The SEMATECH Berkeley MET: 2D patterning at 20 nm HP and progress towards 0.5-NA

CXRO
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SEMATECH

Authors

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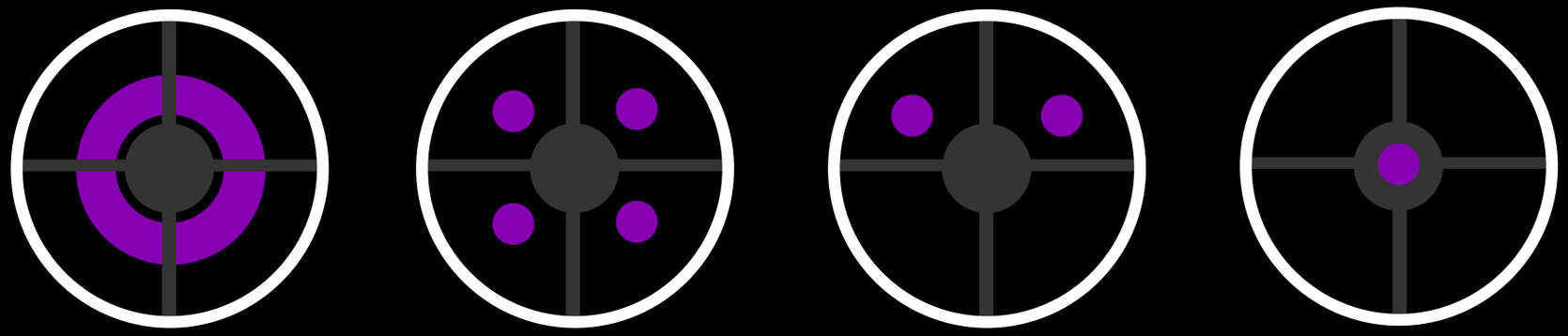
CXRO

Yoshi Hishiro
Ken Murayama
JSR Mirco

Dominic Ashworth
Stefan Wurm
SEMATECH

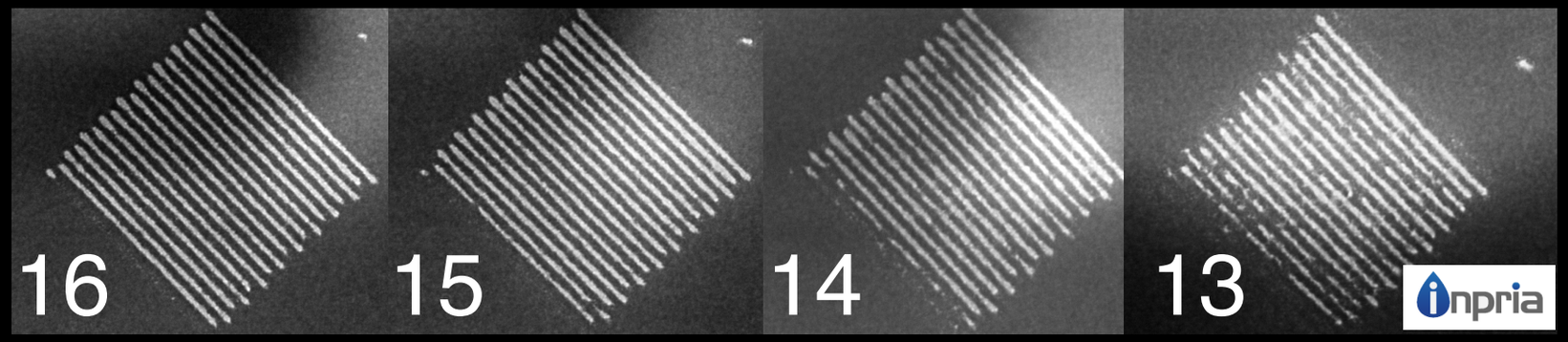
Toolset



Engineered coherence

15 nm HP

Naulleau, et. al. EUVLS 2010



EUV resist and mask research

0.3-NA SEMATECH Berkeley MET

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Sensitivity & contrast of EUV resist

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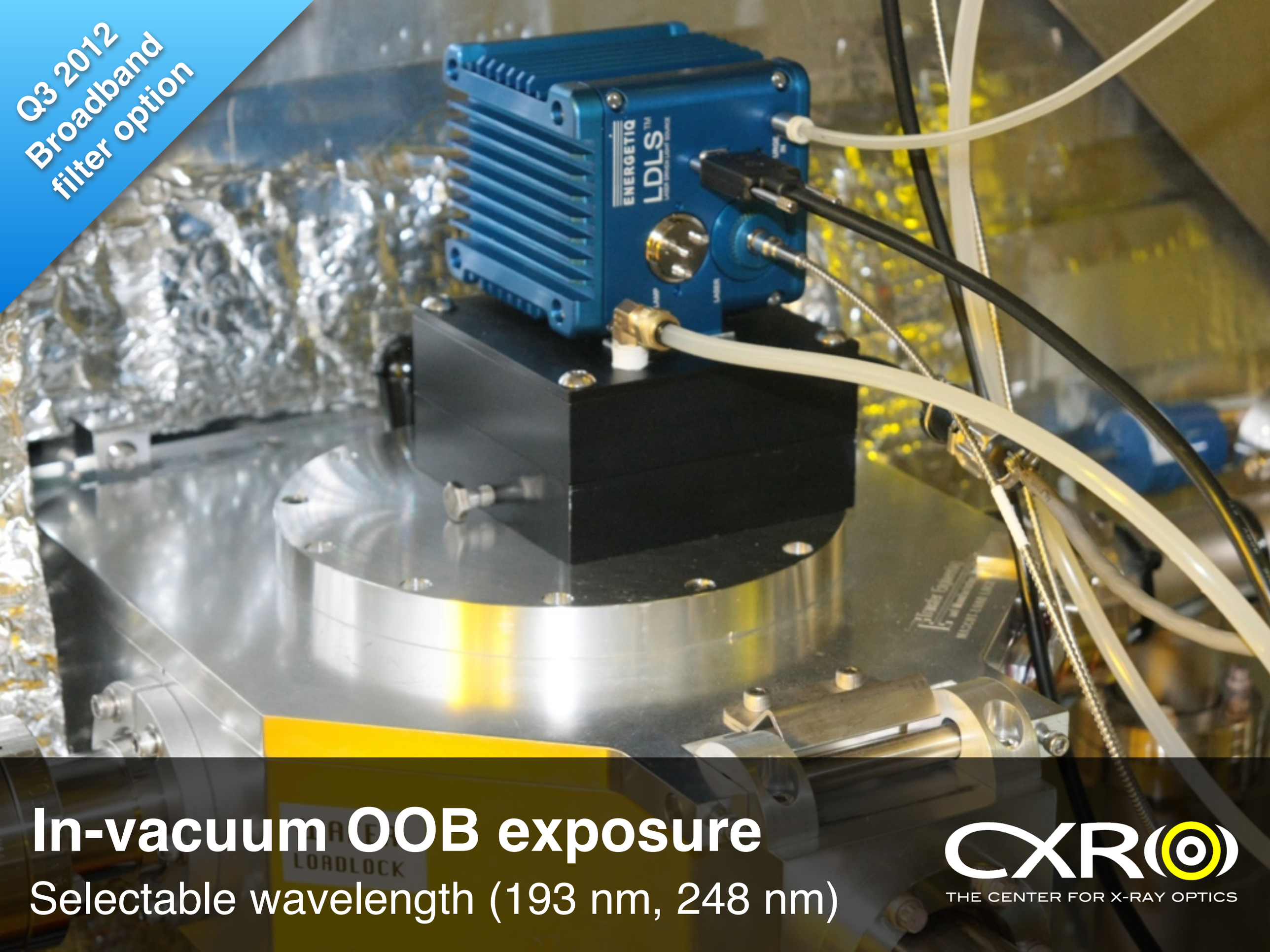
Dose Calibration Tool



Q3 2012
Broadband
filter option

In-vacuum OOB exposure

Selectable wavelength (193 nm, 248 nm)

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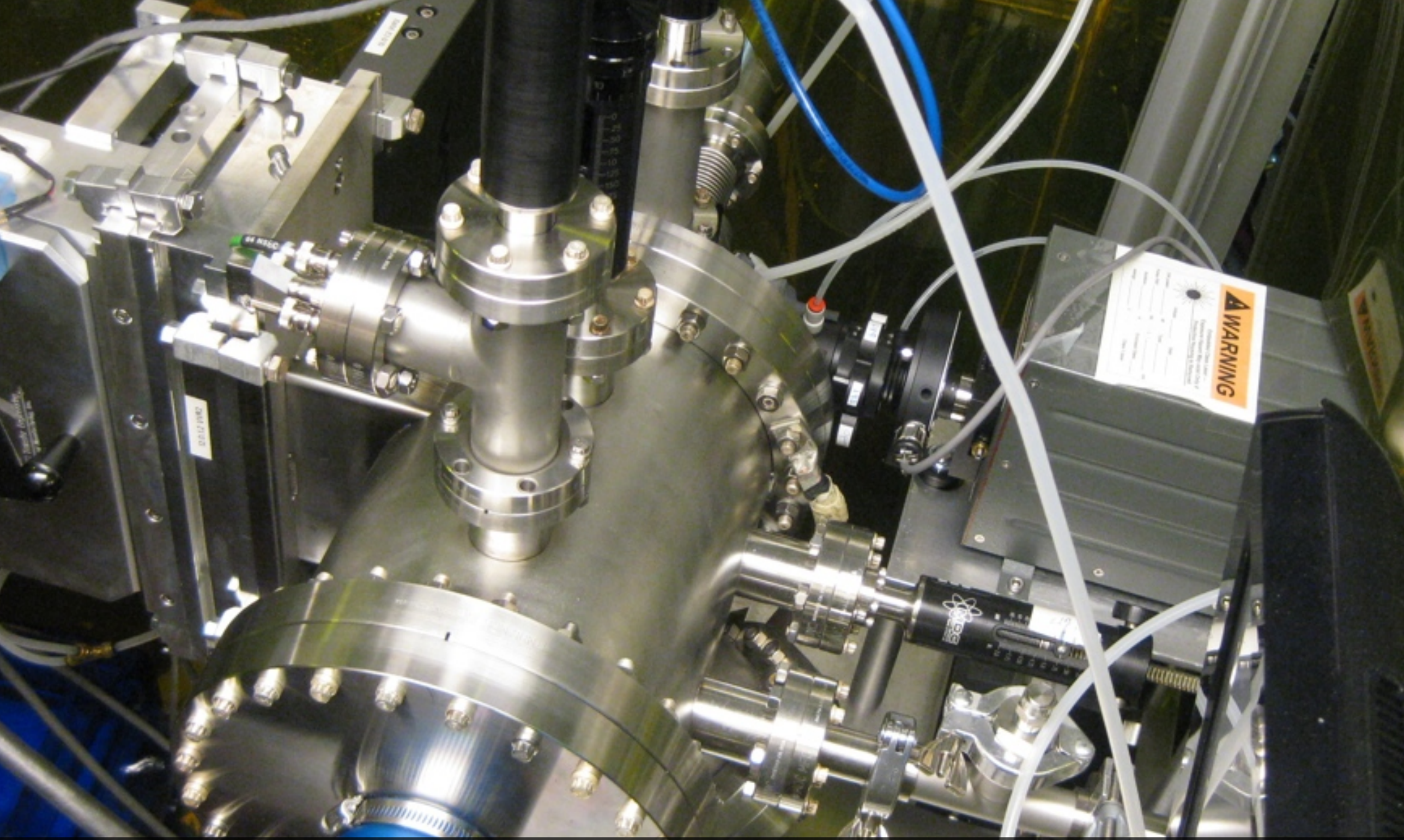

OOB contrast curves

Selectable wavelength (193 nm, 248 nm)

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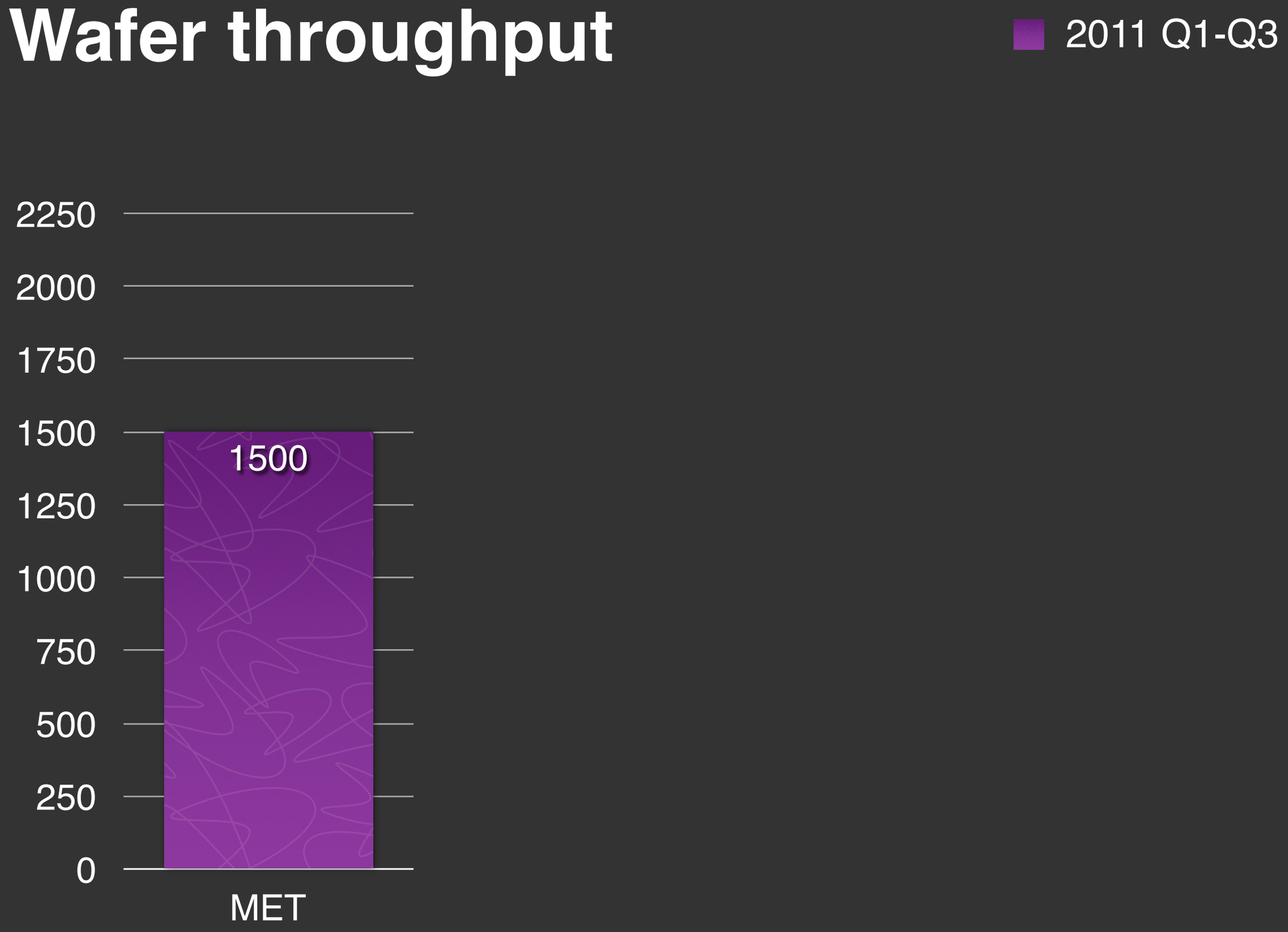
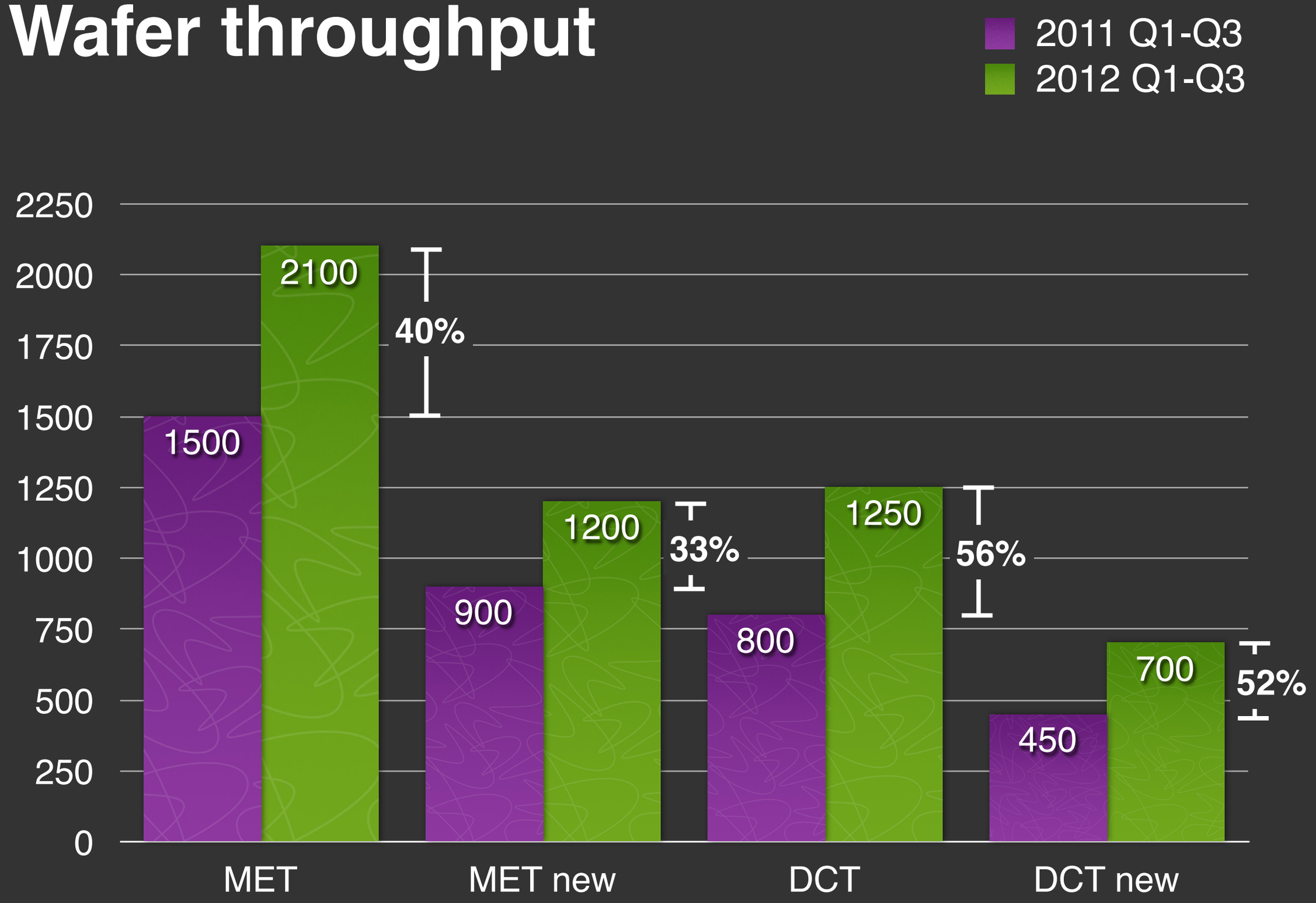
Wafer throughput

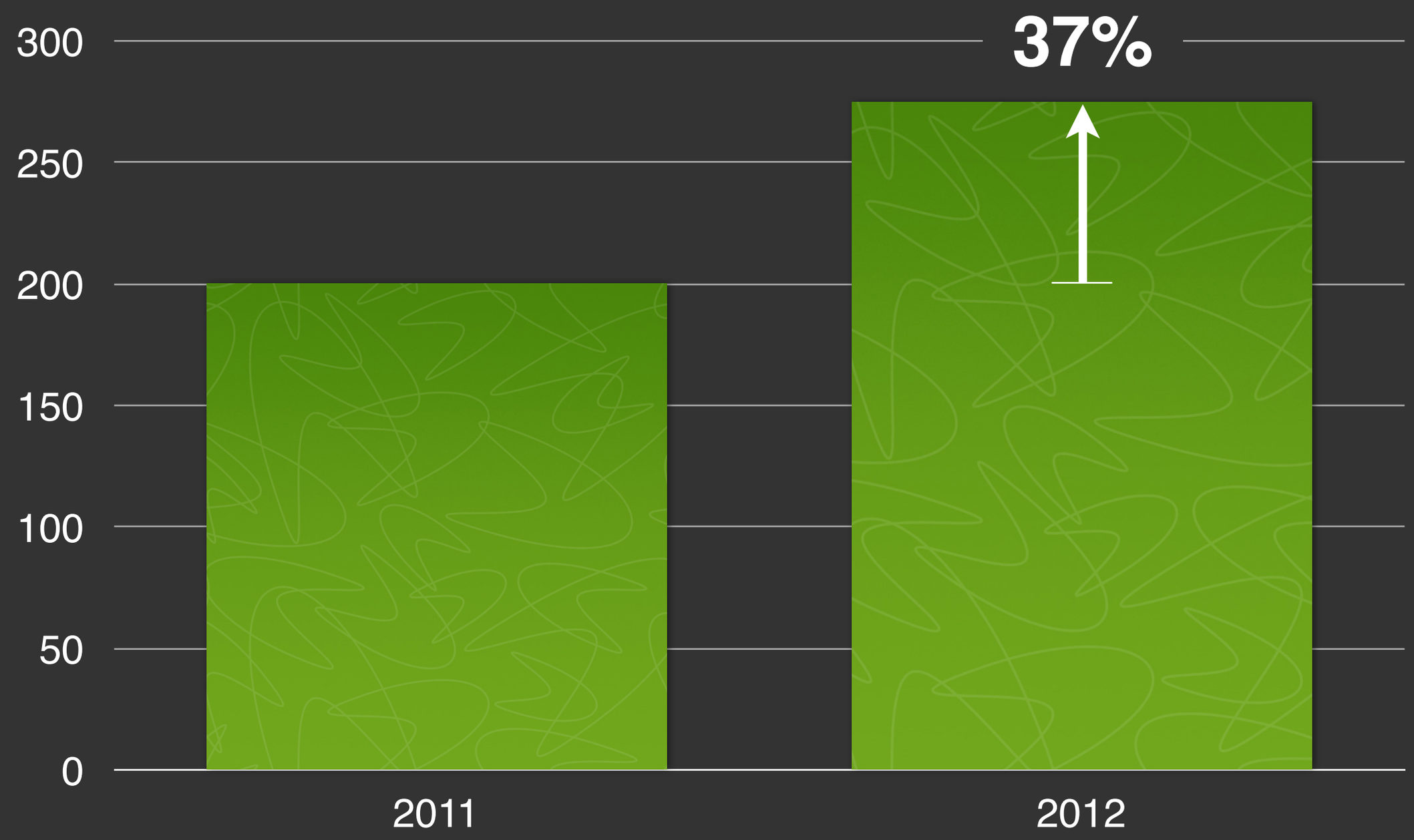


Wafer throughput



*new resist + UL + dev

MET user shifts



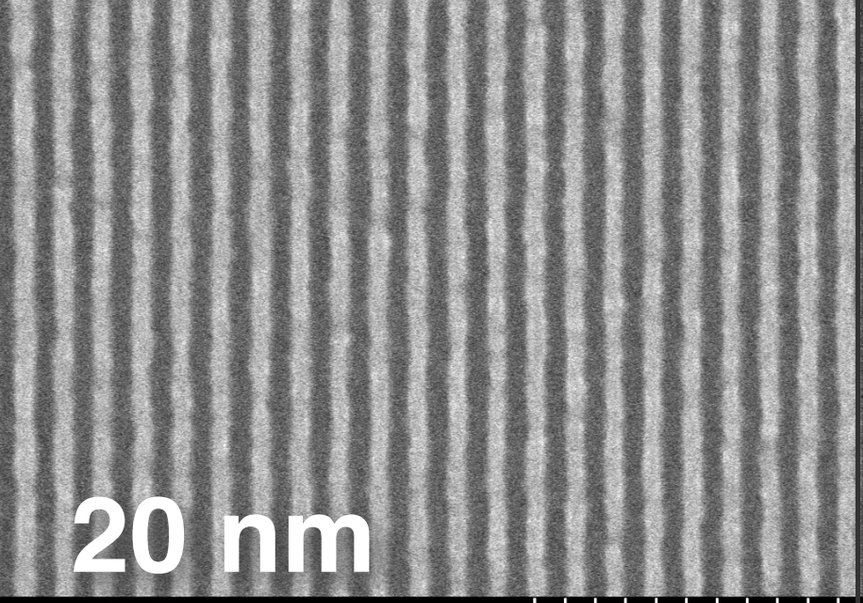
Operations improvements

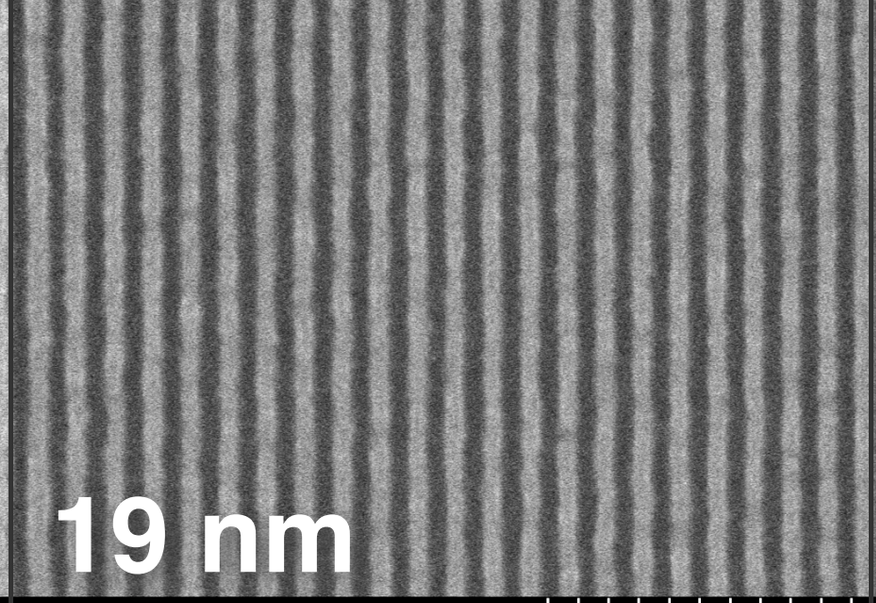
- 24/4 cycle
- 4 new operators hired and trained
- New user website met.lbl.gov

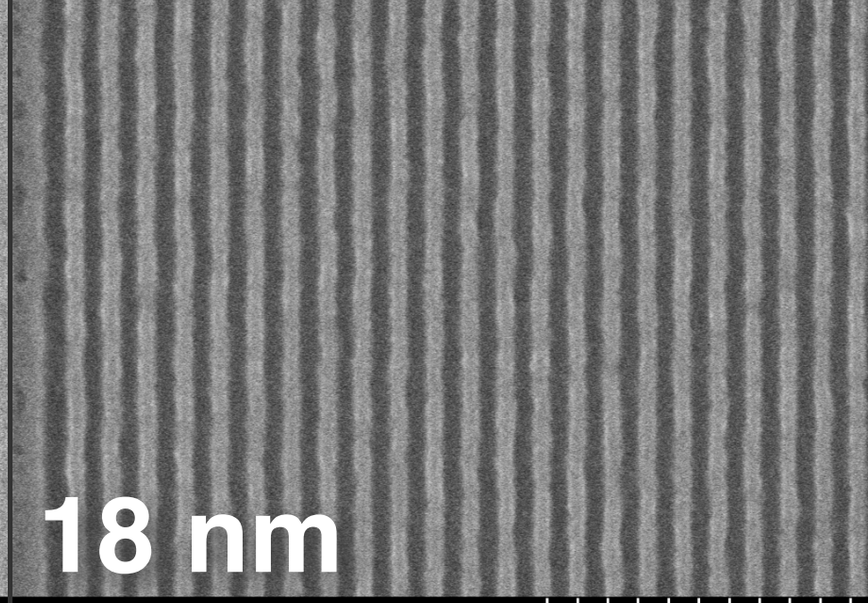
2012 operations

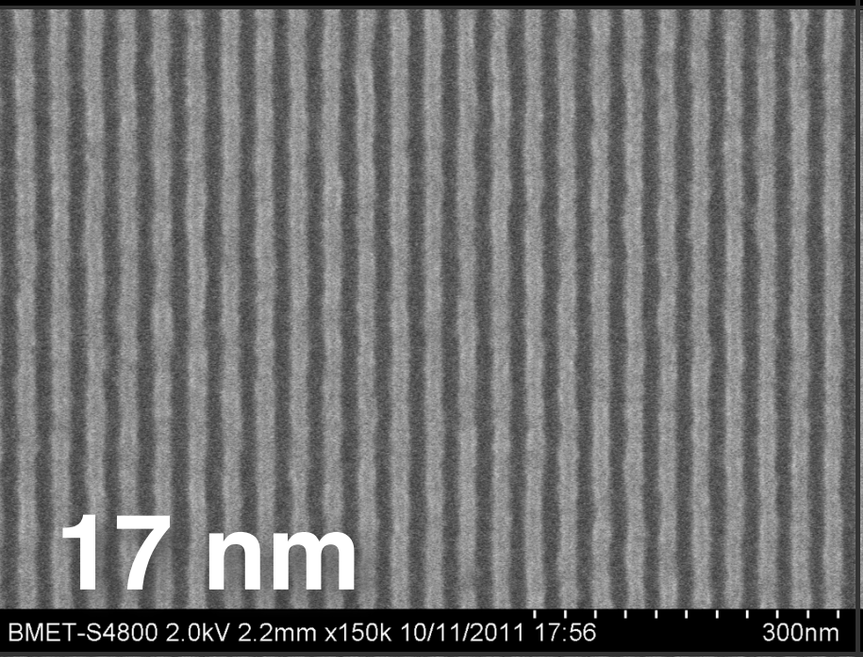
- 1200 new resists tested Q1-Q3 2012
- 37% increase in user shifts

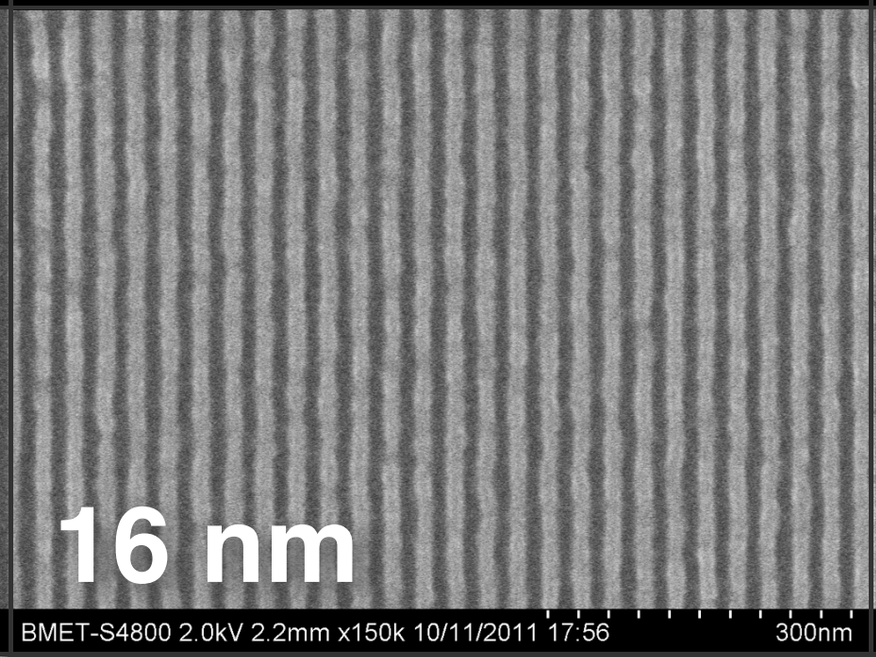
2011 Champion CAR

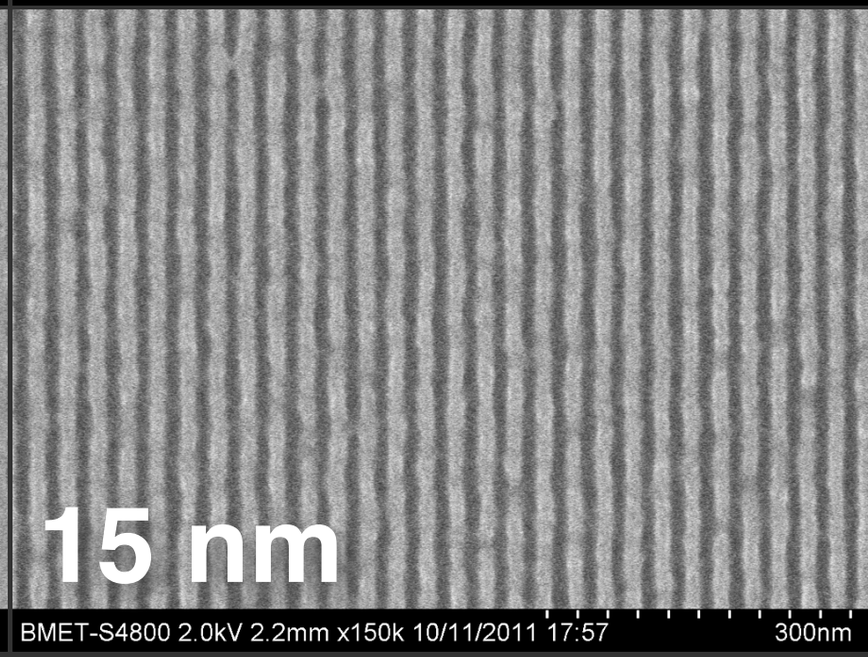


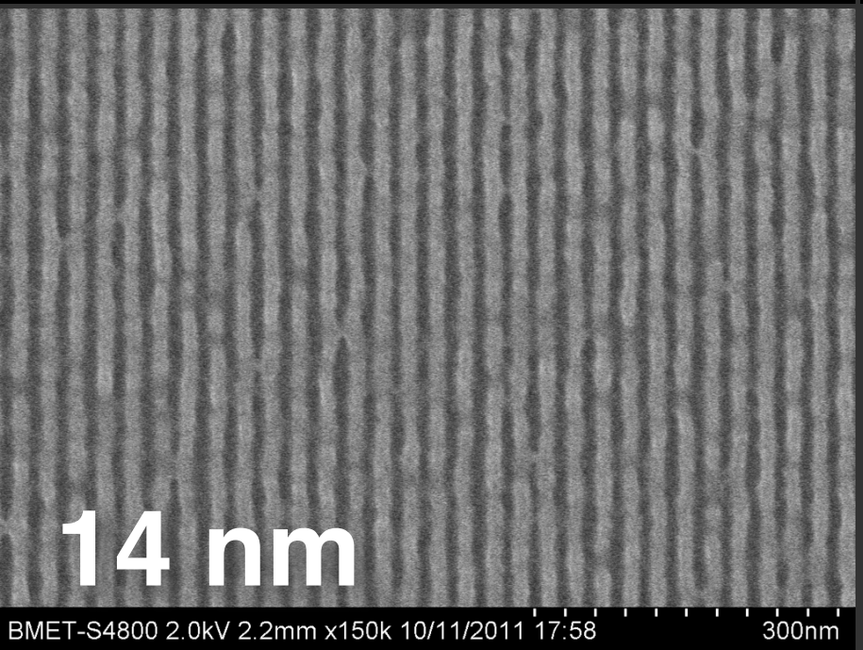












@16-nm

E-size: 31 mJ/cm²

LER: 3.5-nm*

FT: 30-nm

***High cutoff frequency == HP (ITRS spec)**

JSR Micro JSR MATERIALS INNOVATION

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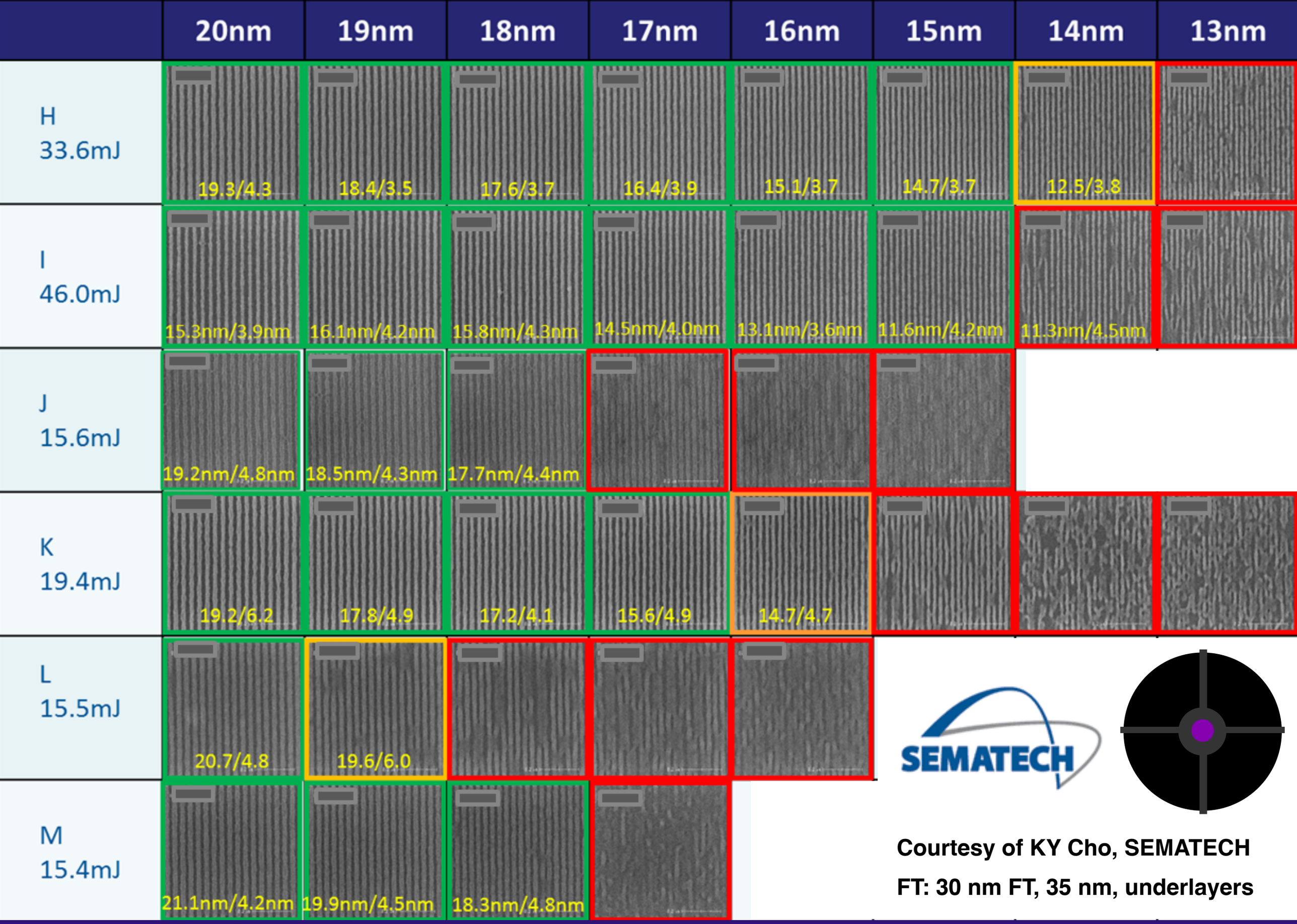
2012



Courtesy of KY Cho, SEMATECH

FT: 30 nm FT, 35 nm, underlayers

FUJIFILM

EUVL performances on LBNL-MET

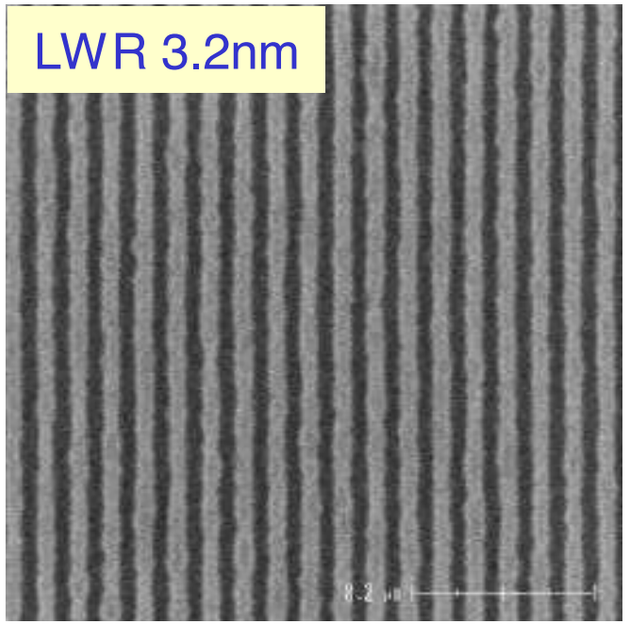
SEMATECH

BERKELEY LAB

FEVS-P1593E2: Highest CA, new polymer-A

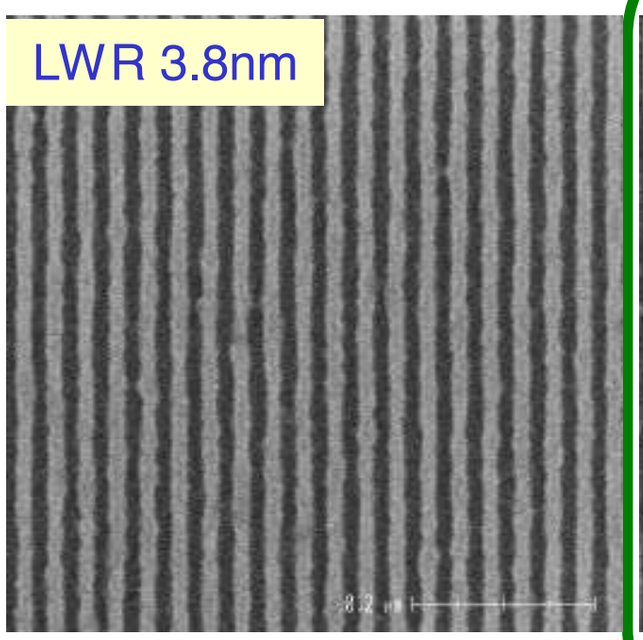
NA 0.3
Pseudo PSM@LBNL

HP 18nm



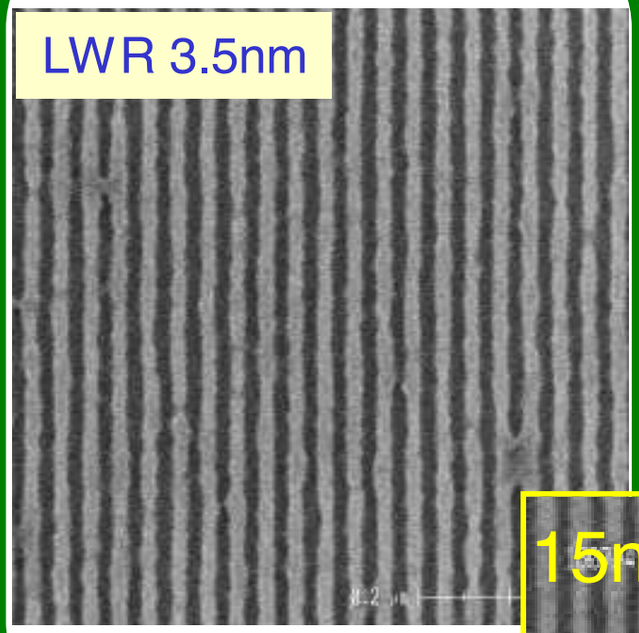
19.3 mJ/cm^2

HP 17nm



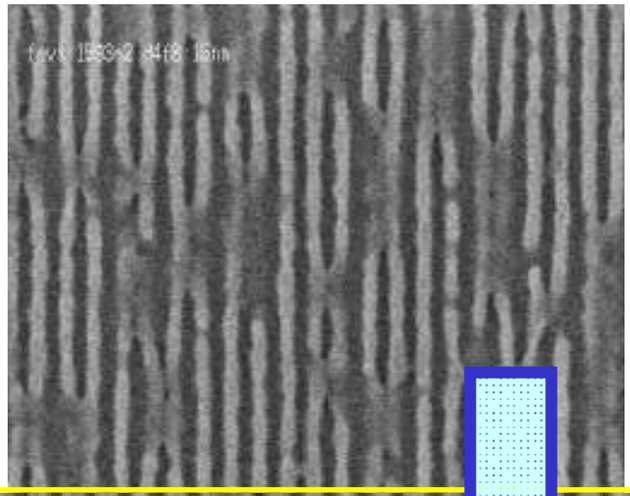
19.3 mJ/cm^2

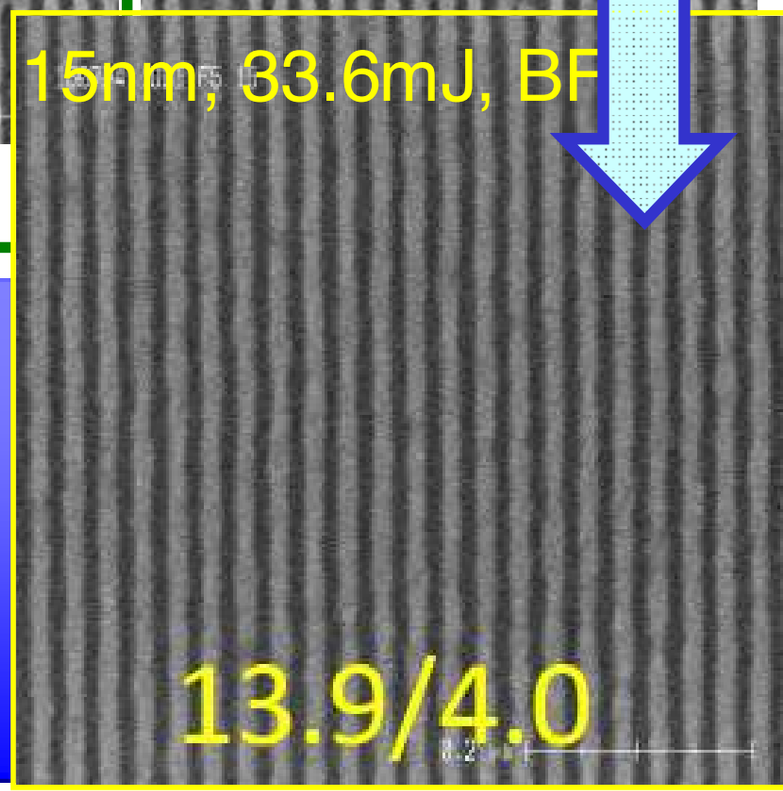
HP 16nm



20.8 mJ/cm^2

HP 15nm





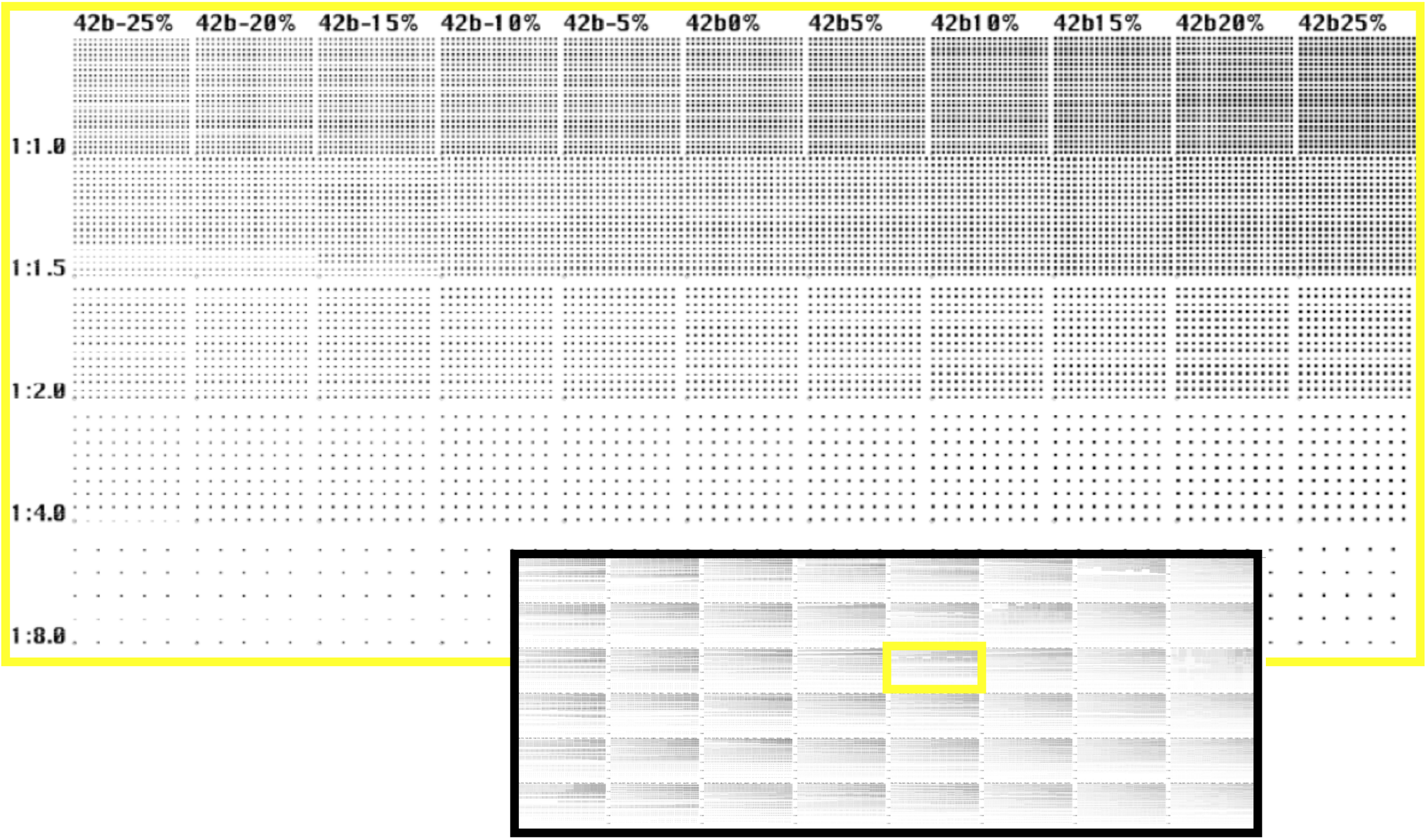
Resolution: **16 nm HP** (15 nm HP @33mJ/cm^2)
LWR: **3.2 nm** (2.2nm LER)
Sensitivity: **19 mJ/cm^2**

Z-factor: 3.8 x 10^{-9} mJ nm^3 (best to our knowledge)

2D patterning

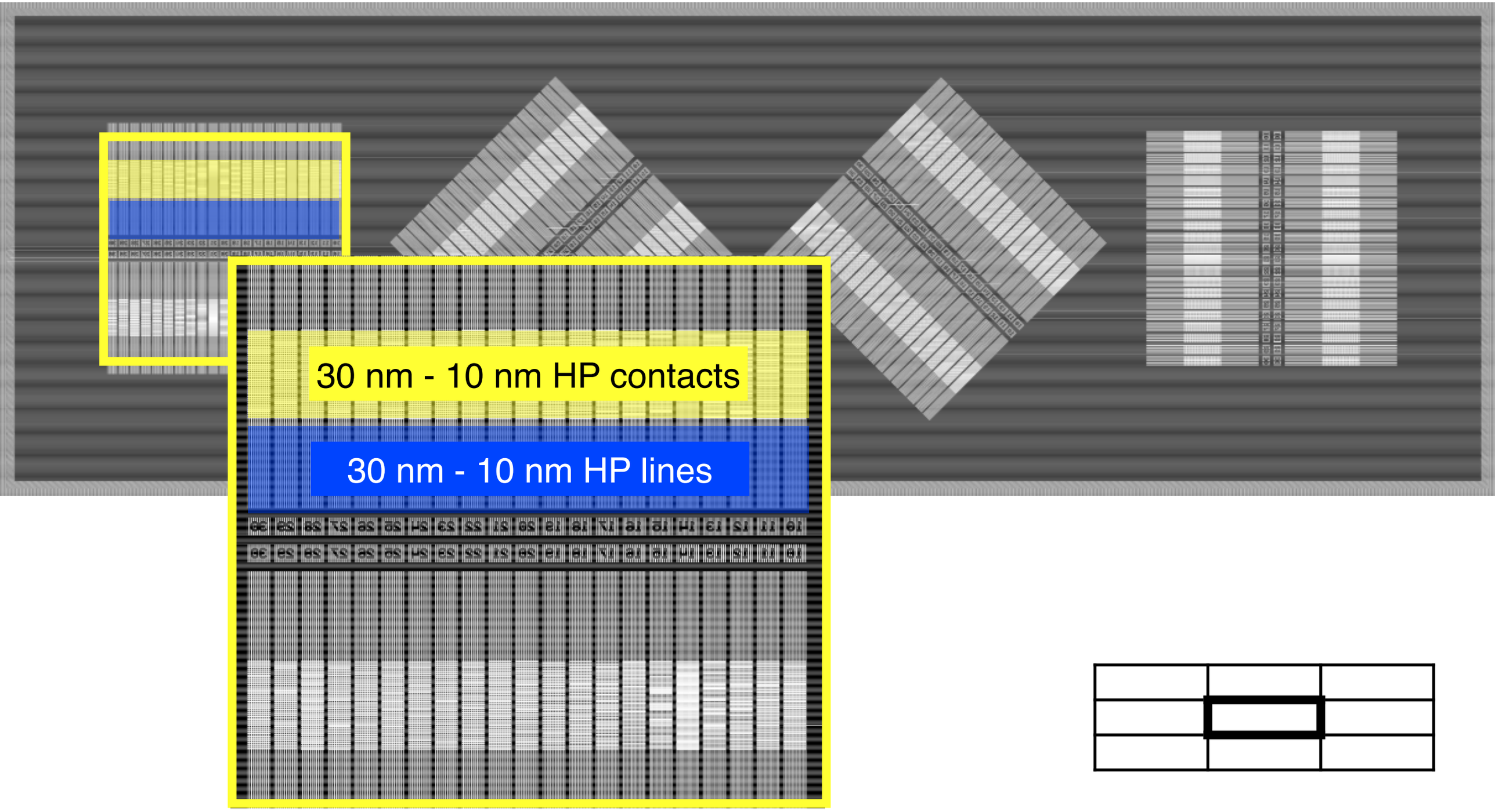
Contact Bias

New
Q3 2012

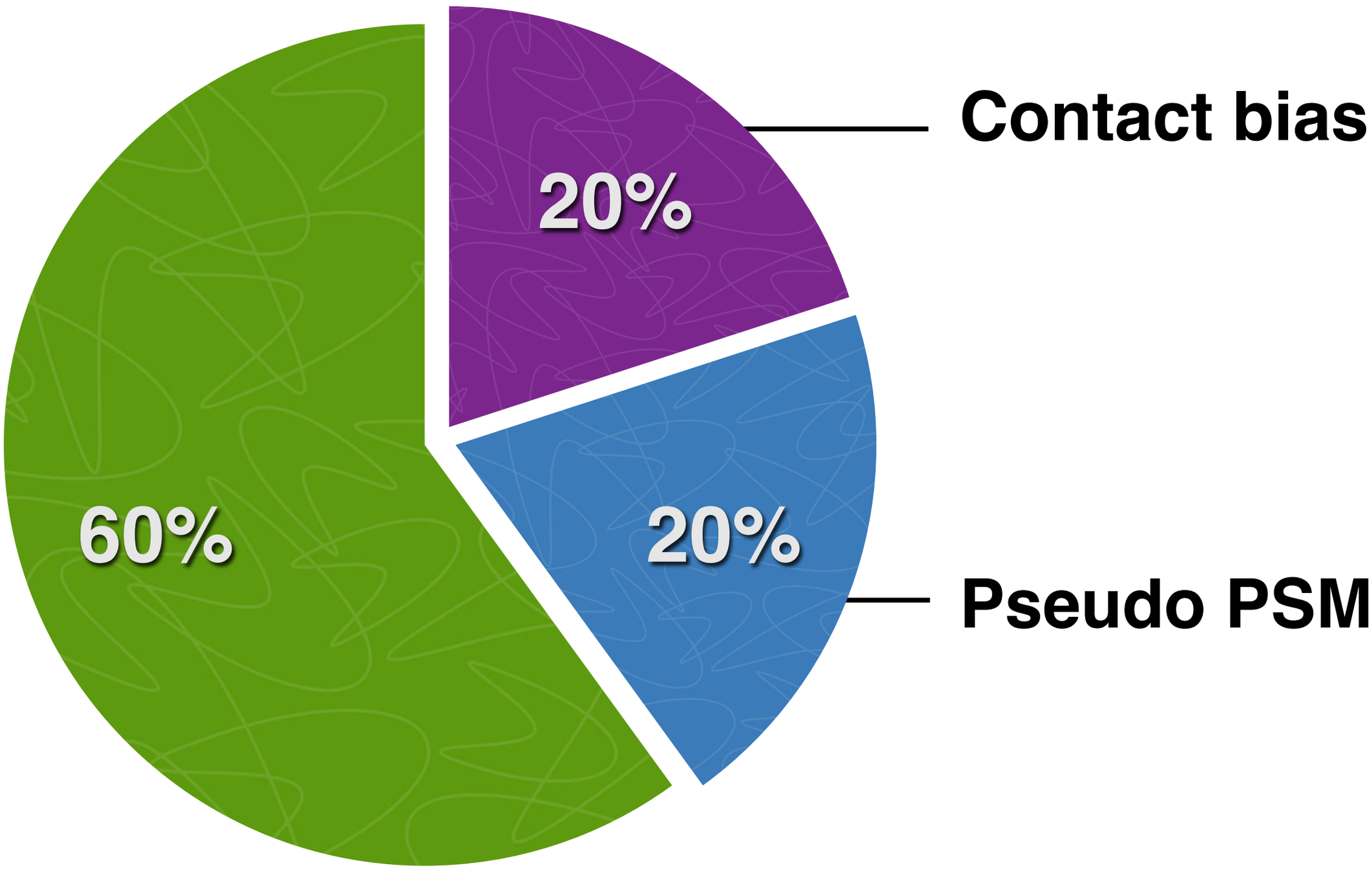


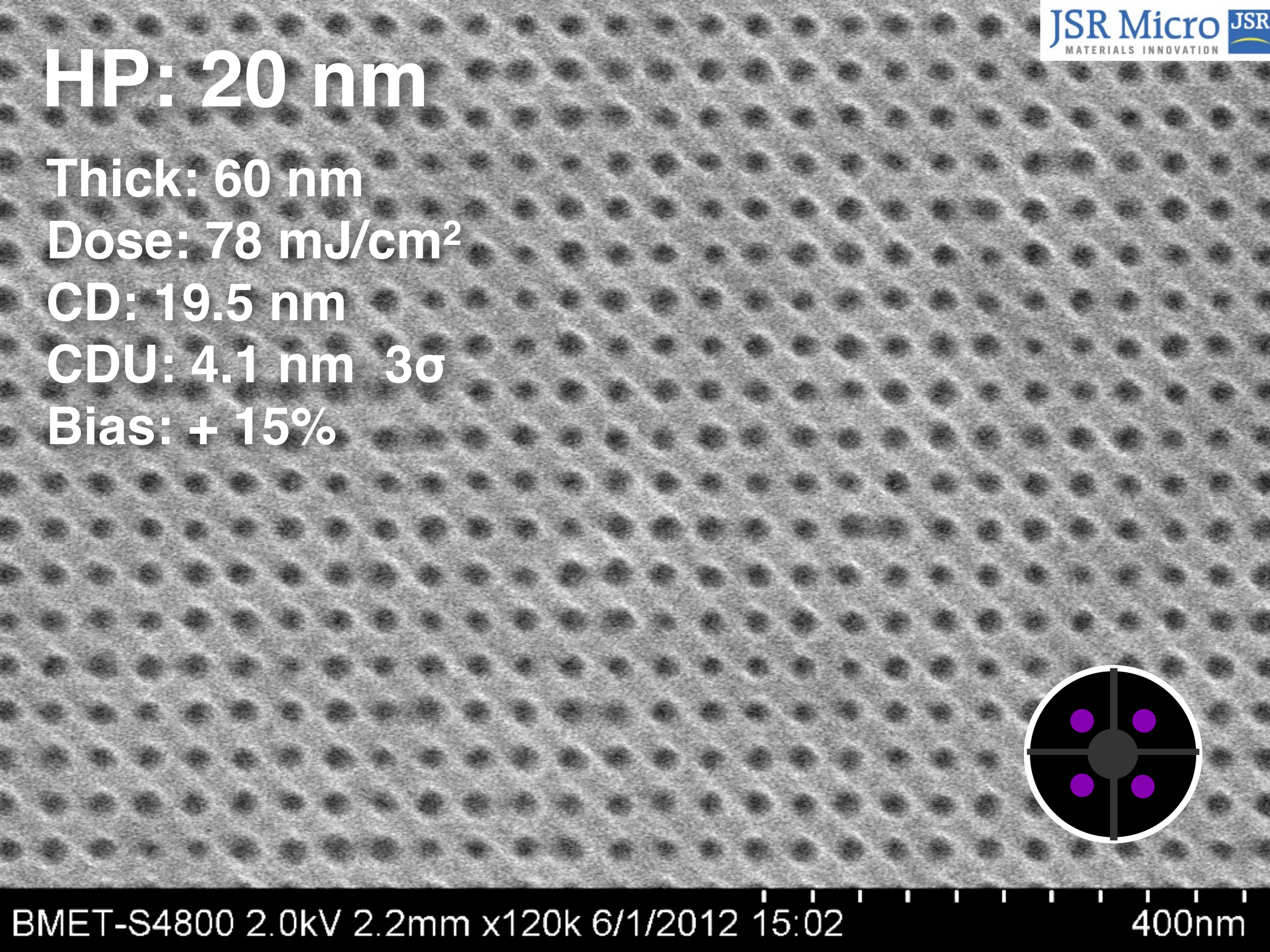
Pseudo PSM 2D

New
Q3 2012



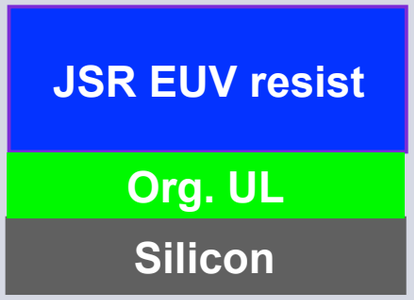
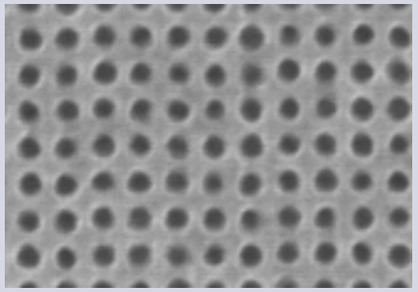
Field breakdown




JSR Micro
MATERIALS INNOVATION
JSR
HP: 20 nm
Thick: 60 nm
Dose: 78 mJ/cm²
CD: 19.5 nm
CDU: 4.1 nm 3σ
Bias: + 15%
BMET-S4800 2.0kV 2.2mm x120k 6/1/2012 15:02
400nm

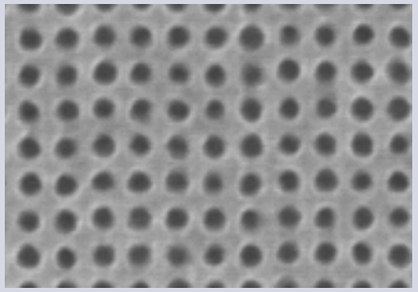
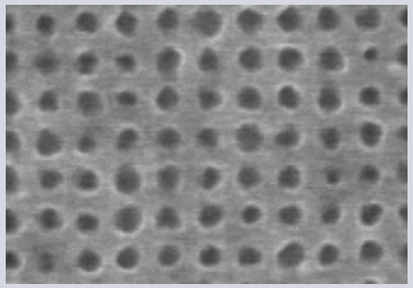
OOB research

Top-coat reduces OOB effect

Stack	
30nmCH image	
EUV Dose (mJ/cm^2)	29.8
OOB Dose (mJ/cm^2)	0
LCDU(nm)	4.0
DLCDU(nm)	-

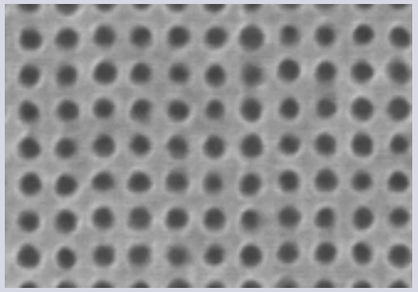
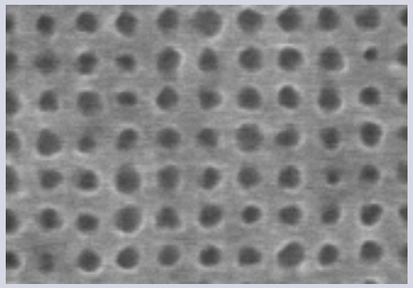
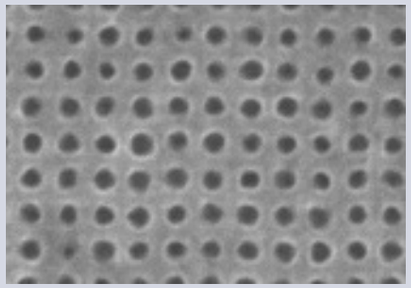
LBNL MET NA0.3, annular
*193nm

Top-coat reduces OOB effect

Stack	JSR EUV resist Org. UL Silicon	JSR EUV resist Org. UL Silicon
30nmCH image		
EUV Dose (mJ/cm^2)	29.8	18.1
OOB Dose (mJ/cm^2)	0	2.7*
LCDU(nm)	4.0	7.2
DLCDU(nm)	-	+3.2

LBNL MET NA0.3, annular
*193nm

Top-coat reduces OOB effect

Stack	JSR EUV resist Org. UL Silicon	JSR EUV resist Org. UL Silicon	JSR EUV TC JSR EUV resist Org. UL Silicon
30nmCH image			
EUV Dose (mJ/cm^2)	29.8	18.1	29.8
OOB Dose (mJ/cm^2)	0	2.7*	2.7*
LCDU(nm)	4.0	7.2	4.3
DLCDU(nm)	-	+3.2	+0.3

LBNL MET NA0.3, annular
*193nm

MET II

Optical system

- Same capabilities as MET I

Facilities

- Track
- Clean room
- Solvent develop
- Compatible with a robotic upgrade

2012 ... a year of progress

- 1200 new resists tested Q1-Q3 2012
- 37% increase in user shifts
- Demonstration of 20 nm HP contacts
- Demonstration of OOB suppression
- Several resist suppliers @ 16 nm HP

Acknowledgements

Shinji Tarutani
Fujifilm

Harry Levinson
Tom Wallow
Obert Wood
Global Foundries

Bill Hinsberg
Greg Wallraff
IBM

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Rene Delano
Jeff Gamsby
Eric Gullikson
Bob Gunion
Drew Kemp
Seno Rekawa
Farhad Salmassi
Ron Tackaberry
LBNL

Jim Thackeray
Katherine Spear
Rohm and Haas

Seong-Sue Kim
Samsung

Kyoungyong Cho
Karen Petrillo
Liping Ren
Bryan Rice
Stefan Wurm
SEMATECH

Yoshio Kawai
Shin Etsu

Rick Uchida
Yohei Kinoshita
TOK

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Thank you.
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Four new operators

Jessalyn Sincher
Tool Operator

Mark Binenbaum
Tool Operator

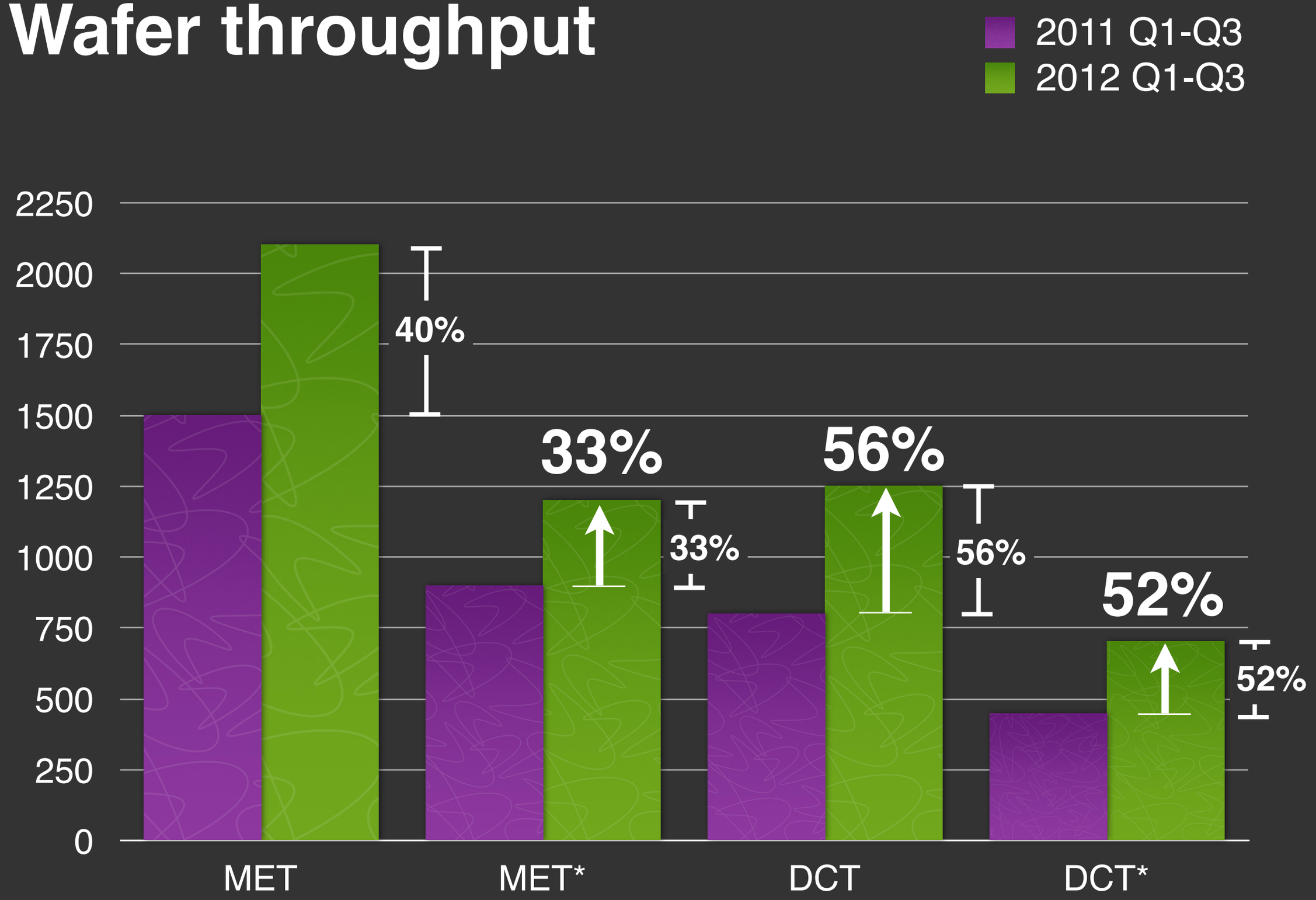
Gideon Jones
Tool Operator

Gayan Pothuhera
Sample Processing Technician

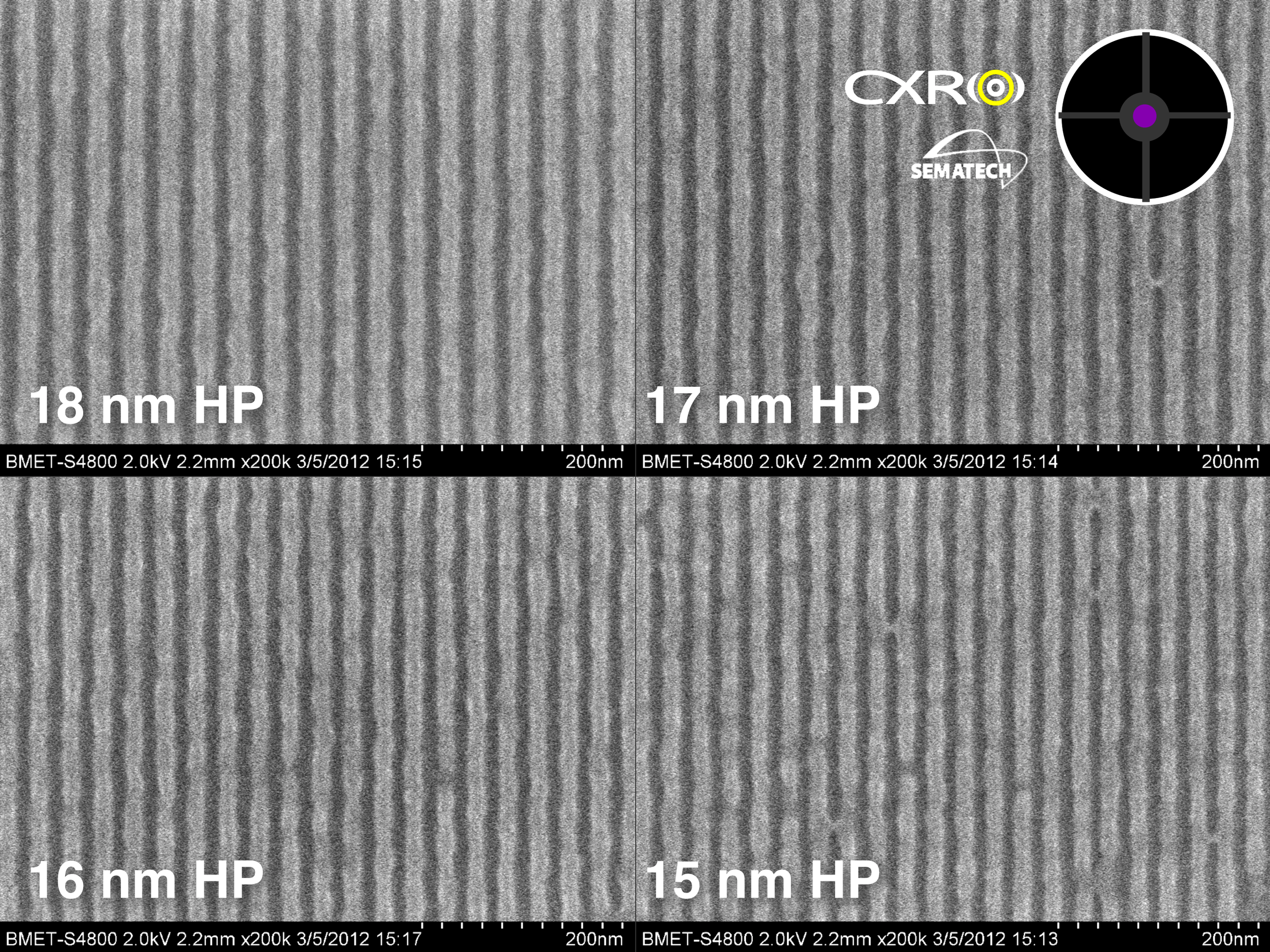
Lorie Mae Baclea-An
Sample Processing Technician

Jessica Ritland
Sample Processing Technician

Wafer throughput



*new resist + UL + dev


CXRO
SEMATECH
18 nm HP
BMET-S4800 2.0kV 2.2mm x200k 3/5/2012 15:15
200nm
17 nm HP
BMET-S4800 2.0kV 2.2mm x200k 3/5/2012 15:14
200nm
16 nm HP
BMET-S4800 2.0kV 2.2mm x200k 3/5/2012 15:17
200nm
15 nm HP
BMET-S4800 2.0kV 2.2mm x200k 3/5/2012 15:13
200nm

CXRO
SEMATECH
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200nm
BMET-S4800 2.0kV 2.2mm x200k 3/5/2012 15:14
200nm
2012 @16-nm
E-size: 15 mJ/cm²
LER: 5.3-nm*
FT: 30-nm
*High cutoff frequency == HP (ITRS spec)
16 nm HP
15 nm HP
BMET-S4800 2.0kV 2.2mm x200k 3/5/2012 15:17
200nm
BMET-S4800 2.0kV 2.2mm x200k 3/5/2012 15:13
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CXRO
SEMATECH
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200nm
2012 @16-nm
E-size: 15 mJ/cm²
LER: 5.3-nm*
FT: 30-nm
*High cutoff frequency == HP (ITRS spec)
vs.
2011@16-nm
E-size: 31 mJ/cm²
LER: 3.5-nm*
FT: 30-nm
*High cutoff frequency == HP (ITRS spec)
16 nm HP
BMET-S4800 2.0kV 2.2mm x200k 3/5/2012 15:17
200nm
15 nm HP
BMET-S4800 2.0kV 2.2mm x200k 3/5/2012 15:13
200nm

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5.3/sqrt(2) = 3.7

18 nm HP

BMET-S4800 2.0kV 2.2mm x200k 3/5/2012 15:15 200nm

17 nm HP

BMET-S4800 2.0kV 2.2mm x200k 3/5/2012 15:14 200nm

2012 @16-nm

E-size: 15 mJ/cm²
LER: 5.3-nm*
FT: 30-nm
*High cutoff frequency == HP (ITRS spec)

vs.

2011@16-nm

E-size: 31 mJ/cm²
LER: 3.5-nm*
FT: 30-nm
*High cutoff frequency == HP (ITRS spec)

16 nm HP

BMET-S4800 2.0kV 2.2mm x200k 3/5/2012 15:17 200nm

15 nm HP

BMET-S4800 2.0kV 2.2mm x200k 3/5/2012 15:13 200nm

2012

FUJIFILM

EUVL performances on LBNL-MET

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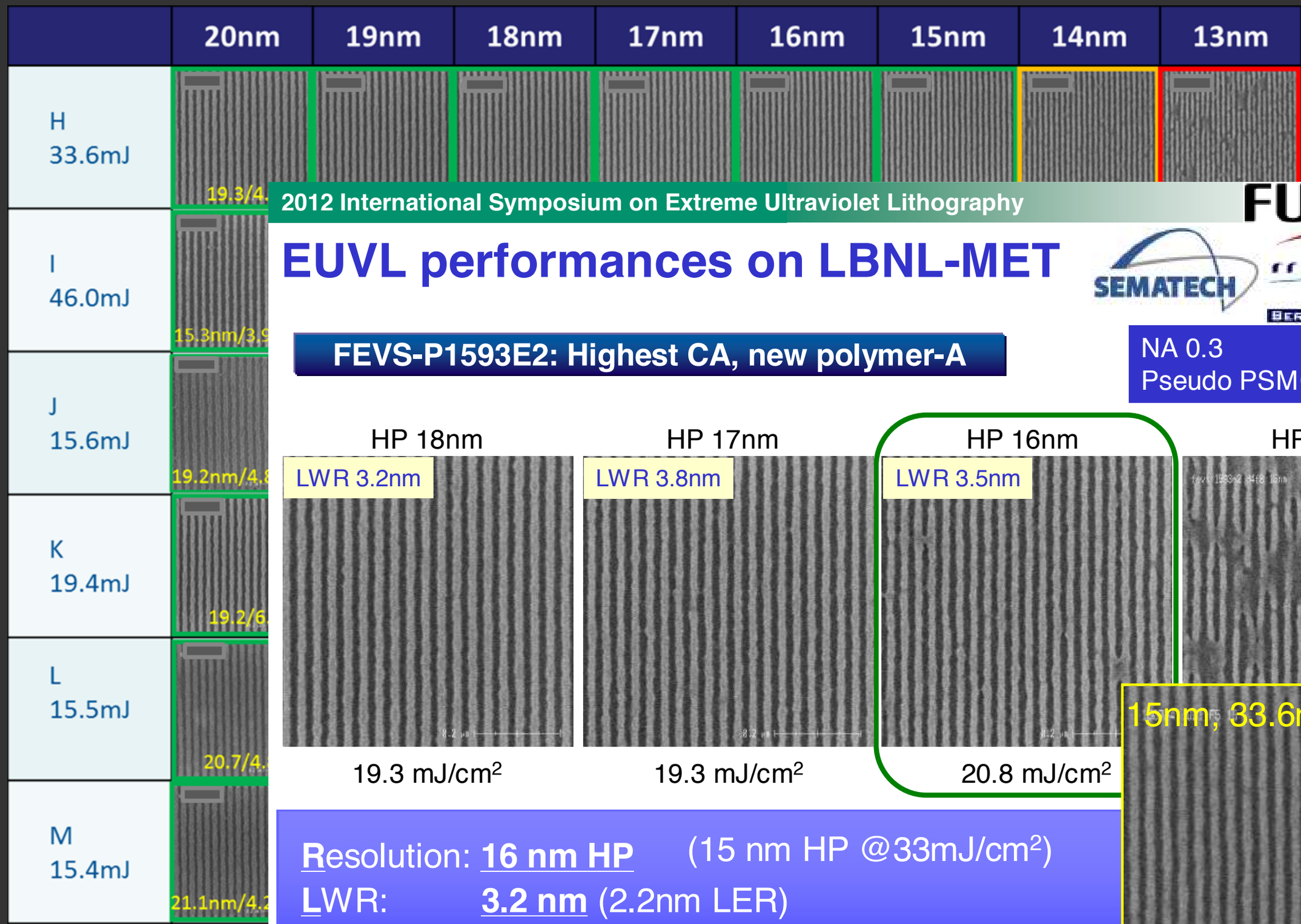
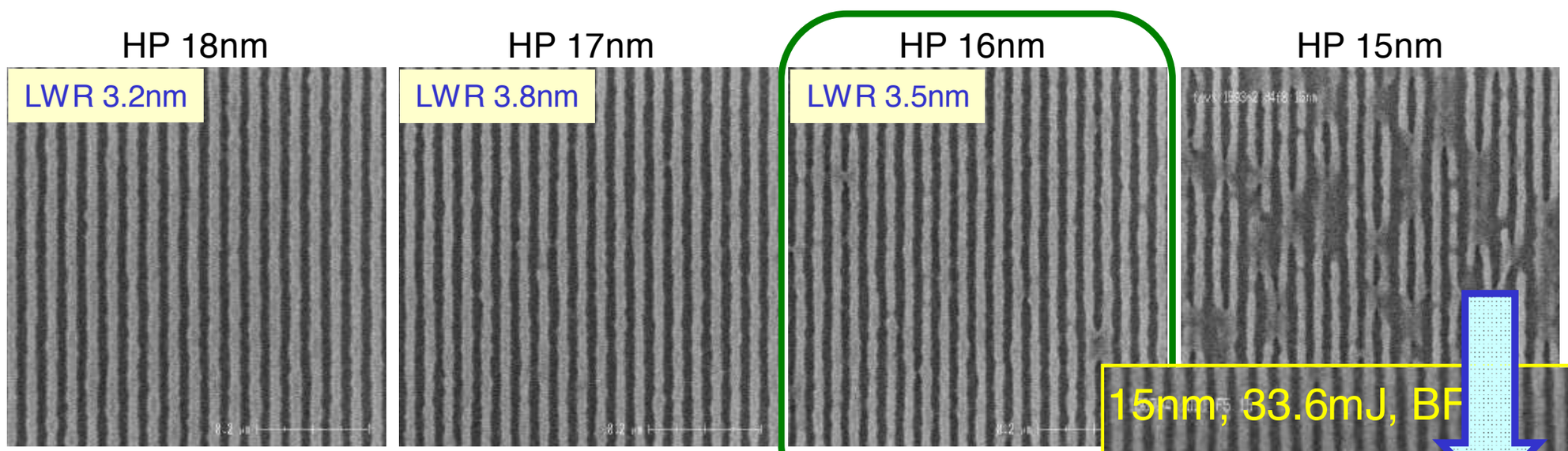
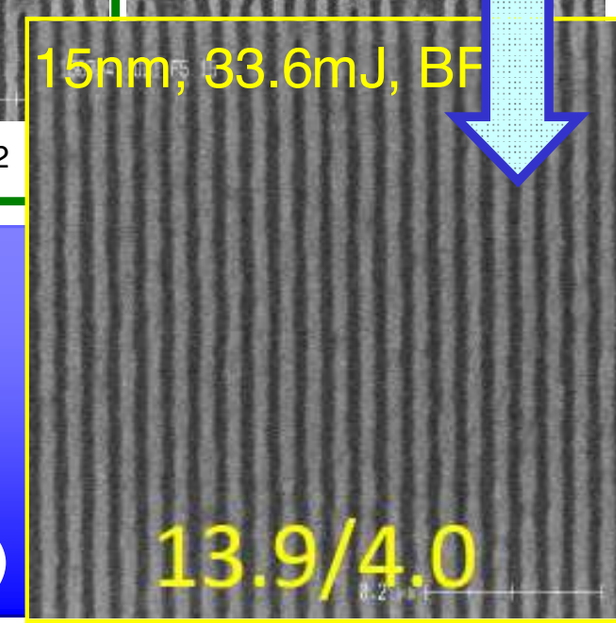
BERKELEY LAB



FEVS-P1593E2: Highest CA, new polymer-A

NA 0.3
Pseudo PSM@LBNL





Resolution: **16 nm HP** (15 nm HP @33mJ/cm²)
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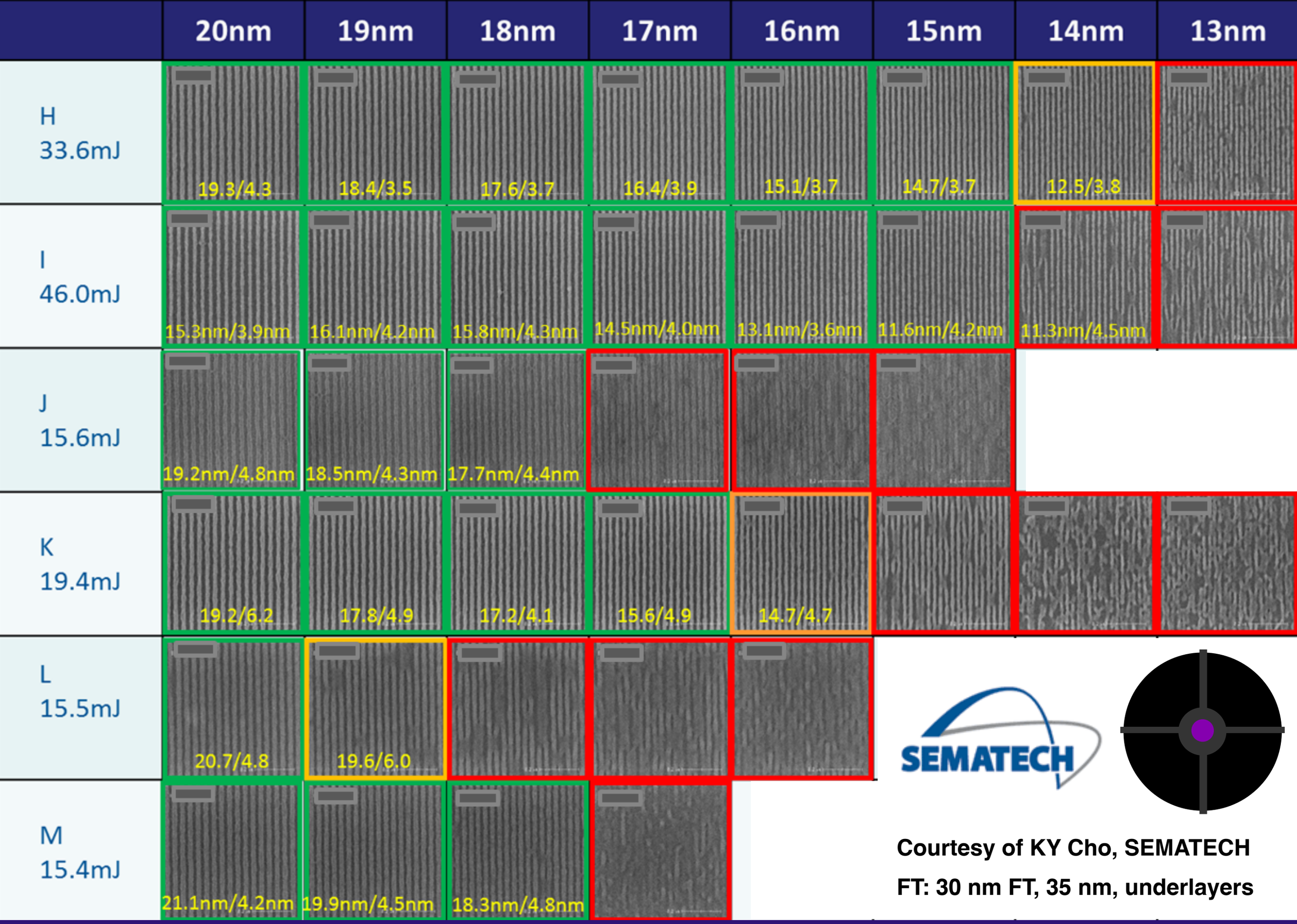
Sensitivity: **19 mJ/cm²**

Z-factor: 3.8 x 10^{-9} mJ nm³ (best to our knowledge)



Courtesy of KY Cho, SEMATECH

FT: 30 nm FT, 35 nm, underlayers

FUJIFILM

EUVL performances on LBNL-MET

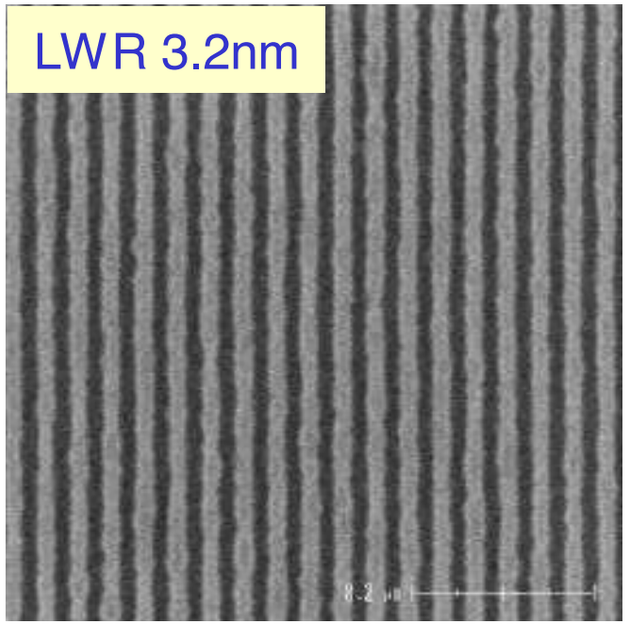
SEMATECH

BERKELEY LAB

FEVS-P1593E2: Highest CA, new polymer-A

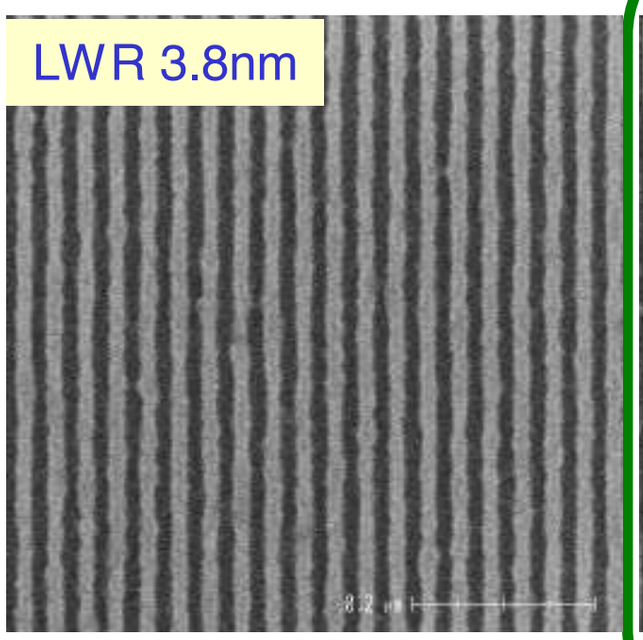
NA 0.3
Pseudo PSM@LBNL

HP 18nm



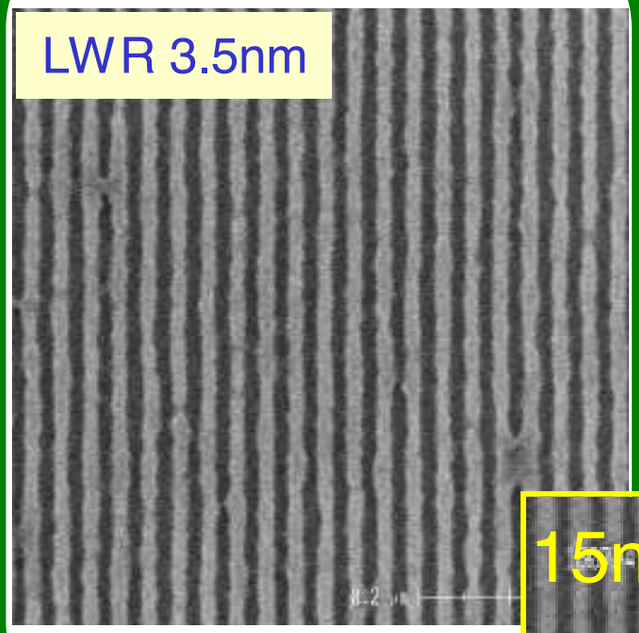
19.3 mJ/cm^2

HP 17nm



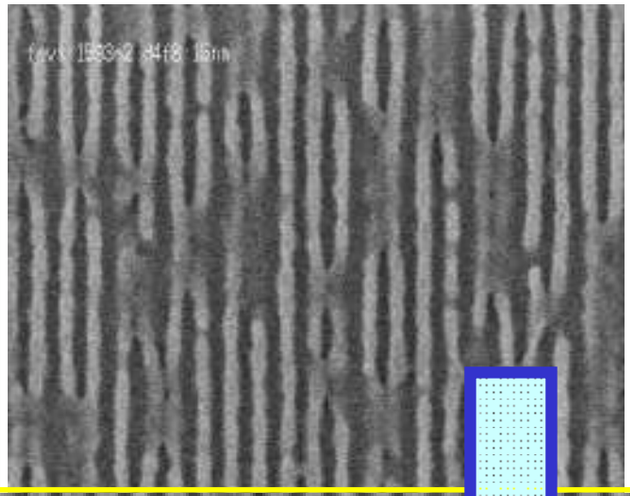
19.3 mJ/cm^2

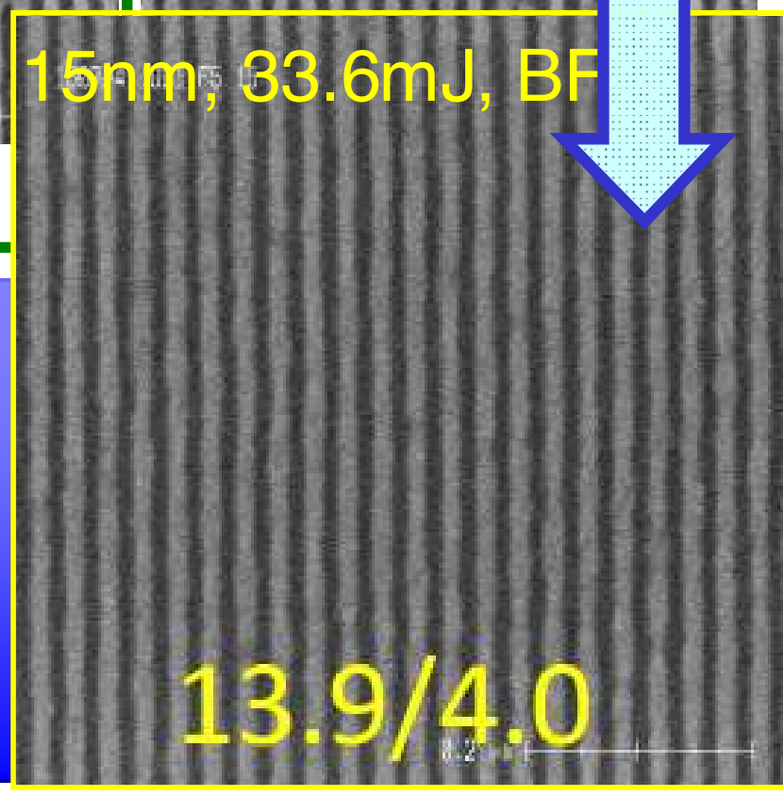
HP 16nm



20.8 mJ/cm^2

HP 15nm

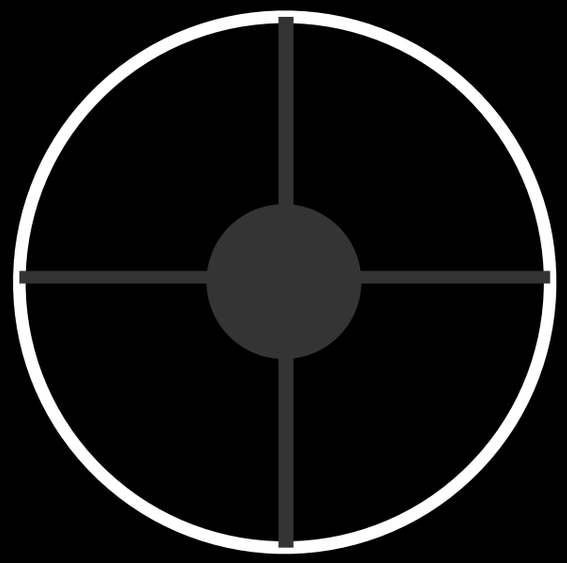




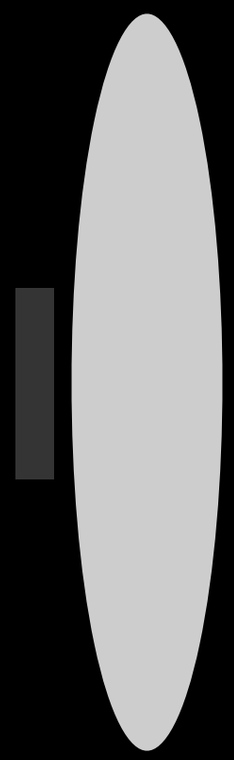
Resolution: **16 nm HP** (15 nm HP @33mJ/cm^2)
LWR: **3.2 nm** (2.2nm LER)
Sensitivity: **19 mJ/cm^2**

Z-factor: 3.8 x 10^{-9} mJ nm^3 (best to our knowledge)

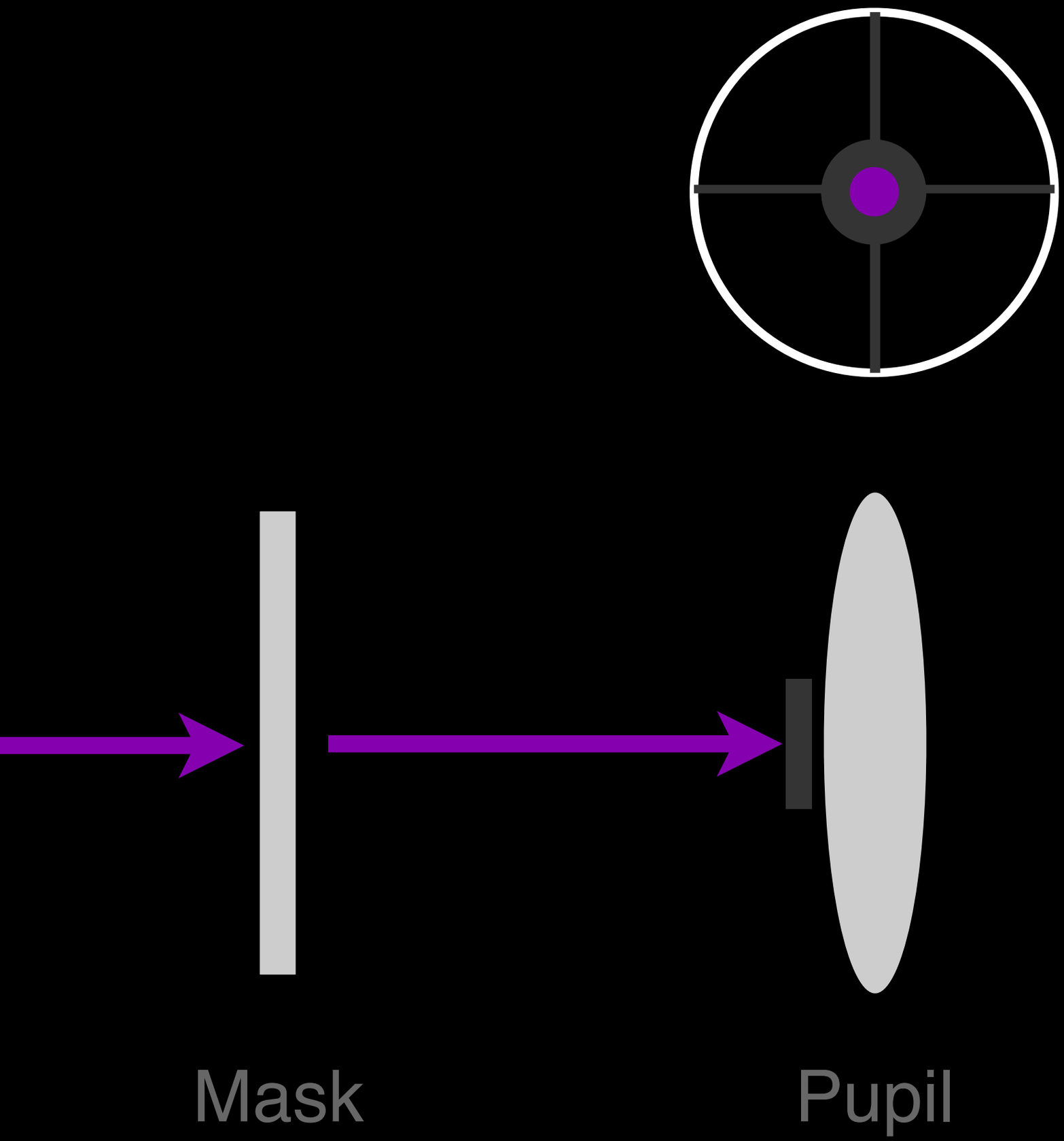
Pseudo phase-shift-mask

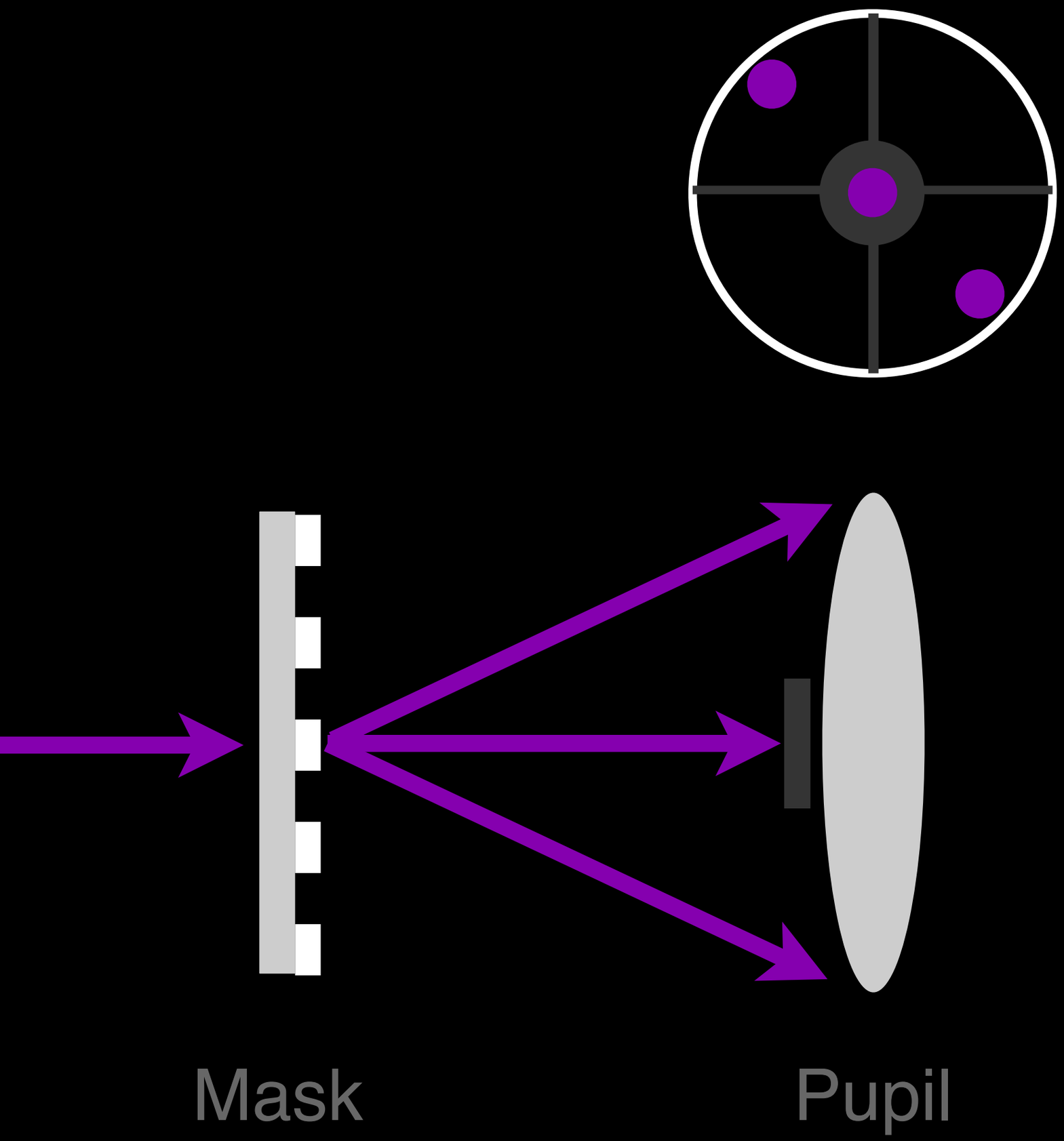


Mask



Pupil


Mask
Pupil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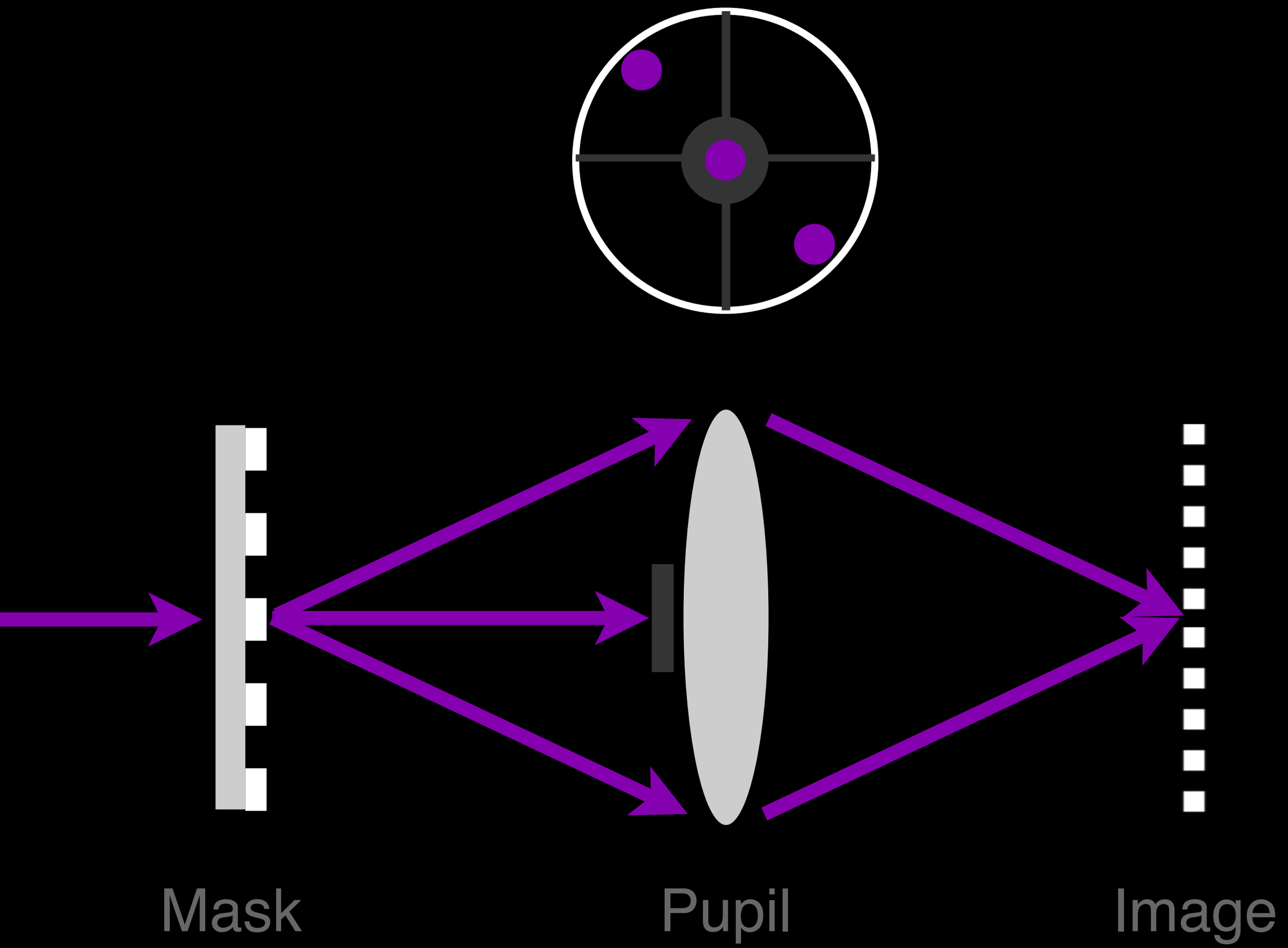
Mask
Pupil
Image