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Session 3: Innovative and Complementary Lithographic Technologies

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Performance of Bandwidth Tuning Laser for Focus Drilling

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Gigaphoton Inc.



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 - ✓ ArF Model & Specifications
 - ✓ Needs for focus drilling
- Approach for Focus Drilling by bandwidth tuning
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 - ✓ BP/BD/Pointing/Energy stability
- Conclusion



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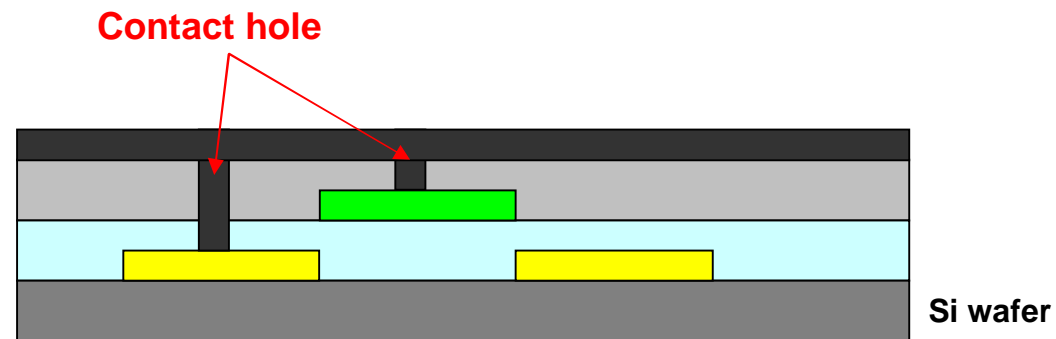
ArF Model & Specifications

Technology Node (typical)	Model	Main driver	Power [W]	Pulse energy [mJ]	Rep. rate [Hz]	E95 [pm]
65 nm	GT40A	higher throughput	45	11.25	4000	<0.5
50 nm	GT60A	higher throughput	60	10	6000	<0.5
45 nm	GT61A	higher NA	60	10	6000	0.3
32 nm	GT62A-1S	Double Patterning	60	10	6000	0.3
	GT62A-1N	higher throughput	90	15	6000	0.3
	GT62A-1SxE	flexiiblity	60-90	10-15	6000	0.3

GRYCOS: chamber lifetime extension technology
 MPL: technology for extension of LNM lifetime
 TGM: technology for extension of gas lifetime

Needs for focus drilling

- Needs: Increasing Depth-of Focus (DoF)
 - ✓ To enhance the process window of contact hole or VIA printing



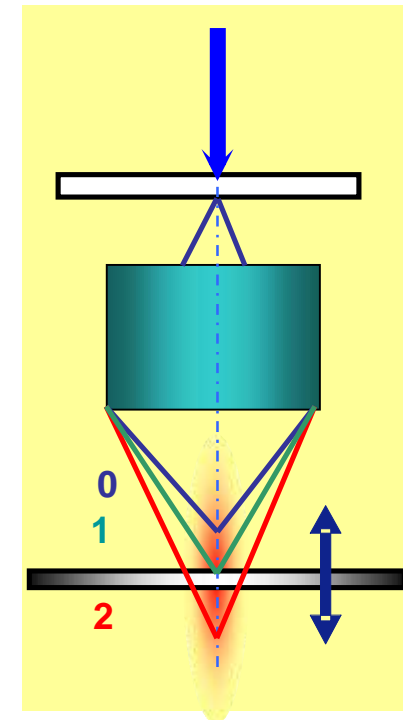
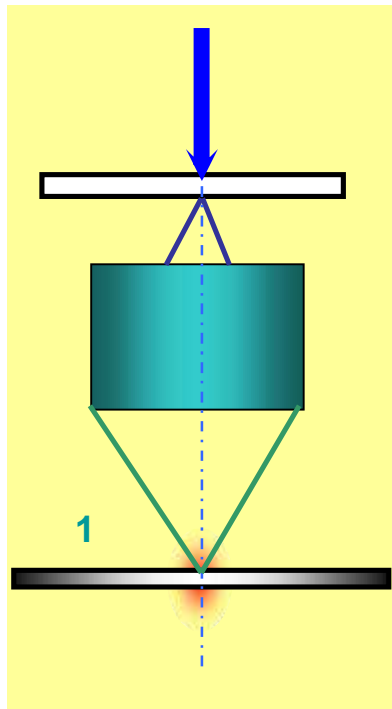
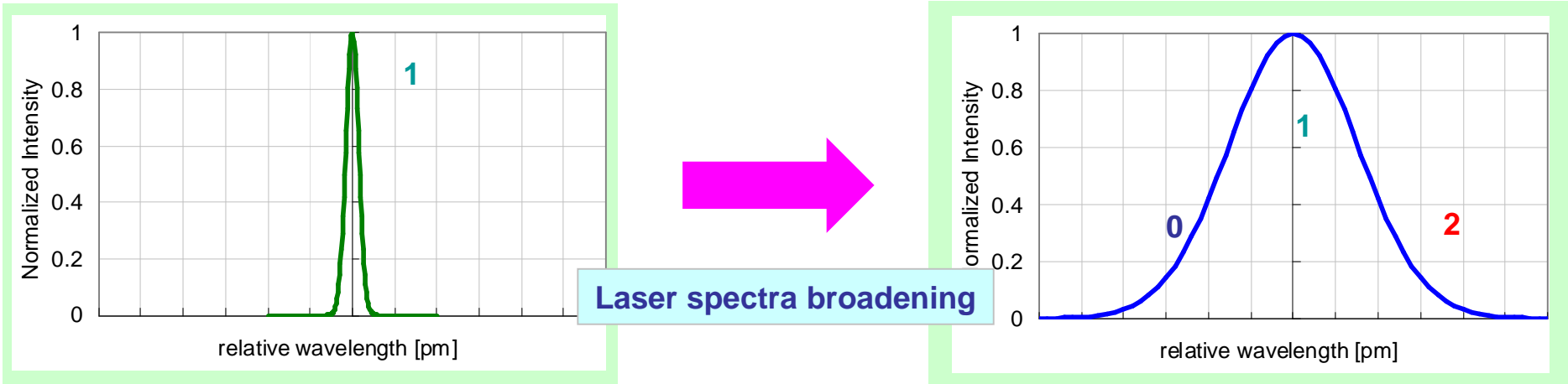
* Current narrow-band spectrum is also needed for immersion technology



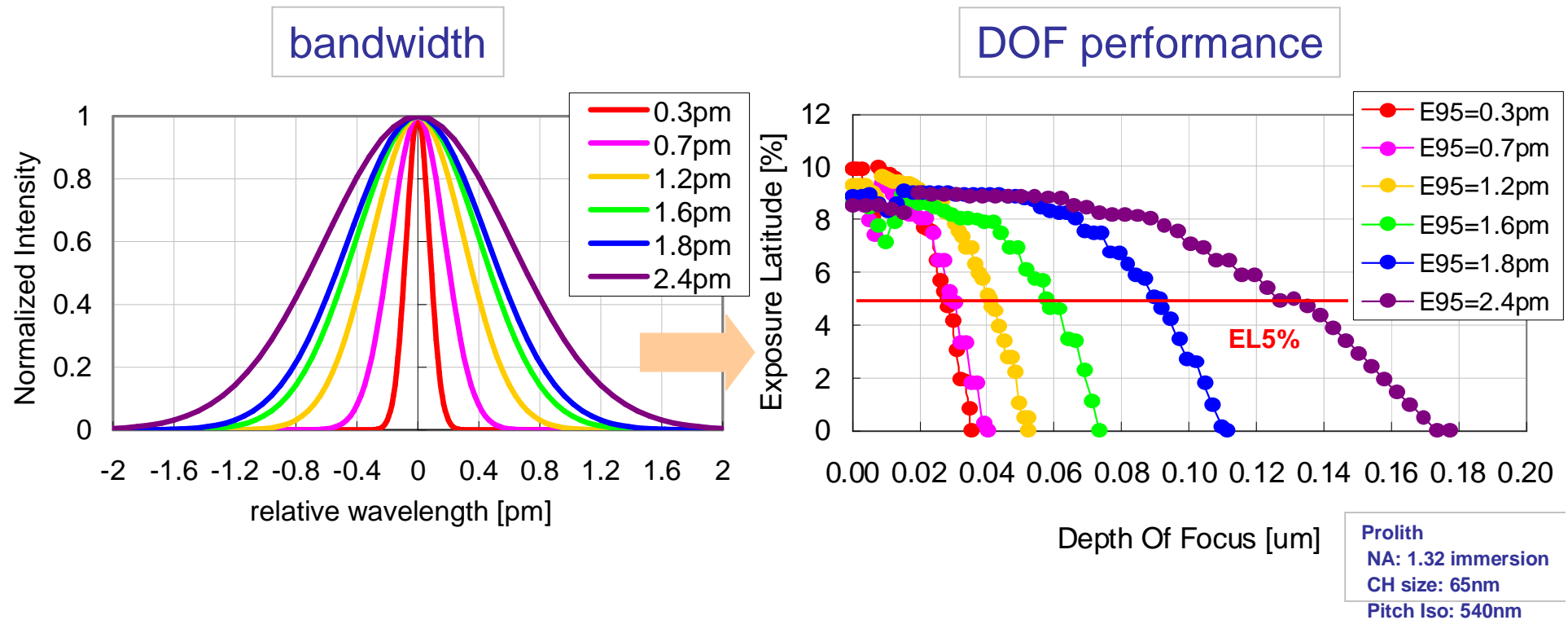
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Approach for Focus Drilling by laser bandwidth tuning

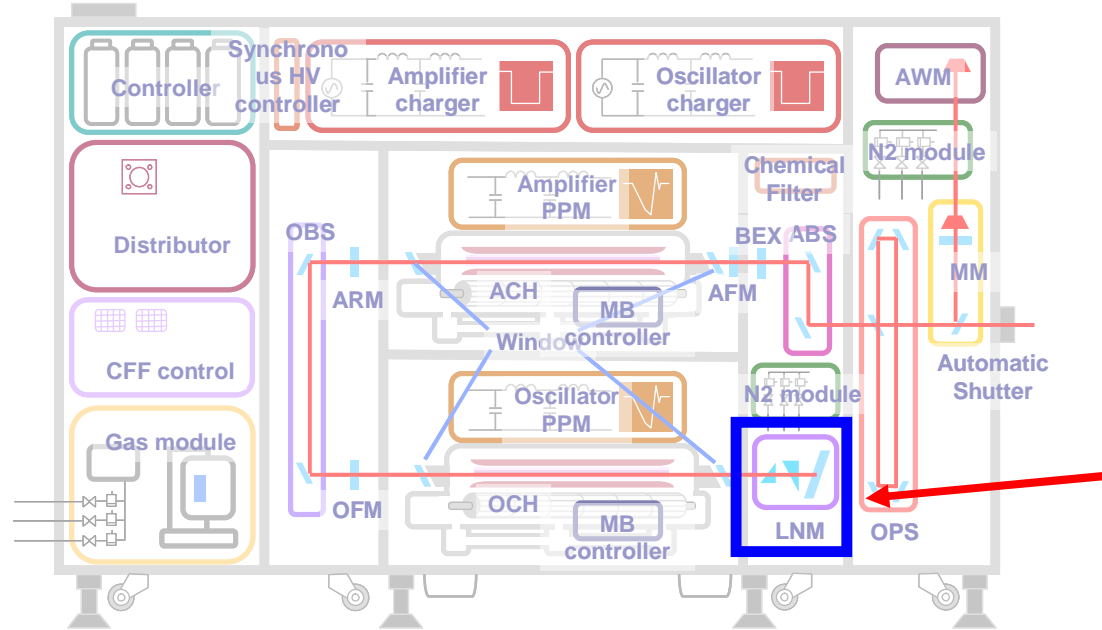


Simulation of DOF by bandwidth tuning



➤ DOF can be expanded by tuning spectrum bandwidth

Configuration for the function



- **Bandwidth tuning**
 - ✓ Newly developed LNM is implemented
- **Metrology and Control**
 - ✓ Existing hardware can be useful
 - ✓ No need to upgrade

Upgradability

Technology Node (typical)	Model	Main driver	Power [W]	Pulse energy [mJ]	Rep. rate [Hz]	E95 [pm]	E95 [pm]
65 nm	GT40A	higher throughput	45	11.25	4000	<0.5	<0.5
50 nm	GT60A	higher throughput	60	10	6000	<0.5	<0.5
45 nm	GT61A	higher NA	60	10	6000	0.3	<div style="border: 2px solid green; padding: 5px; text-align: center;"> Upgradable 0.3 ~ >2.0 </div>
32 nm	GT62A-1S	Double Patterning	60	10	6000	0.3	
	GT62A-1N	higher throughput	90	15	6000	0.3	
	GT62A-1SxE	flexiiblity	60-90	10-15	6000	0.3	

GRYCOS: chamber lifetime extension technology
 MPL: technology for extension of LNM lifetime
 TGM: technology for extension of gas lifetime

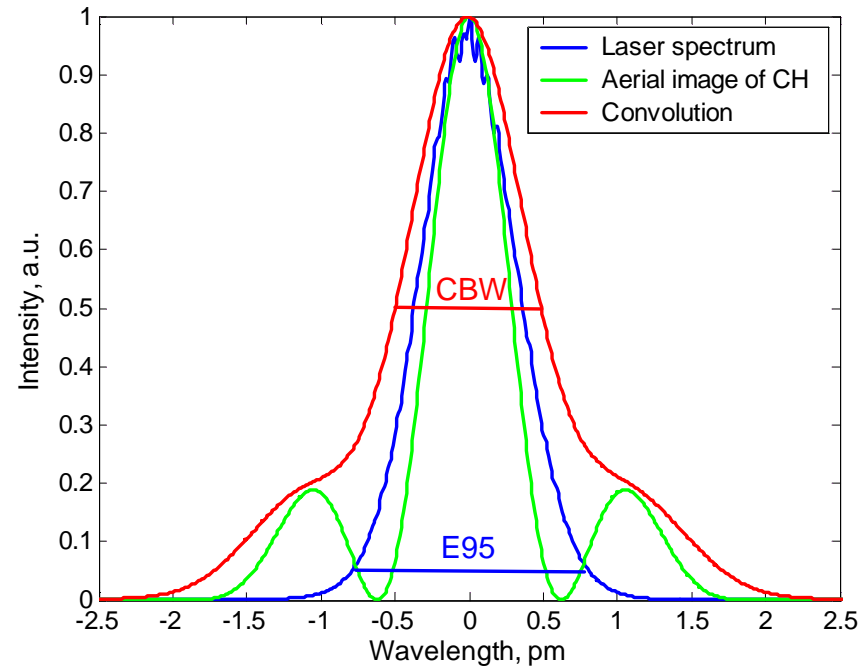
- Easy upgradable to GT61A/62A series
- All other function (MPL, GRYCOS, TGM) can be available



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The definition of new metric CBW

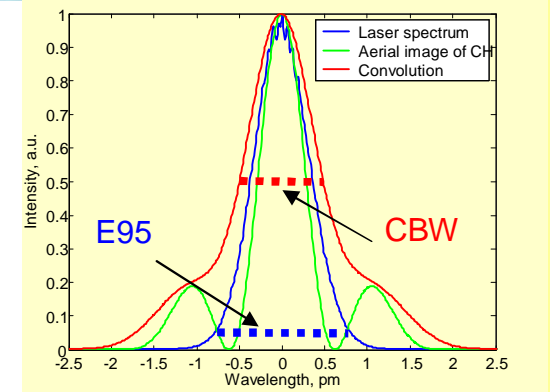
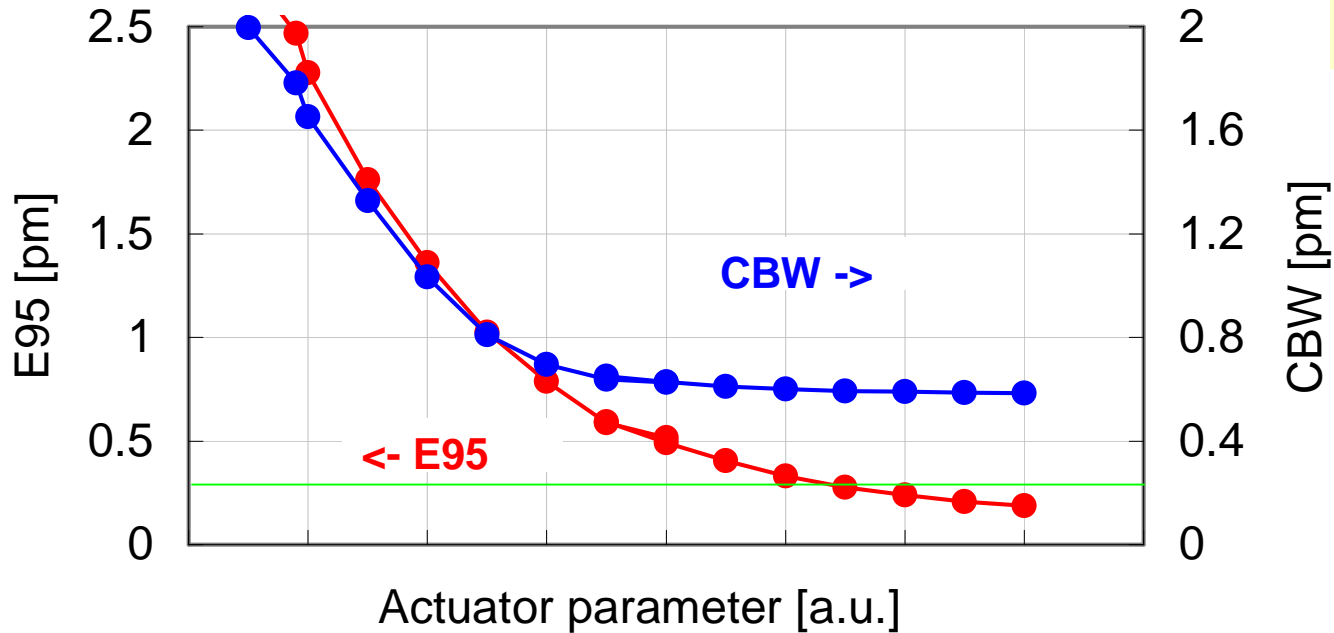


- **Convolved bandwidth (CBW) has been introduced for Focus Drilling**
 - ✓ Convolution of a measured laser spectrum and the aerial image of a contact hole
 - ✓ Good correlation to the lithographic CD over broad variation

Ref: Proc. SPIE Optical Microlithography XXIV 7973, 28

“Focus Drilling for Increased Process Latitude in High-NA Immersion Lithography”

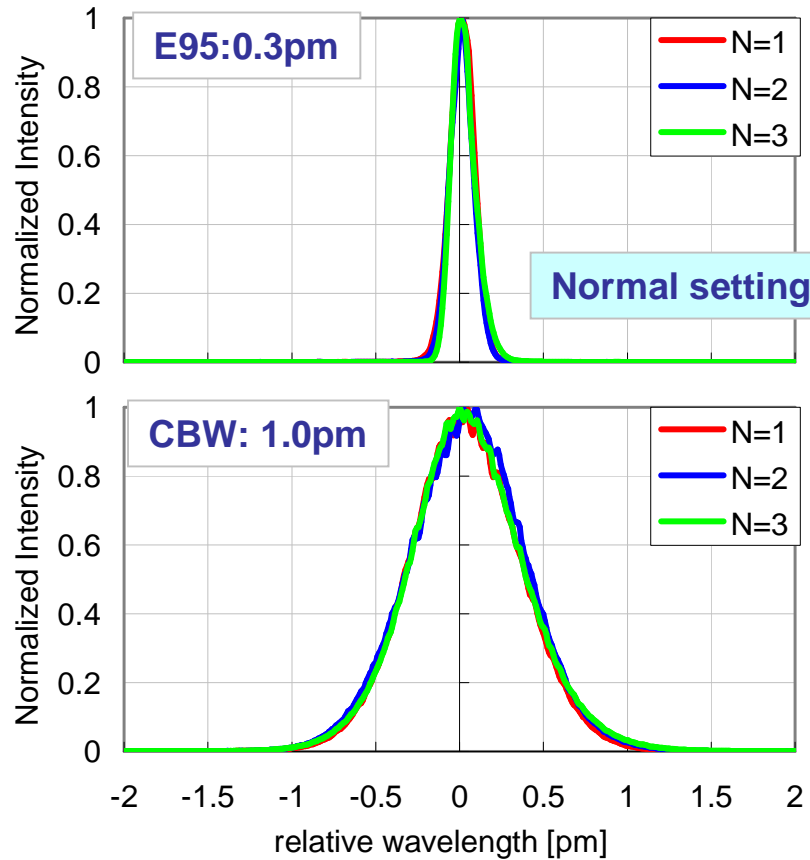
Tuning performance of bandwidth



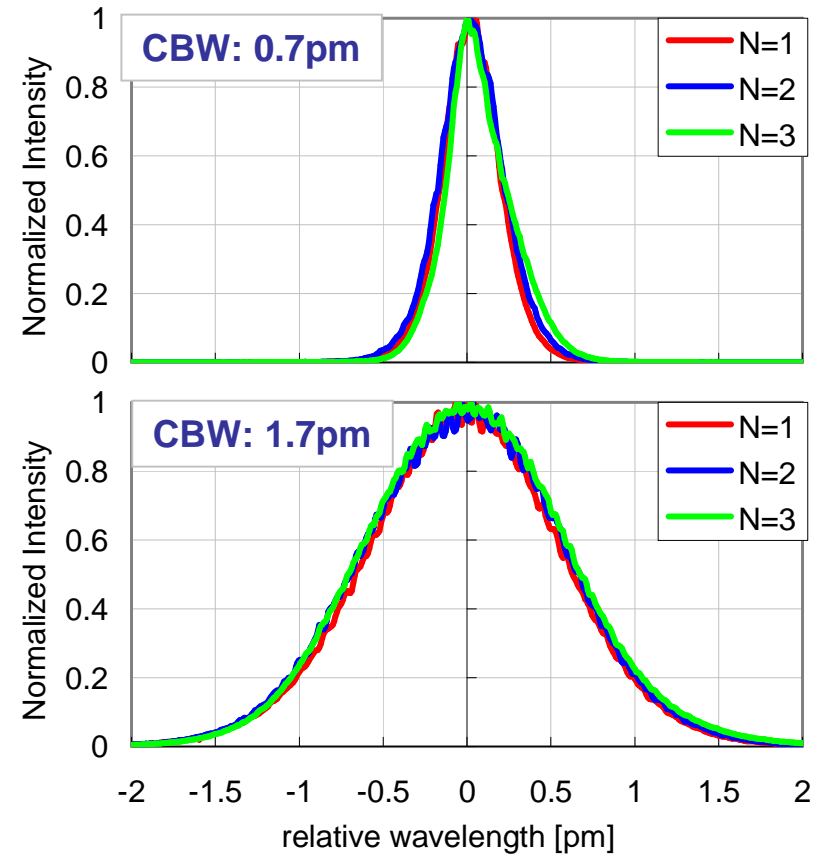
➤ Bandwidth tuning

- ✓ Bandwidth can be tuned continuously

Spectra shape



* Measured external spectrometer

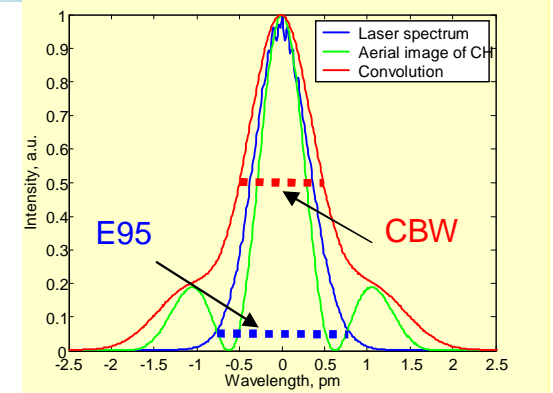
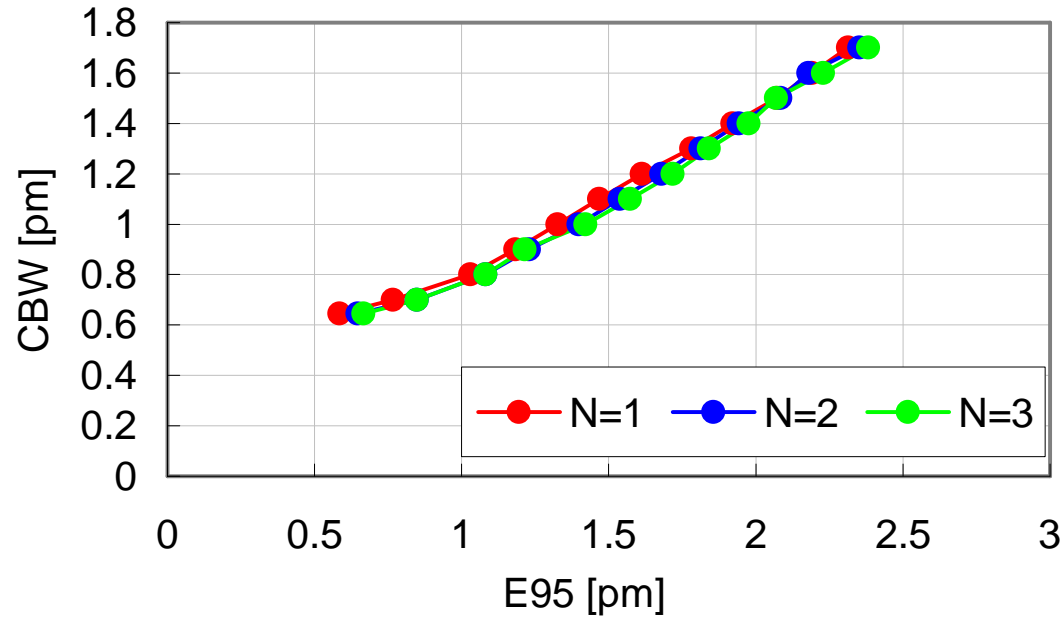


* Performance were measured using 3 different LNM

➤ Bandwidth tuning

- ✓ Symmetric at any bandwidth -> No focus shift
- ✓ High re-productivity -> Little fluctuation tool-to-tool

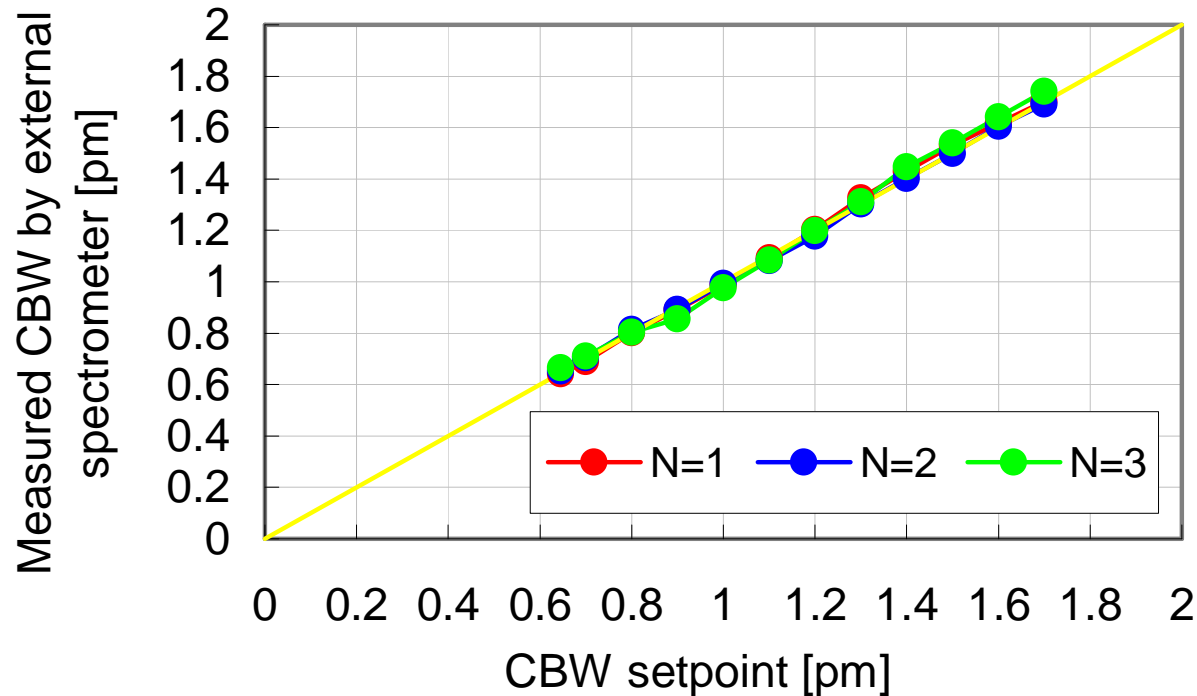
Relationship between CBW and E95



* Performance were measured using 3 different LNM

- Relationship between CBW and E95 are similar for ALL LNM

Accuracy of bandwidth measurement

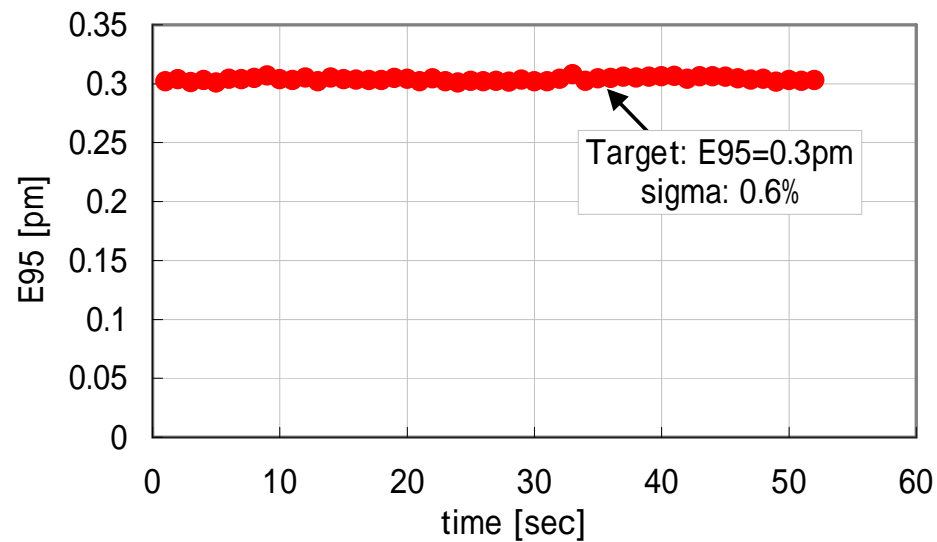


* Performance were measured using 3 different LNM

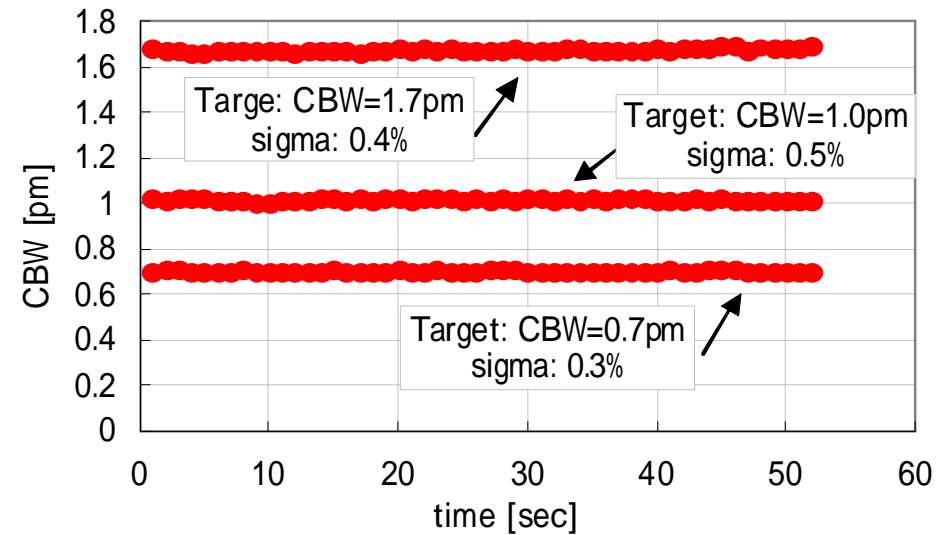
➤ Bandwidth measurement

- ✓ High linearity can be achieved
- ✓ Bandwidth can be measured and controlled well with on-board measurement tool

Spectrum stability (short term)

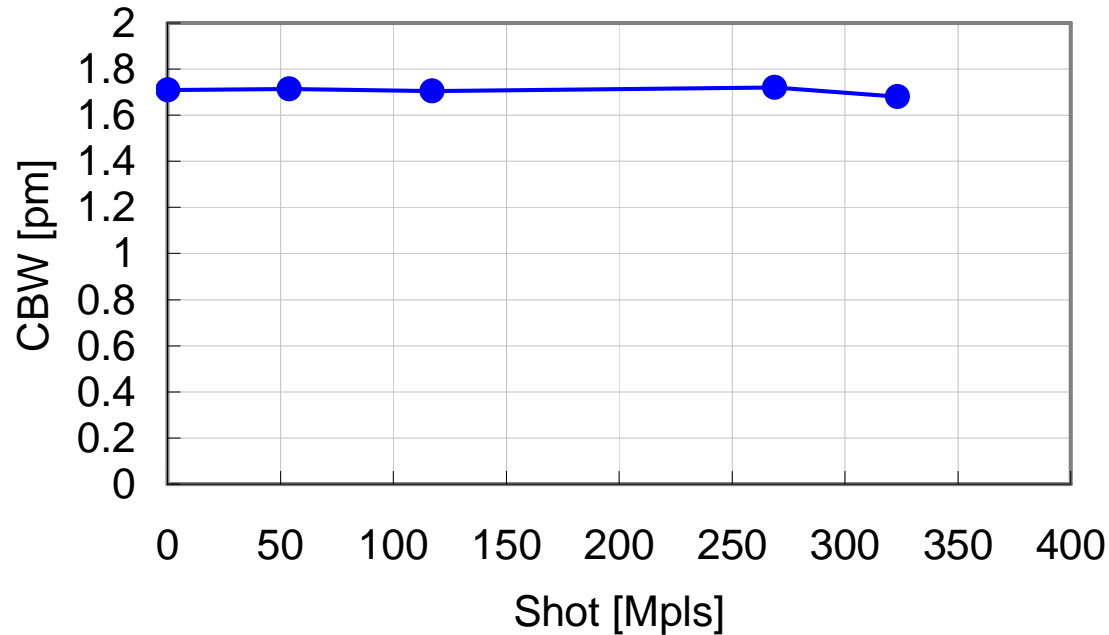


* Measured external spectrometer

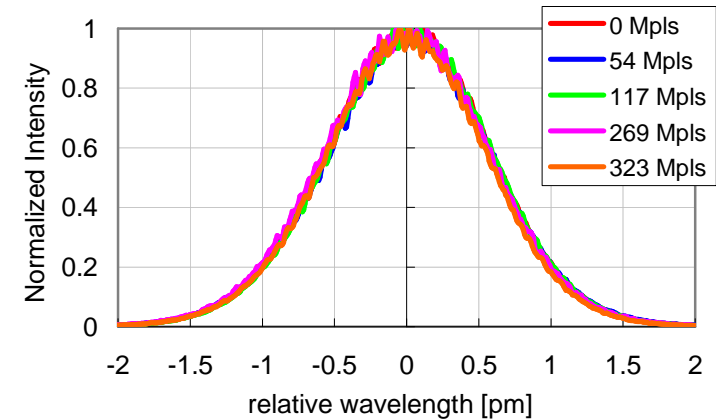


- **Bandwidth can be controlled with high accuracy at any BW set-point**
 - ✓ Little CD fluctuation within chip

Spectrum stability (middle term :Gas Life)



* Measured external spectrometer

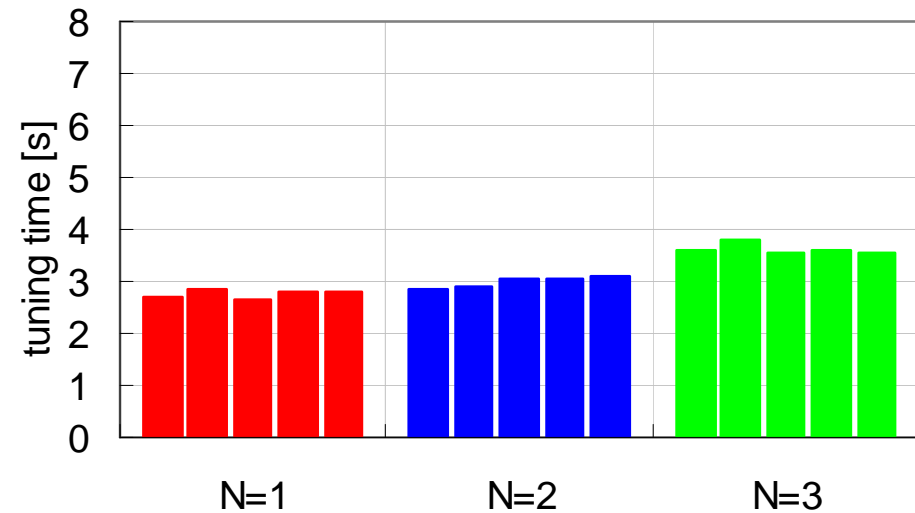
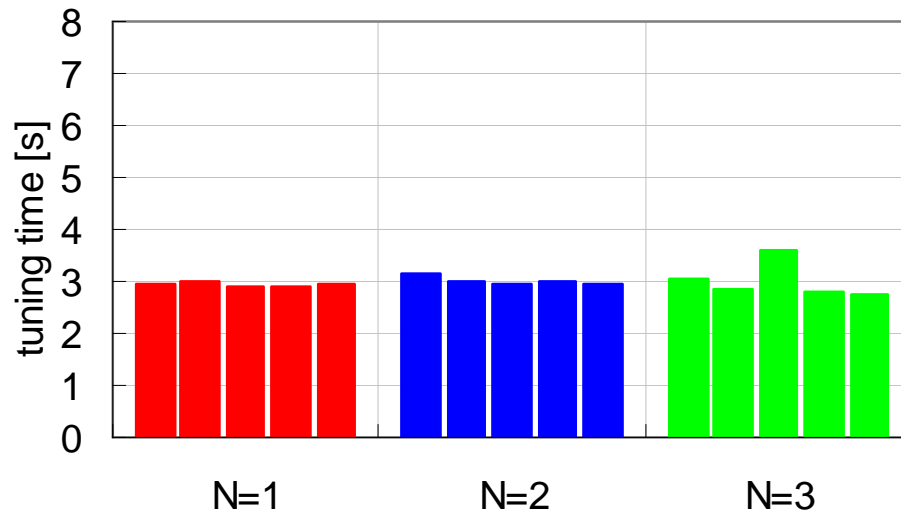


- **Bandwidth can be controlled with high accuracy over gas-life**
 - ✓ Little CD fluctuation lot-to-lot

Bandwidth Tuning time

Low(E95:0.3pm) -> High(CBW:1.7pm)

High (CBW:1.7pm) ->Low (E95:0.3pm)



* Tuning time were measured 5 times at each condition

➤ **Bandwidth can be tuned within several seconds**

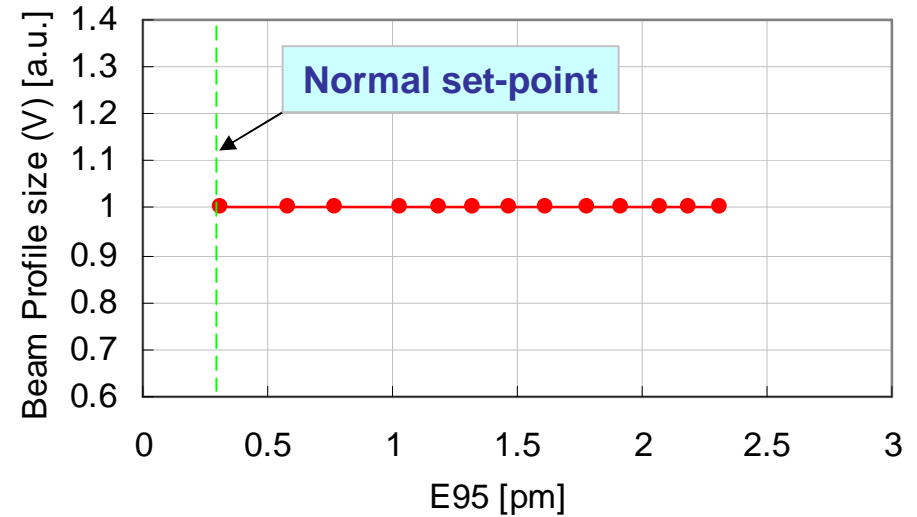
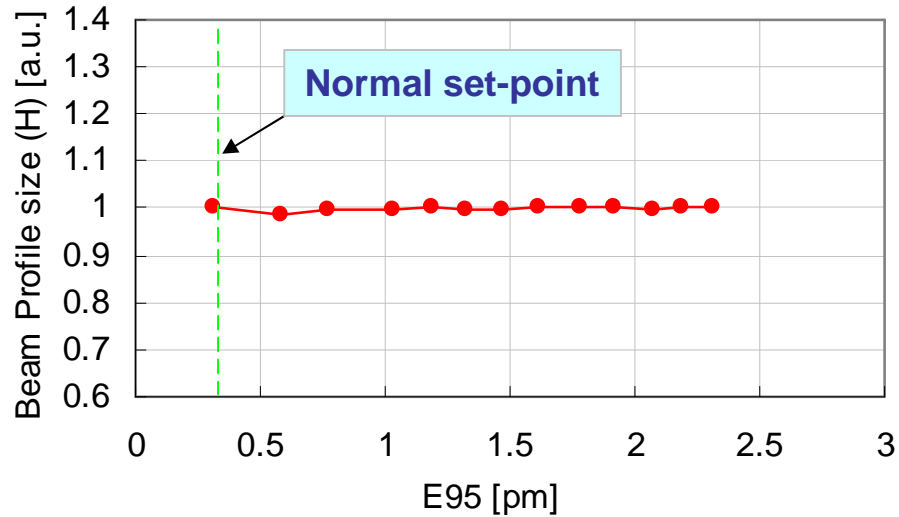
✓ Low influence to Lithography throughput



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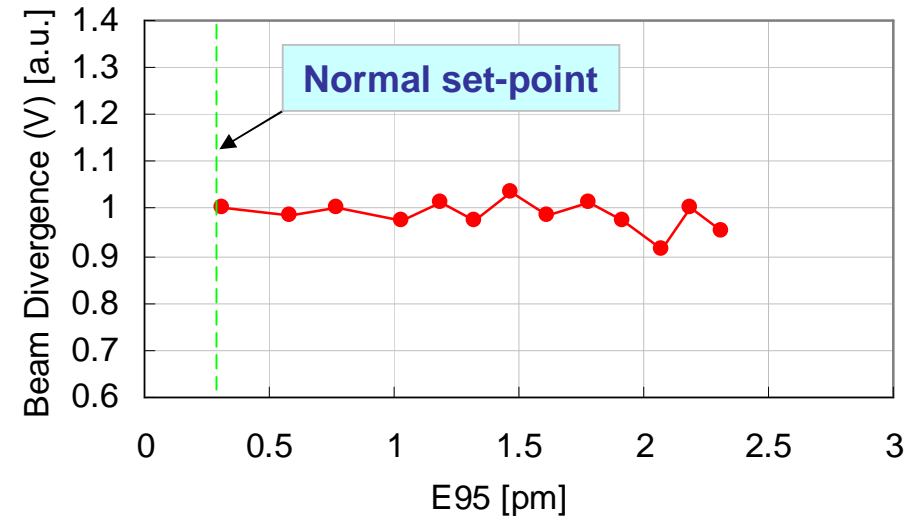
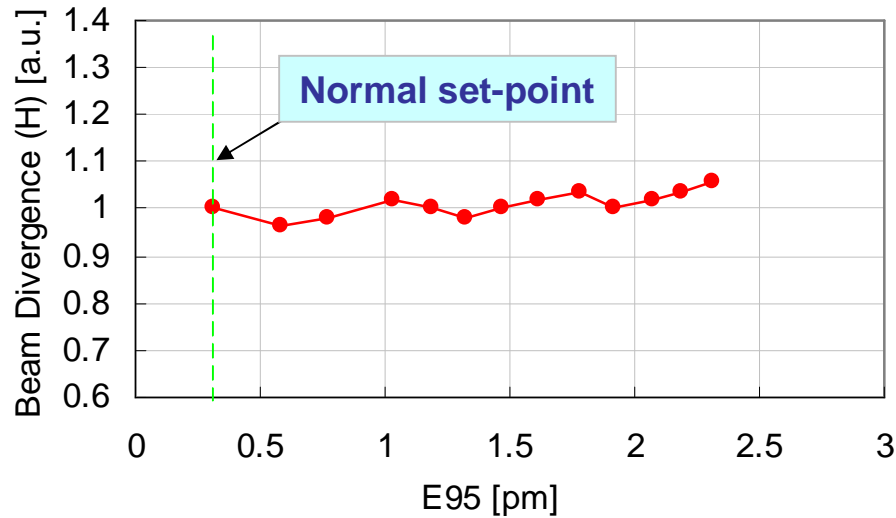
Beam Profile stability



➤ **High stability of Beam Profile size**

- ✓ Stable illumination uniformity will be expected at any bandwidth

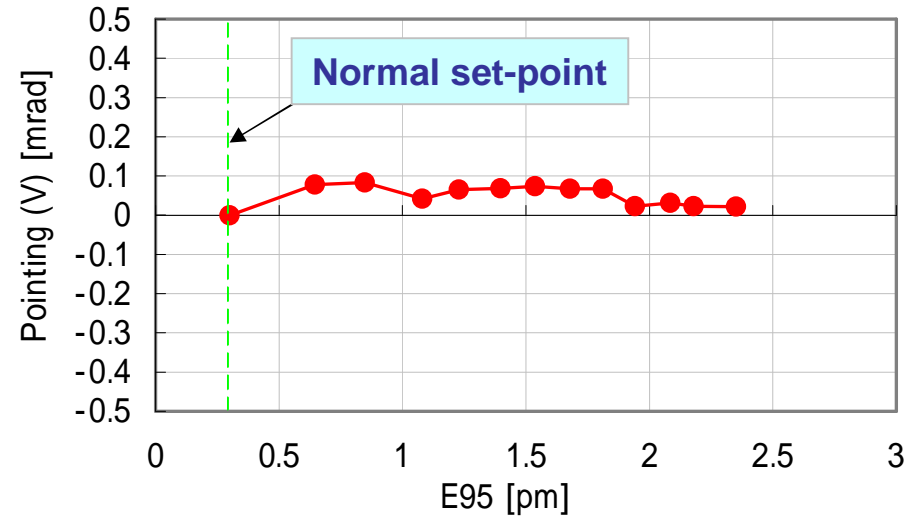
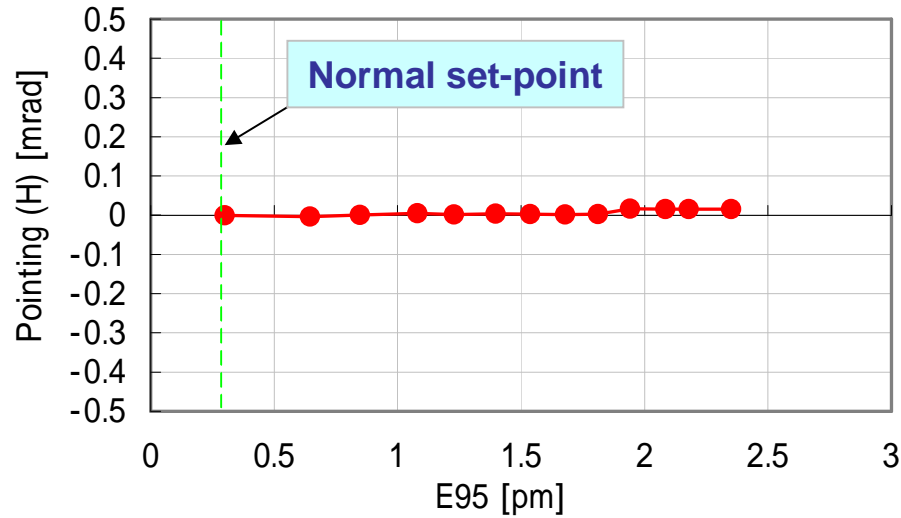
Beam Divergence stability



➤ High stability of Beam Divergence

- ✓ Stable illumination uniformity will be expected at any bandwidth

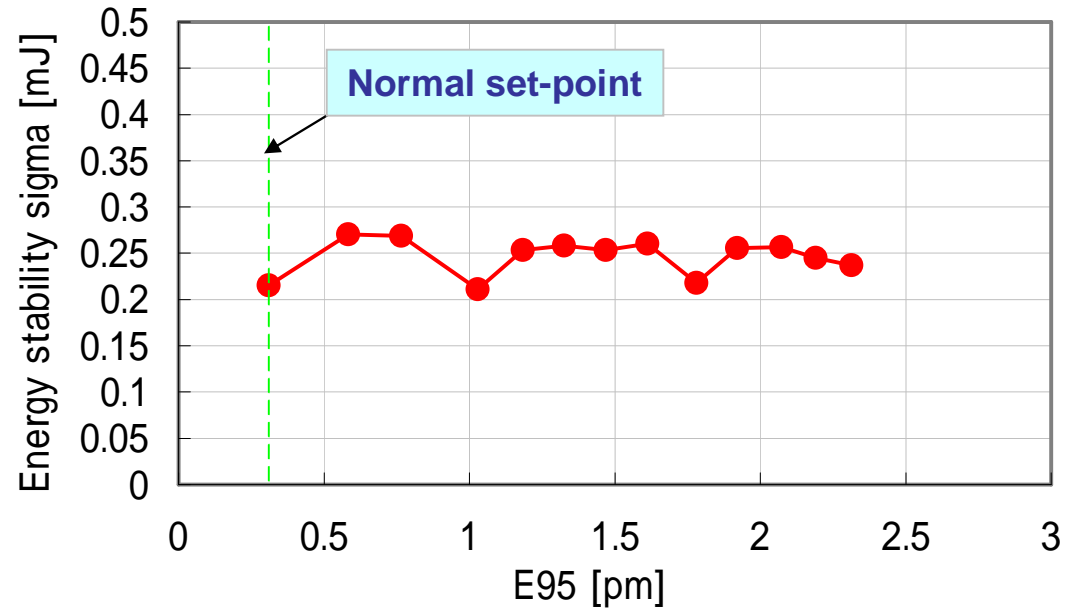
Pointing stability



➤ **High stability of Beam pointing**

- ✓ Stable illumination uniformity will be expected at any bandwidth

Energy stability



➤ **High Energy stability**

- ✓ No impact to CD variation



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Conclusion

- Gigaphoton have developed the new flexible function for Focus Drilling
 - ✓ Bandwidth performance
 - **Wide tuning range**
 - **Accurately stabilized, Low fluctuation**
 - **Cell-to-cell, Lot-to-lot, Tool-to-tool**
 - **High-speed Tuning time**
 - ✓ Little impact to other laser key performance
 - ✓ Easy-upgradable to GT61A/62A series

Acknowledgement

We thank to ASML for discussing and supporting this project.

Gigaphoton's mission is to be the No. 1 provider of advanced technology and quality products and to contribute to society as the industry leader.
We at Gigaphoton aim at being a team of professionals who can build a strong relationship of mutual trust, both within and outside of the company.

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