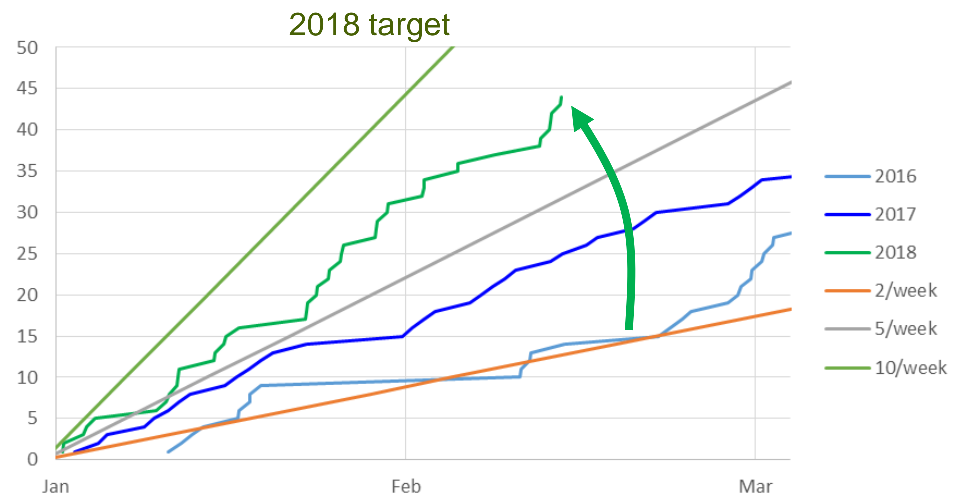
Performance validation of Mapper's FLX-1200 (Invited Paper)
Marco Wieland, MAPPER Lithography; Yoann Blancquaert, Stéfan Landis, Laurent Pain, Jonathan Pradelles, Guido Rademaker, Isabelle Servin, CEA-LETI; Guido de Boer, Pieter Brandt, Michel Dansberg, Remco Jager, Jerry Peijster, Erwin Slot, Stijn Steenbrink, MAPPER Lithography **[10584-15]**

THE LETI ECOSYSTEM FOR IMAGINE PROGRAM

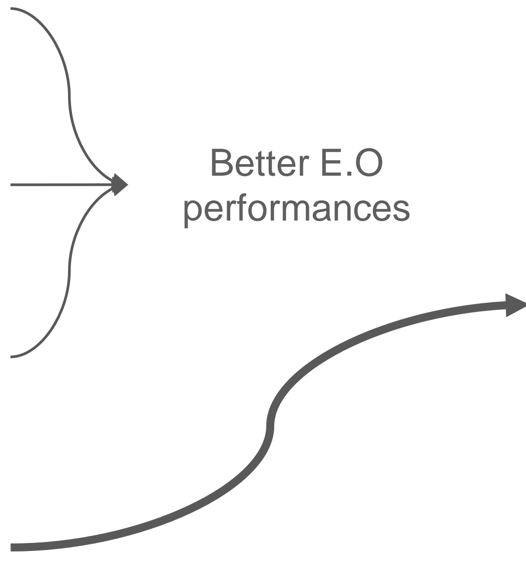


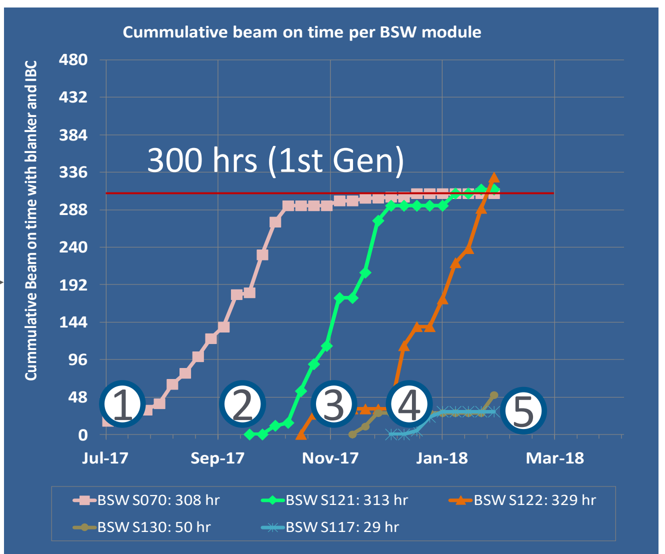
THE MAIN ACHIEVEMENTS (ABOUT THE TOOL)

- ✓ Cumulative exposure on the FLX1200 (2016-2017-2018)
  - Since 2016 large ↗ of # of exposures
  - Wafer clamping yield > 80%
  - In 2017 only 1 week without exposure
  - Constant increase of the exposure capability



- ✓ Improvement of the beam alignment on beam stop
  - 100% of the beams still aligned after exposure
- ✓ Dose to size monitoring (CD target 42 nm ½ pitch).
  - Mean value 34.00 µC/cm² (σ= 2.80 µC/cm²)
- ✓ Exposure latitude monitoring (CD target 42 nm ½ pitch)
  - Mean value 1.5 %/nm (σ= 0.24 %/nm)
- ✓ Switch from static blanker to dynamic blanker (H2-2017)

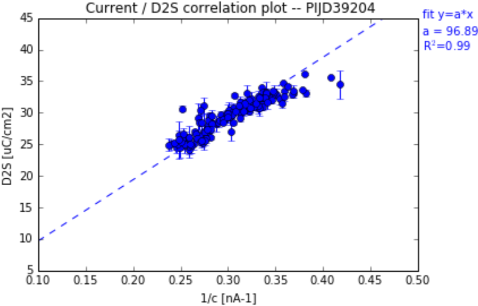




THE MAIN ACHIEVEMENTS (ABOUT THE INTERNAL METROLOGY)

Goal = to correlate the in tool measurements (tool parameters) with the in resist (after exposure) measurements:

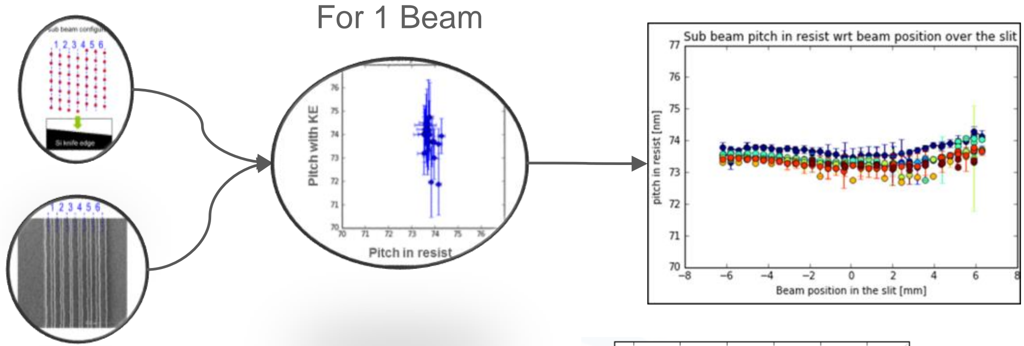
- ✓ Beam current vs dose to size
  - Current measurement of each Beam (@ ≠ process steps)
  - Dose to size measurement CD-SEM in resist exposed for each beam



Stable correlation kept for >5h with multiple loading & unloading in the tool

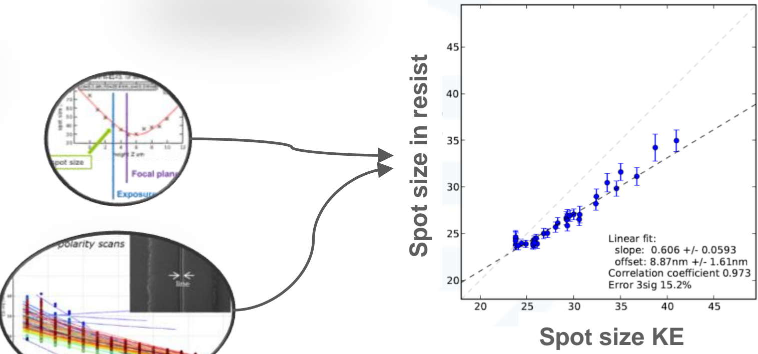
- ✓ Sub beam pitch
  - 49 Sub Beams scan a Knife Edge
  - CD SEM measurement from exposed dense line

For 1 Beam



Uniform & Narrow distribution across the slit (blanker)

- ✓ Sub beam spot size
  - All beams scan a Knife Edge in parallel (spot size vs focus)
  - CD SEM measurement from exposed line (CD vs Dose)



Robust & good correlation (performed on several exposure & sub-beams)

THE MAIN ACHIEVEMENTS (ABOUT METROLOGY)

✓ Metrology challenges:

- Critical dimension
- ‘Overlay’ in two passes & with respect to previous layer
- Beam Stitching
- Beam deflection strength measurements

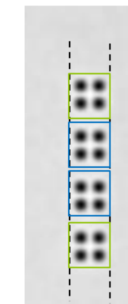
Current solution = CD-SEM

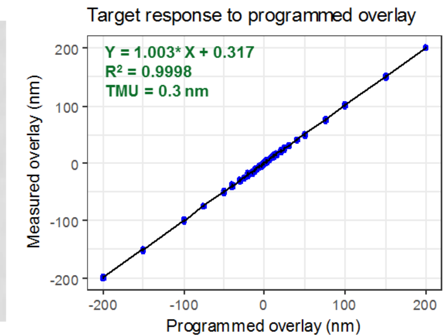
➔ *time consuming // need post data treatment*
➔ *Not scalable to qualify all beams*

✓ Optical methods tailored to Mapper’s needs to be developed and assessed

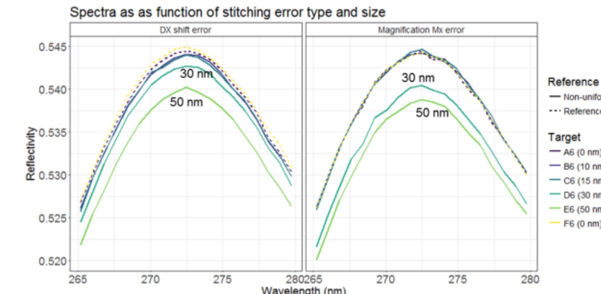
- KLA Tencor: Image based overlay and stitching
  - Actual mark design wider (4µm) than pattern written by single beam
  - New variation of the AIMid (in-die) metrology targets with smaller mark size & Archer 600 platform
  - Used programmed overlay (programed misalignment)

Overlay and stitching metrology for massively parallel electron-beam lithography
Guido Rademaker, Jonathan Pradelles, Stéfan Landis, Stephane Rey, CEALETI; Anna Golotsvan, KLA-Tencor Corp.; Tal Itzkovich, KLA-Tencor Israel; Tetyana Shapoval, Ronny Haupt, KLA-Tencor GmbH; Erwin Slot, Guido de Boer, Dhara Dave, Marco Wieland, MAPPER Lithography; Laurent Pain, CEA-LETI **[10585-29]**



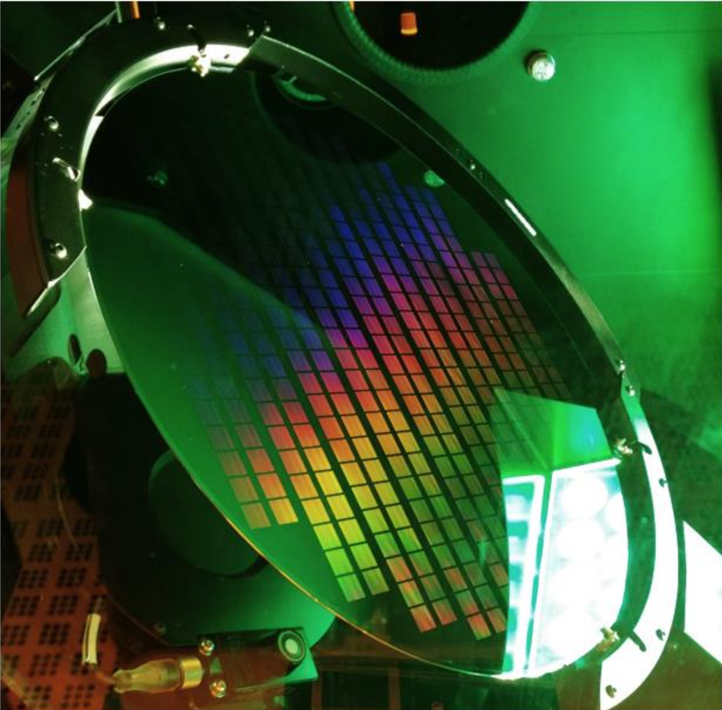


- NOVA: OCD based on Scatterometry
  - Used of programmed non uniformity in line array
  - CD errors: Leads to ‘effective CD’ of grating; < 0.6 nm precision
  - Displacement in X (DX): 6 beams with 30 nm shifts can be detected in spectrum
  - Beam magnification in X (MX): 6 beams with 30 nm shifts can be detected in spectrum



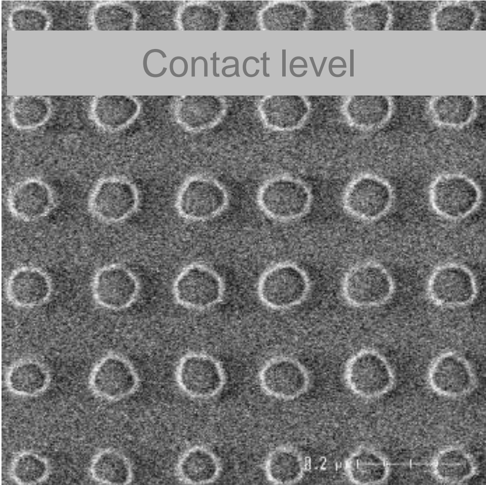
THE MAIN ACHIEVEMENTS (ABOUT THE IMAGING CAPABILITIES)

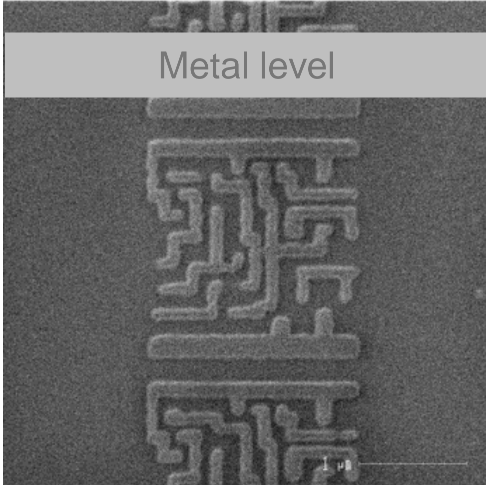
Getting close to covering a full 300 mm wafer in 52 minutes with the static blanker

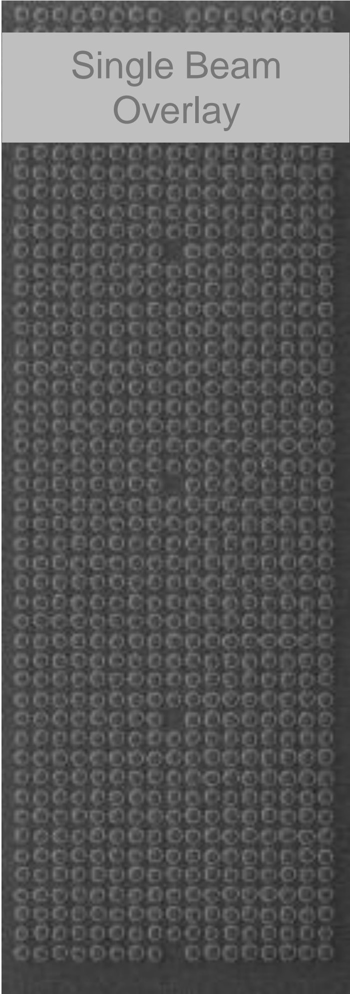


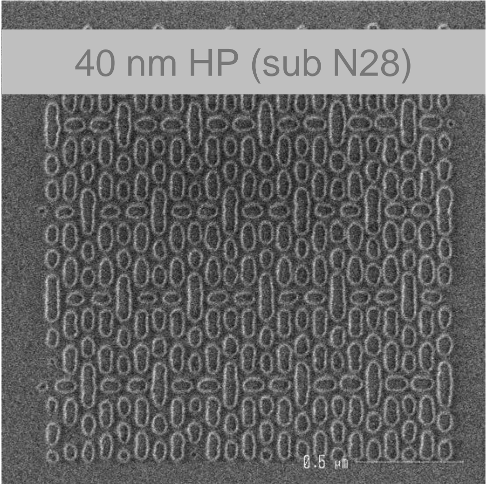
&

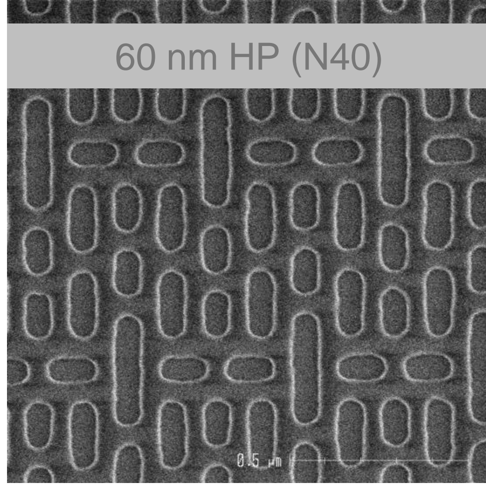
First exposures after upgrade to fully programmable blanker





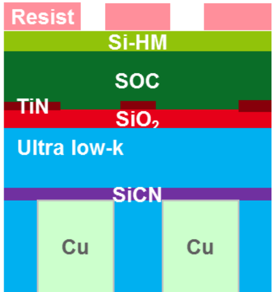


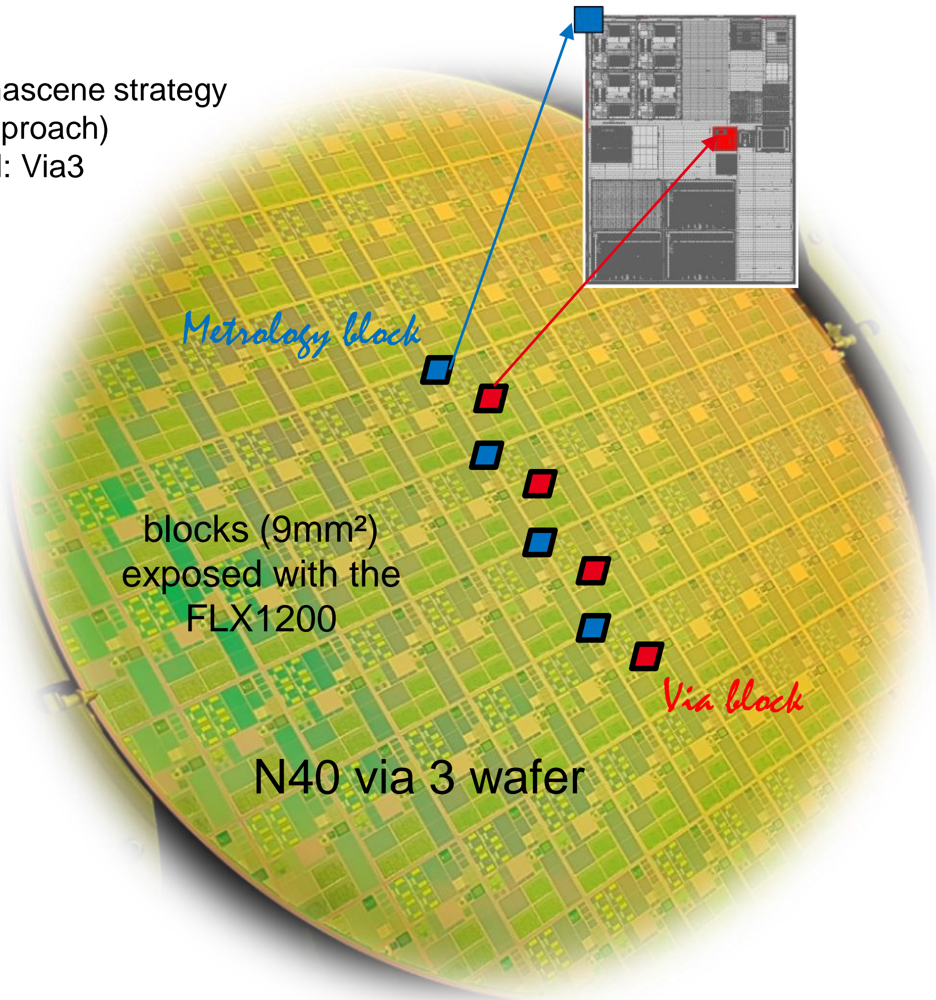




THE MAIN ACHIEVEMENTS (ABOUT INTEGRATION)

Product selected:
Mature node N40
BEOL – Double damascene strategy
(Trench 1st MHM approach)
EB Lithography level: Via3





Metrology block

MESDIM VIA 3

CD ~67 nm
(target 85 nm)
Under exposed
due to stack
modification

Exposed with FLX1200
Exposed with immersion scanner

Overlay
AIM Mark

Via block (Logic)

4µm
2,8µm (→ 2 to 3 beams)

Process development for the maskless N40 via layer for security application
Isabelle Servin, Patricia Pimenta-Barros, Allan Germain, Arthur Bernadac, Jonathan Pradelles, Yoann Blancquaert, Philippe Essomba, Stéfan Landis, CEA-LETI; Gerard F. ten Berge, Marco Wieland, MAPPER Lithography **[10584-36]**

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THE 2018 ROADMAP

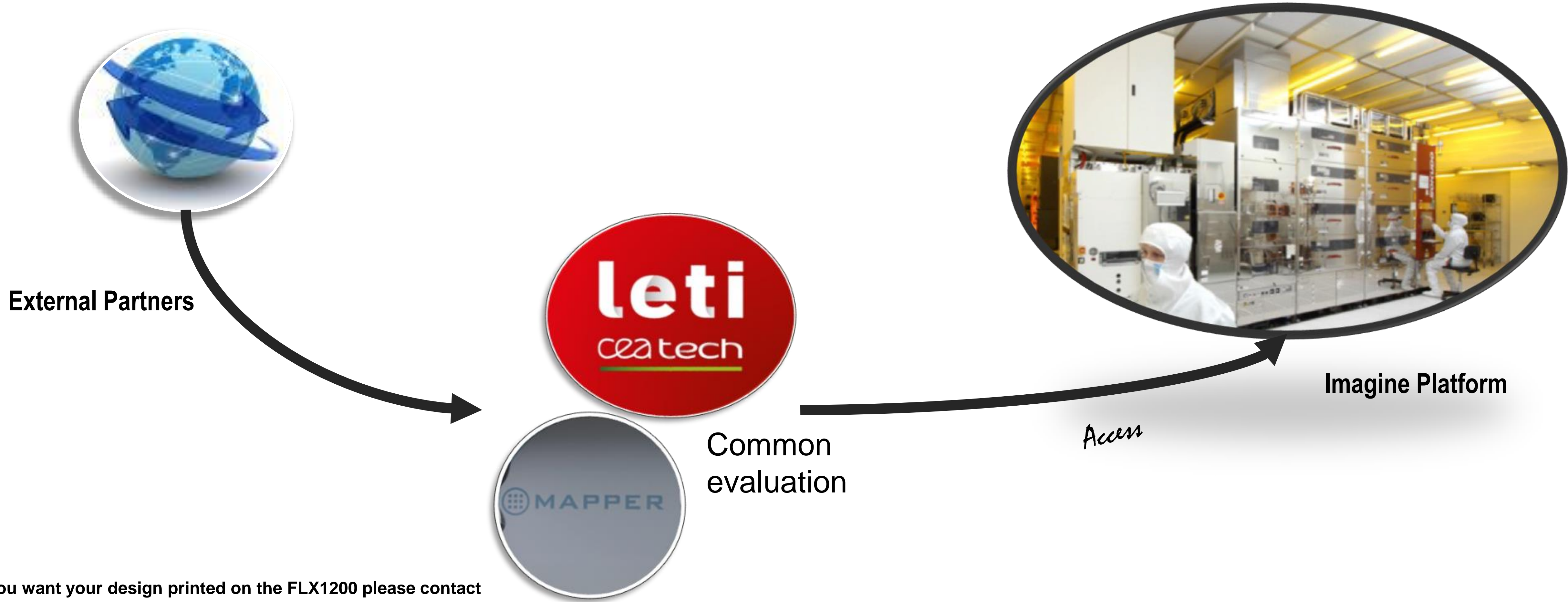
- ✓ Stabilize number of exposures to ~ 3 expos/day with the 5x5 mm² field configuration.
- ✓ Assess new Dynamic Blanker integration to target lifetime > 500 h with >90 % of usable stripes

- ✓ Assess platform/processes for VIA 3 (N40) on customer wafers to qualify the full patterning (lithography & etching) process
- ✓ Identify & Classify defectivity sources to improve beams yield & selection

- ✓ CD non uniformity assessment (multi sources) with Optical Scatterometry Approach with NOVA
- ✓ Overlay and Stitching characterization with new overlay marks with KLA

- ✓ Fast shuttle slots set-up “open” for customer demonstration

THE NEXT STEPS FOR FURTHER ASSESSMENT AND VALIDATION



If you want your design printed on the FLX1200 please contact

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