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# Ecology and high durability injection locked laser with flexible power for double patterning ArF immersion lithography

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Gigaphoton Inc.



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- Introduction
  - ✓ ArF Roadmap
  - ✓ ArF Specifications
- Approach for the Ecology
  - ✓ EcoPhoton concept
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    - **CoD reduction**
  - ✓ Technological Overview
- Performance
  - ✓ Durability performance
  - ✓ Gas and electric power consumption
  - ✓ Availability
- Conclusion



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# INTRODUCTION

- **ArF excimer laser for the 32nm node and beyond**
  
- **Environmentally conscious lithography tools**
  
- **Gigaphoton's target is CoO(Cost of ownership) reduction.**
  
- **'Eco-Photon' concept**
  - ✓ **CoC (Cost of Consumable)**
  - ✓ **CoD (Cost of Downtime)**
  - ✓ **CoE (Cost of Energy)**
  
- **Technologies to be reported in this presentation.**

# ArF Laser Product Roadmap

Power	Technology Node	Main driver	Requirement for ArF Laser	~2004	2005	2006	2007	2008	2009	2010	2011
60 - 90W	32 nm	double patterning higher throughput (advanced system)	6kHz/60-90W/0.30pm(E95)								GT62A-1SxE
90W	32 nm	double patterning higher throughput	6kHz/90W/0.30pm(E95)							GT62A-1N	
60W	32 nm	double patterning higher throughput	6kHz/90W/0.30pm(E95)						GT62A-1S		
60W	45 nm	higher NA	6kHz/60W/0.30pm(E95)				GT61A				
60W	50 nm	higher throughput higher NA	6kHz/60W/<0.50pm(E95)			GT60A					
45W	65 nm	higher throughput	4kHz/45W/<0.50pm(E95)		GT40A						
										GT40A-2	

# Specifications

ArF model		GT40A	GT60A	GT61A	GT62A-1S	GT62A-1N	GT62A-1SxE
Wavelength	nm	193	193	193	193	193	193
Power	W	45	60	60	60	90	60 - 90
Pulse energy	mJ	11.25	10	10	10	15	10 - 15
Max. rep rate	Hz	4000	6000	6000	6000	6000	6000
FWHM	pm	0.2	0.2	N.A	N.A	N.A	N.A
E95	pm	<0.5	<0.5	0.3	0.3	0.3	0.3
Durability (Expected)							
MO Chamber	Bpls	40*	40*	40*	40*	40*	>40***
PO Chamber	Bpls	40*	40*	40*	40*	40*	>40***
LNM / MO LNM	Bpls	60**	60**	60**	60**	60**	60**
MM	Bpls	30	30	30	30	30	30
FM / PO FM	Bpls	30	30	30	30	30	30
PO RM	Bpls	30	30	30	30	30	30

- \* GRYCOS technology
- \*\* MPL (Multi Positioning LNM)
- \*\*\* Durability can be extendable @ <90W

**GT62A-1SxE meets the requirements of the advanced exposure systems.**



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## ➤ Gigaphoton's EcoPhoton concept

<b>Aim</b>	<b>Ecology : Eco-Friendly Lithography Tools</b>		
<b>Benefit</b>	<b>Total CoO (Cost of Ownership) reduction</b>		
<b>Cost element</b>	<b>CoE</b>	<b>CoC</b>	<b>CoD</b>
	<b>Electric power consumption Gas consumption</b>	<b>Reliability (Durability test)</b>	<b>Availability</b>
	<b>Durability</b>		
<b>Technologies</b>	<b>60-90W Flexible output power</b>		<b>GT Platform</b>
	<b>Injection Lock</b>	<b>Long lifetime modules</b>	
	<b>TGM</b>	<b>GRYCOS, MPL</b>	<b>TGM</b>

### ➤ EcoPhoton concept

- ✓ CoC (Cost of Consumable)
- ✓ CoD (Cost of Downtime)
- ✓ CoE (Cost of Energy & Environment)



BEAM to the FUTURE

## Approach to EcoPhoton

### ➤ **CoC:**

- ✓ Laser's module lifetime extension
  - GRYCOS
  - MPL
- ✓ Flexible power

### ➤ **CoE**

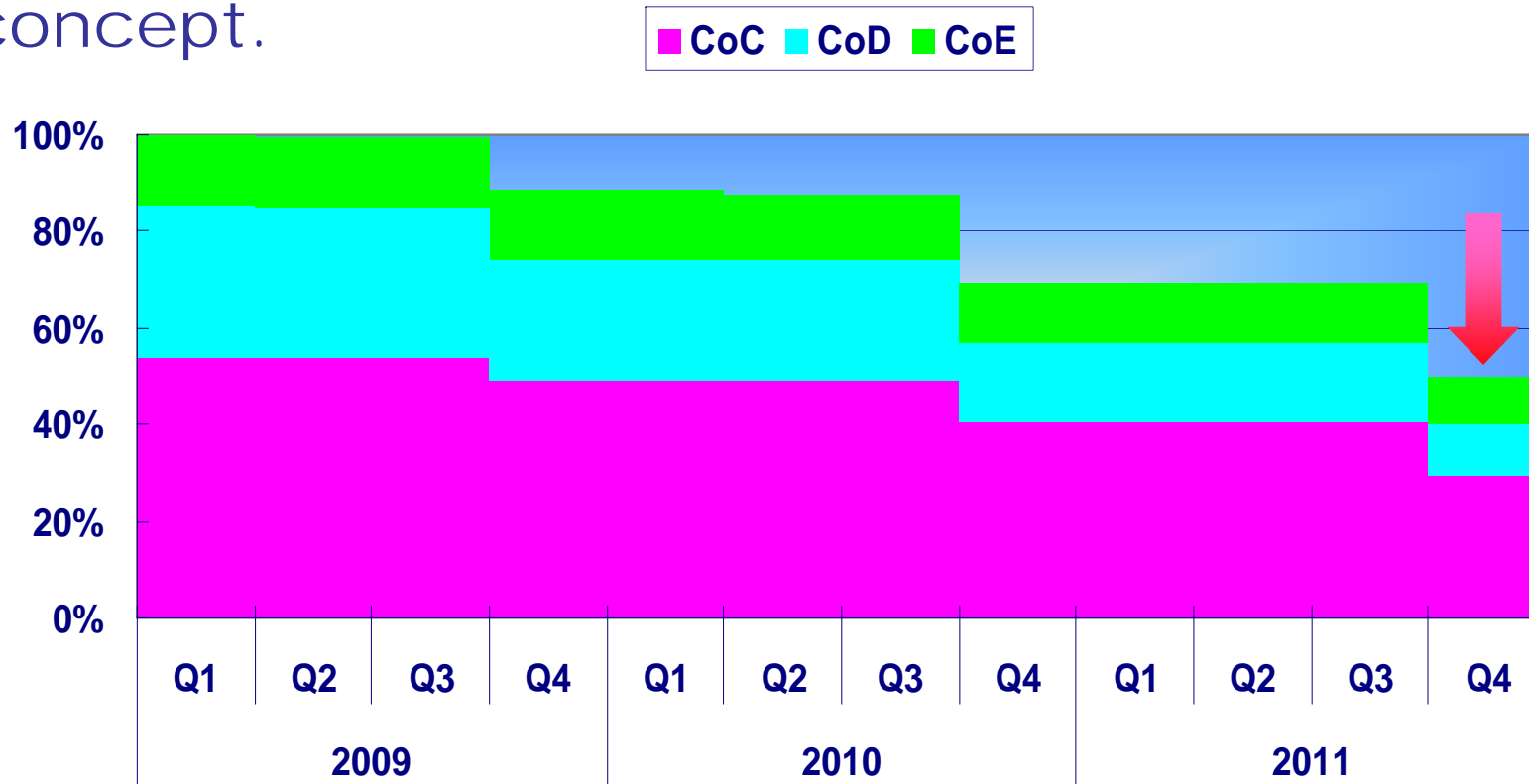
- ✓ Efficient injection locked system
- ✓ TGM

### ➤ **CoD**

- ✓ Proven GT Platform
- ✓ Lifetime extension technologies

# Cost Reduction Roadmap

Since 2009 Gigaphoton has been working on the cost reduction roadmap under the “EcoPhoton” concept.



**To support ArF extension, targeting >50% cost reduction before Y2012\* with EcoPhoton technology**

\* Based on EcoPhoton policy



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*Latest product*

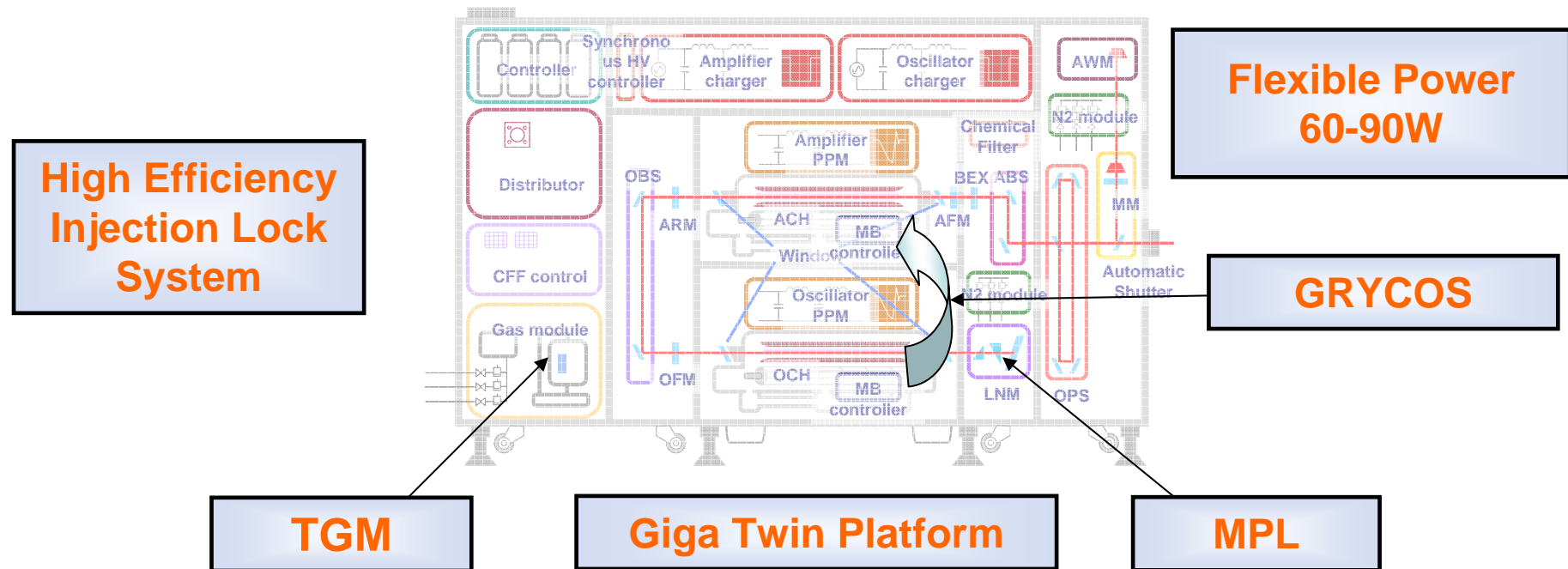
## GT62A-1SxE



- GT62A-1SxE
  - ✓ Meeting the advanced illumination system
  - ✓ Optimized illumination power for various resist sensitivities
  
- Features
  - ✓ Long lifetime modules
  - ✓ Flexible power
    - Possible to operate from 60W to 90W.
    - Possible to operate arbitrarily output
  - ✓ Eco-friendly

# Technologies for EcoPhoton in GT62A-1SxE

- GRYCOS
- MPL
- TGM
- Flexible Power
- Injection Lock system
- GT Platform

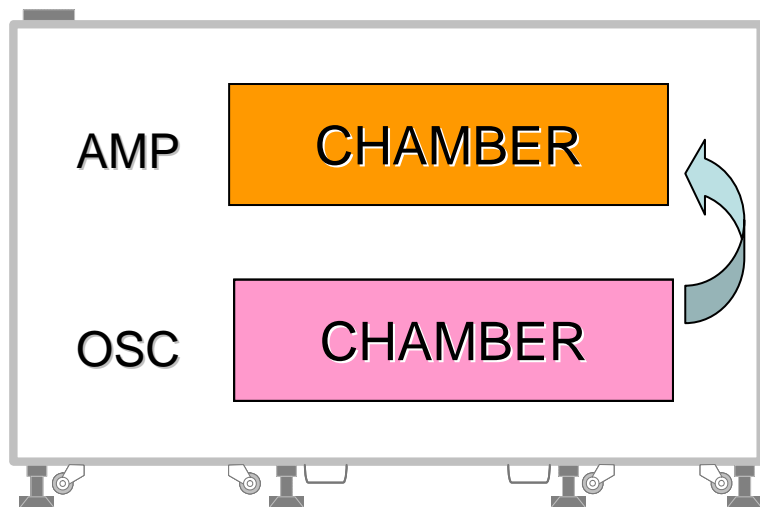


# Technology for CoC Reduction

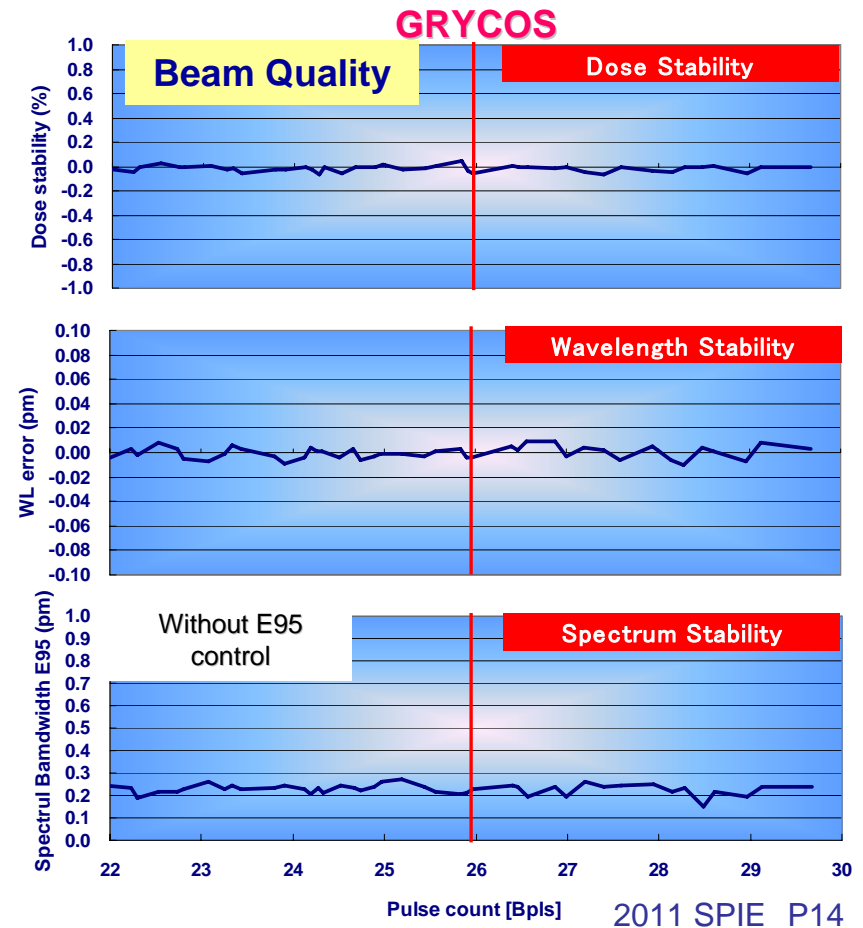
**GRYCOS** (Gigaphoton RecYcle Chamber Operating System)

➤ Each laser chamber can be used up to 40 Billion pulses.

After oscillator chamber lifetime expires, it then can be used as an amplifier chamber.



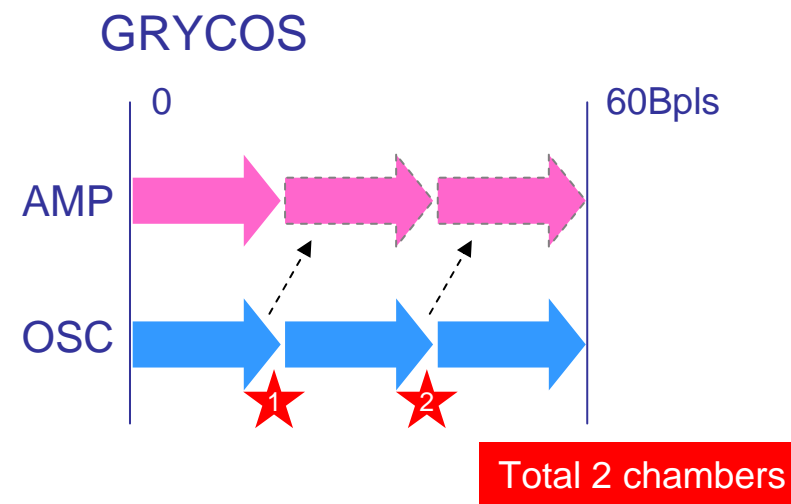
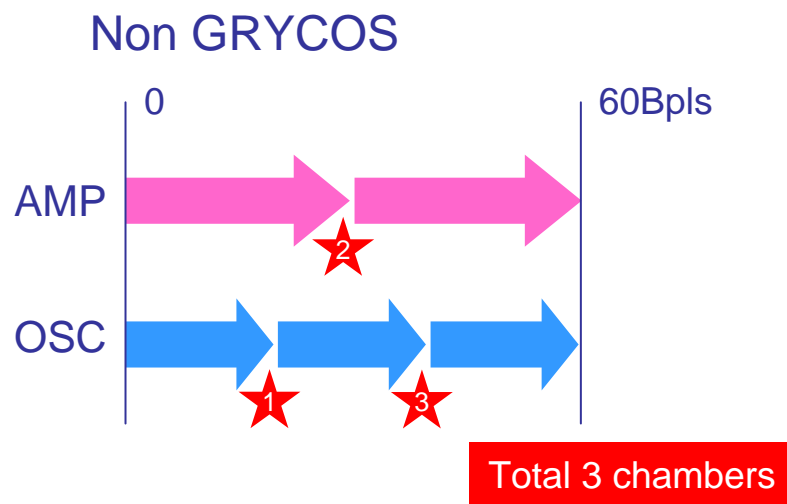
**No impact to Beam Quality @60W operation**



## Technology for CoC Reduction

### Cost simulation

- GRYCOS can reduce the number of chamber replacements, i.e. drastically reducing CoO

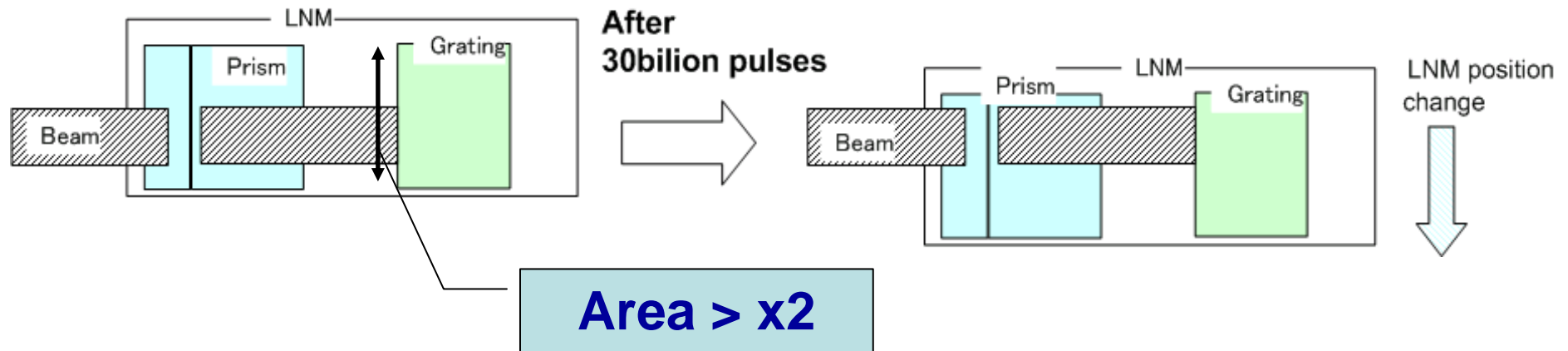


## Technology for CoC Reduction

### MPL (Multi Positioning LNM)

- LNM lifetime can be extended to double (30Bpls ⇒ 60Bpls).

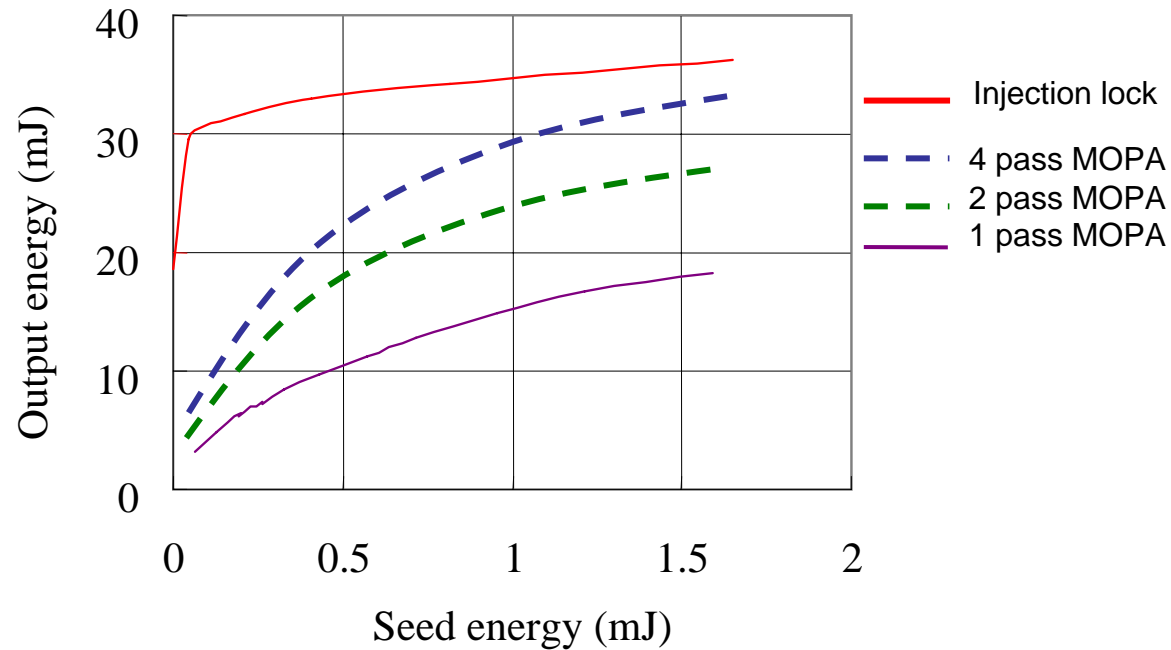
Effectively changing optical path



# Technology for CoE Reduction

## High Efficiency Injection Lock System

- Injection Lock system has a resonator in an amplifier.
- It can generate higher laser energy with less seed energy compared to MOPA system.

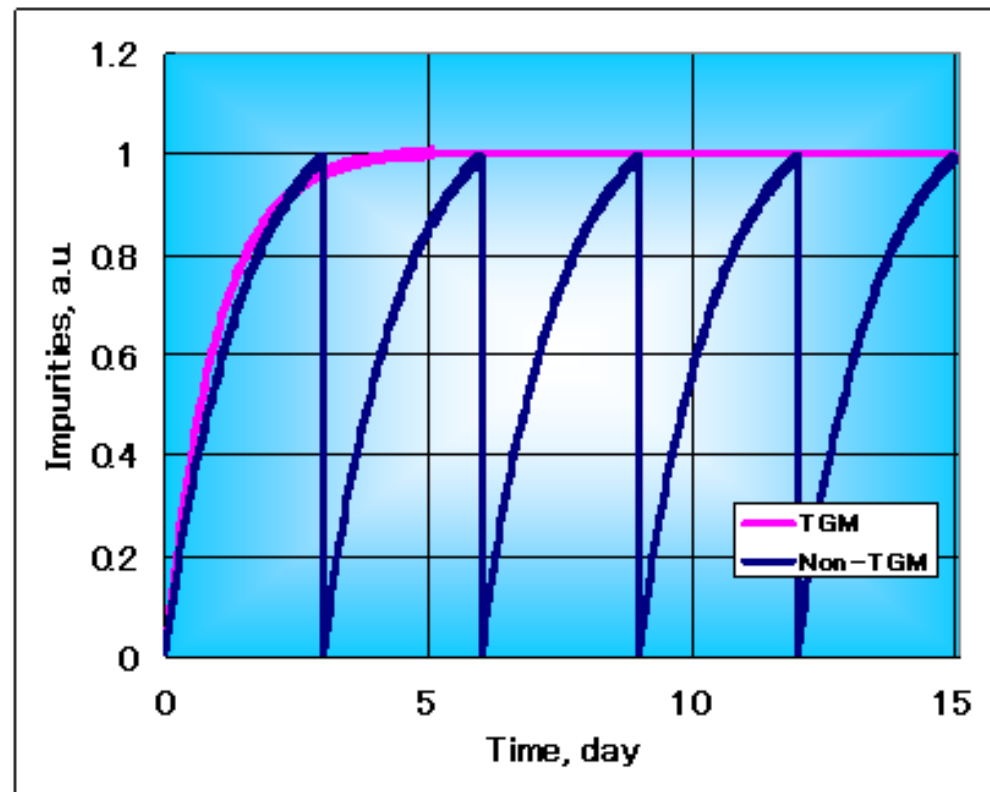


(experiment data in Gigaphoton)

## Technology for CoE Reduction

### TGM (Total Gas Management)

➤ Gas refill interval: 3 days  $\Rightarrow$  15 days

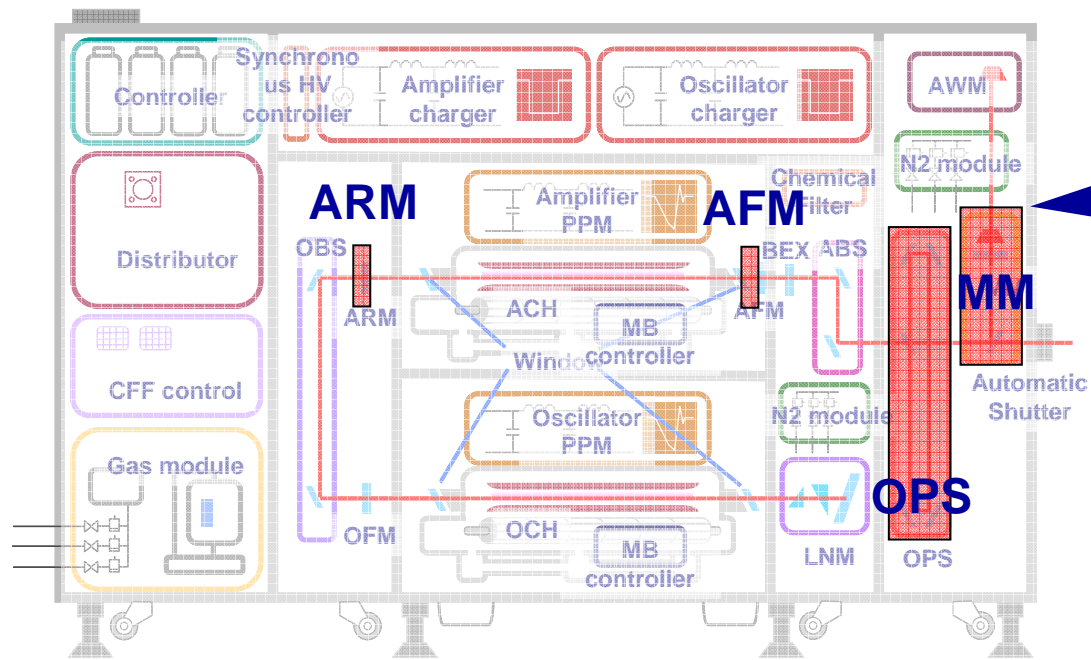


Impurities in chamber

# Advanced technology related with CoC and CoE

## Flexible Power

- Illumination Power optimization for Resist Sensitivity
  - ✓ Power extension from 60W to 90W
  
- Module lifetime extension



90W modules  
 MM  
 AFM  
 ARM  
 OPS

\* New OPS is required for 90W operation only.



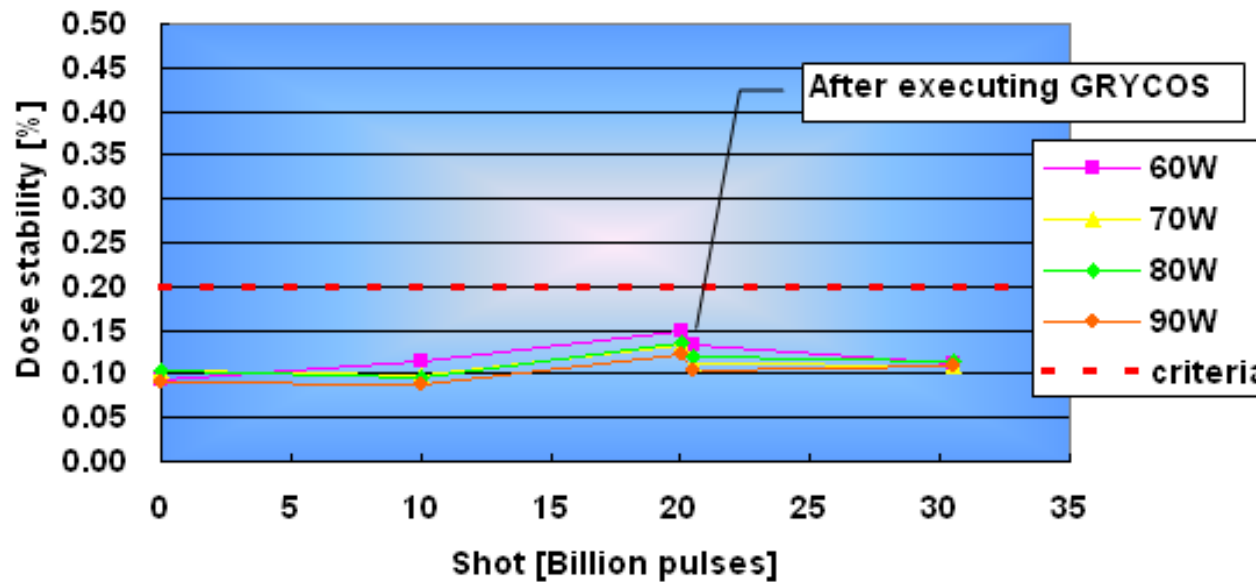
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## Durability test result (CoC)

### ➤ Energy stability (Dose stability)

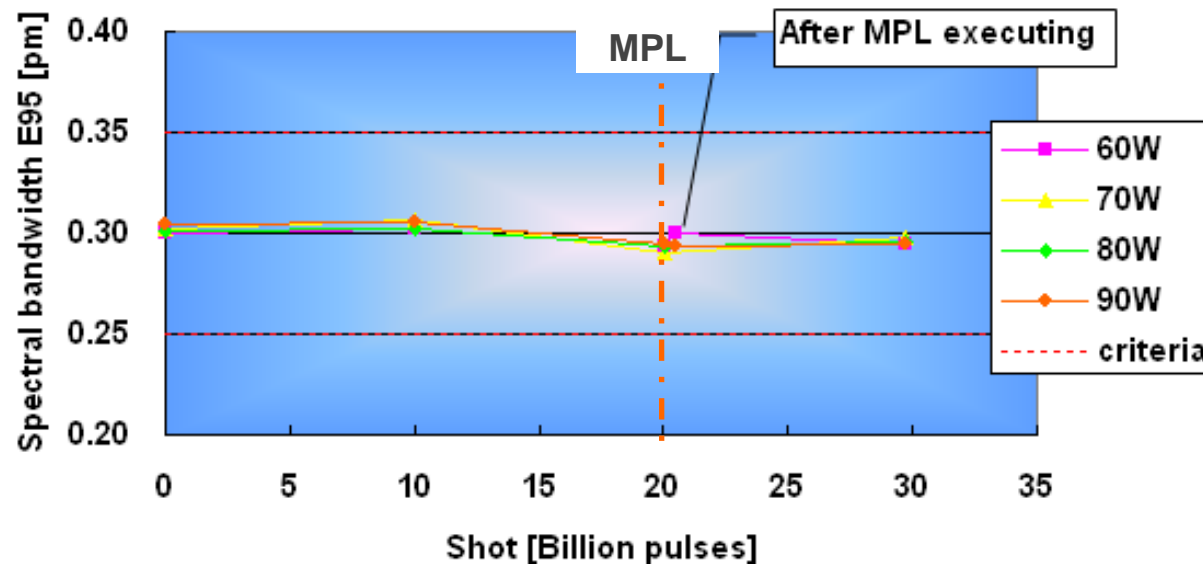
- ✓ Stable between 60W and 90W during durability test.
- ✓ Stability maintained before/after GRYCOS
- ✓ Improved dose stability contributes to better CD control.



## Durability test result (CoC)

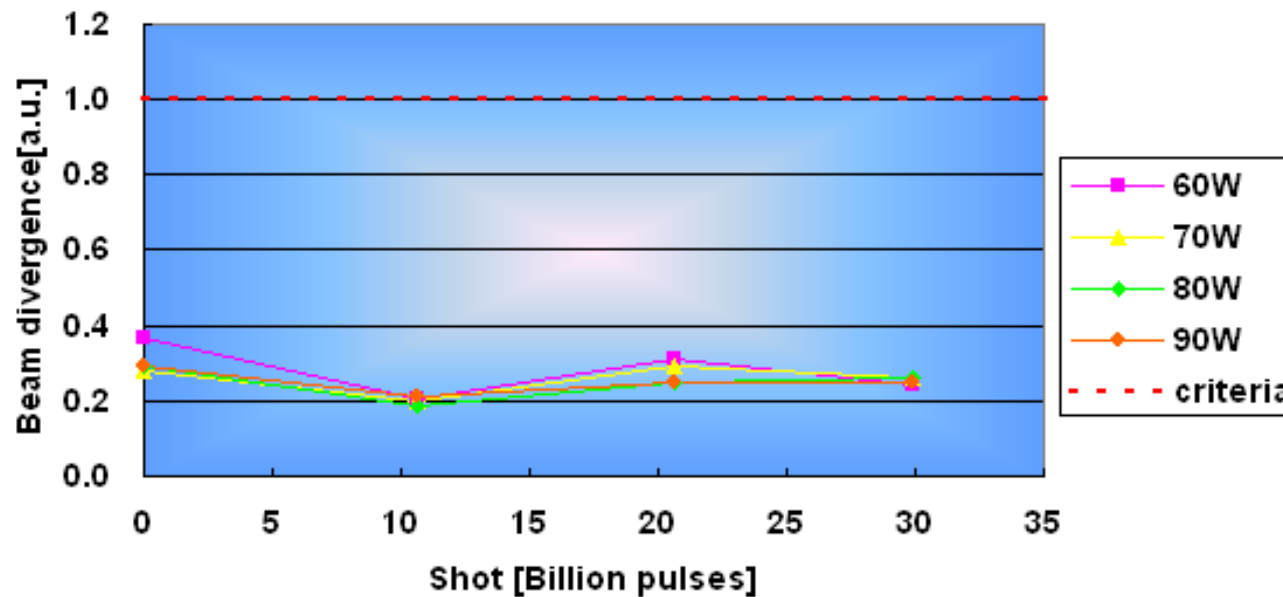
### ➤ Spectral bandwidth and wavelength stability

- ✓ Stable spectrum between 60W and 90W.
- ✓ Consistent E95 before/after MPL



## Durability test result (CoC)

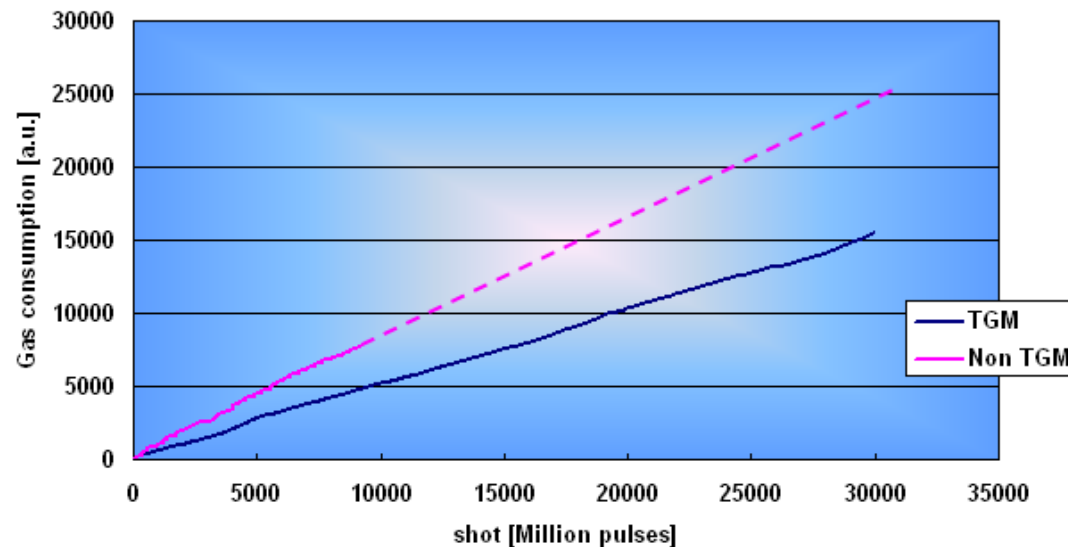
- Beam profile and Beam divergence stability
  - ✓ Stable beam profile and beam divergence between 60W and 90W.
  - ✓ Optimized illumination power for various resist sensitivities.



## Reduction in Gas and Electrical power consumption (CoE)

### ➤ Gas consumption

✓ Gas consumption -30%



\*Condition : Result of the test in Gigaphoton  
 Non-TGM 60W operation in GT61A  
 TGM 90W operation in GT62A-1SxE

## Reduction in Gas and Electrical power consumption (CoE)

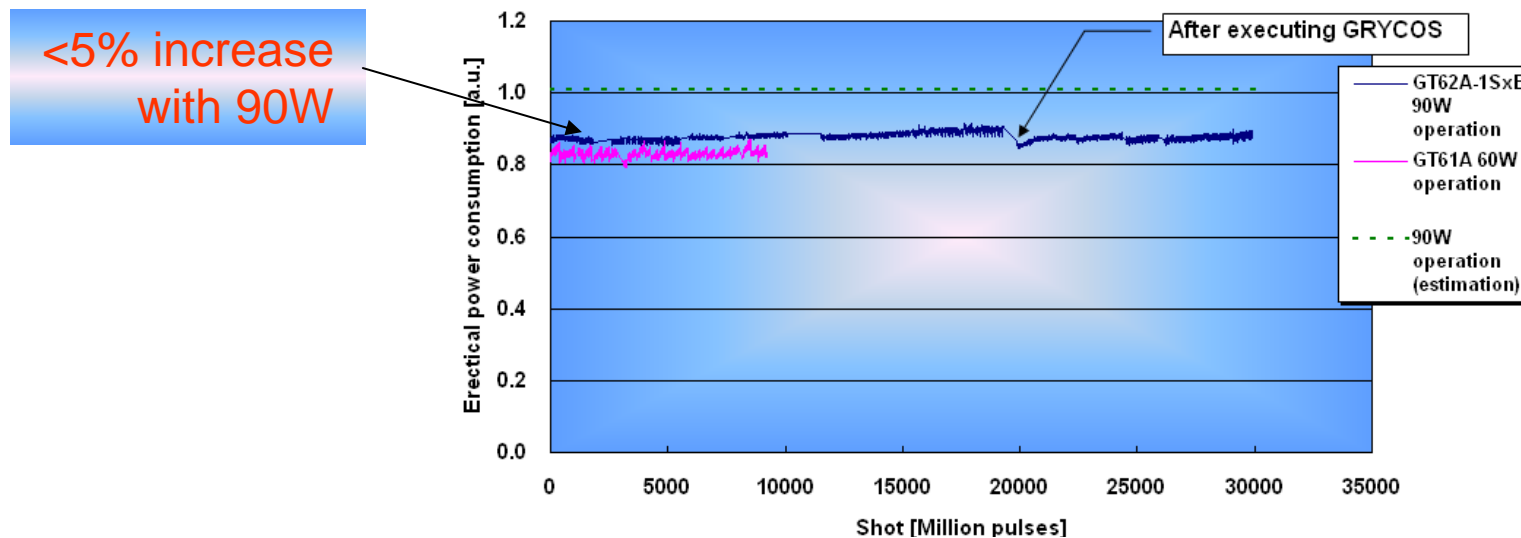
### ➤ Electrical power consumption

✓ GT laser with the injection-lock system achieved 90W operation with less than 5% percent increase in electric power consumption compared to 60W operation.

### ✓ Estimation

- 90W operation is typically estimated to consume 20% more electric power than that of 60W (MOPA).

*Gigaphoton experiment on Injection Lock and MOPA system*

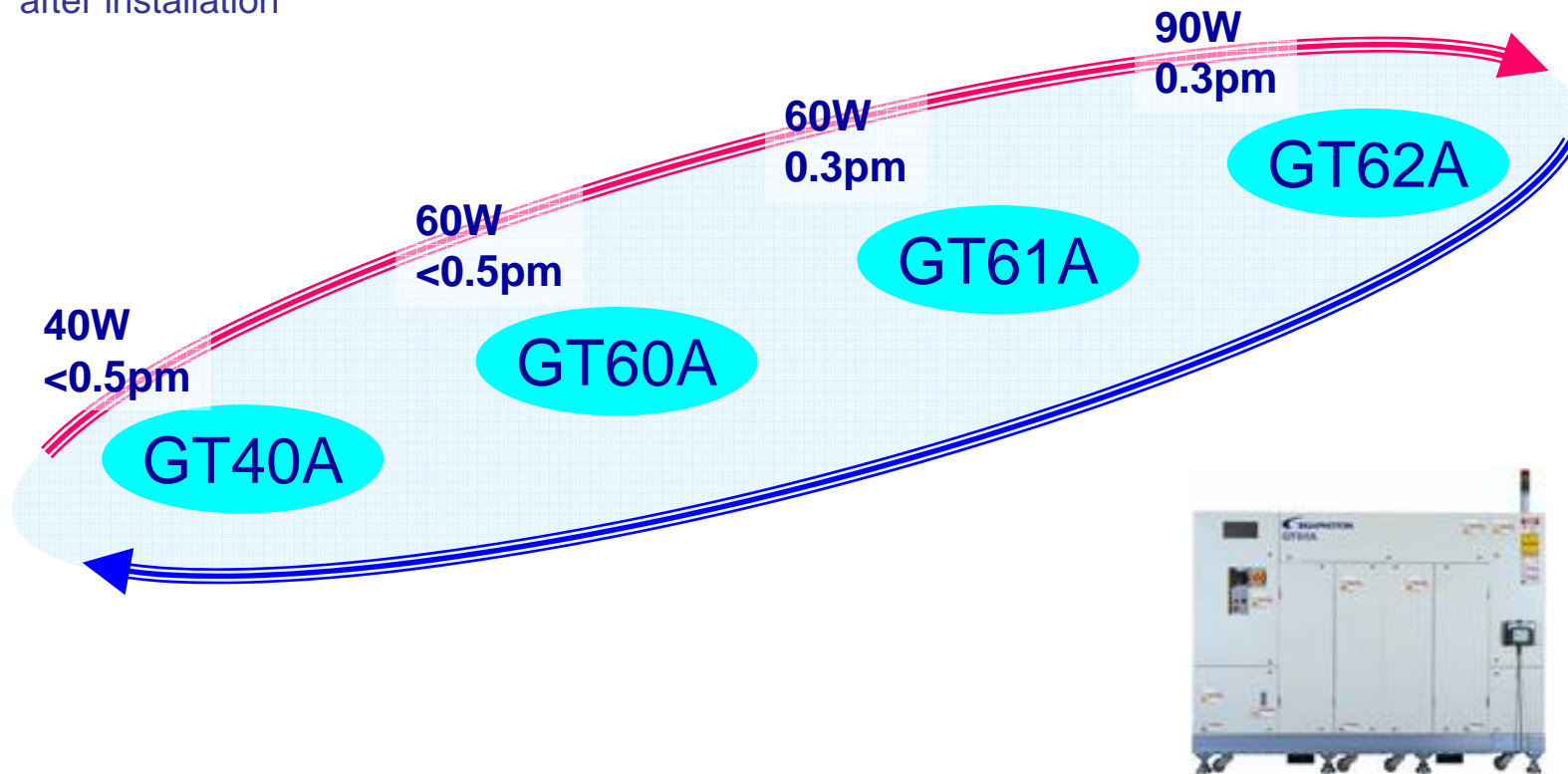


\*Condition : Result of the test in Gigaphoton

# Technology for CoD Reduction

## Giga Twin Platform

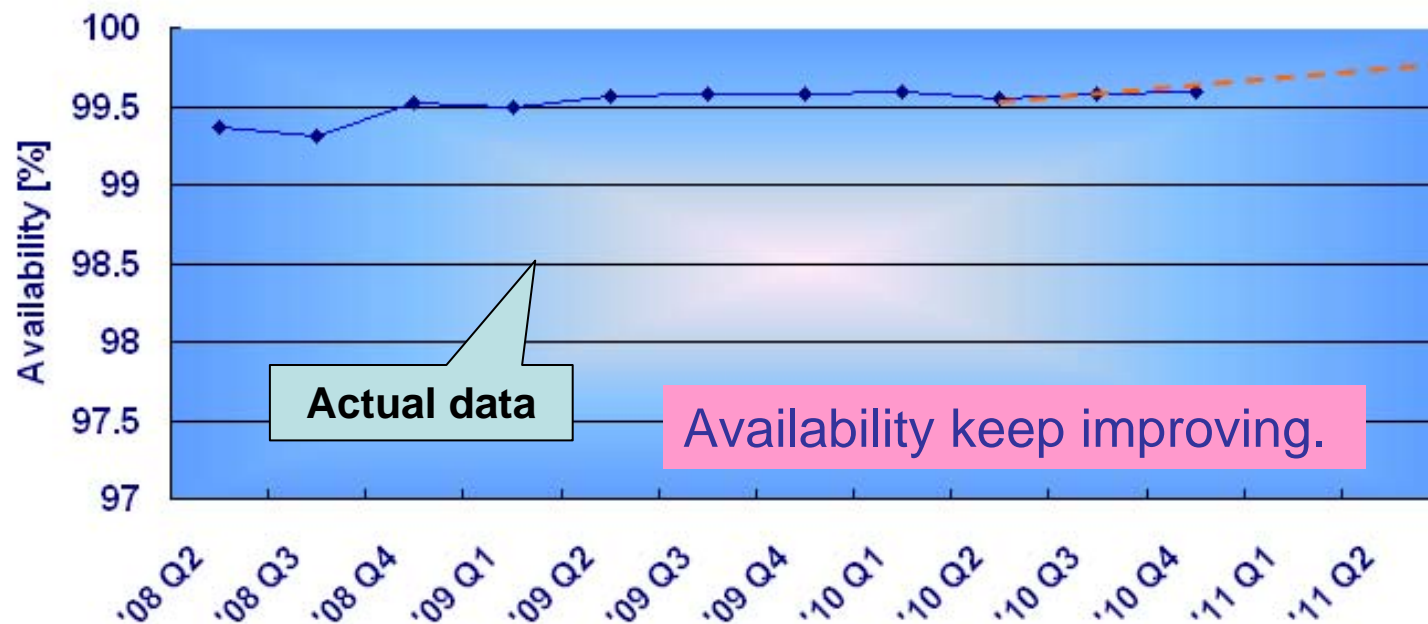
- Performance improvement
  - ✓ Develop new technology quickly
- Inherited Reliability
  - ✓ Smoothly introduced to a mass-production after installation



## Availability: CoD reduction

### ➤ Availability with GT platform

- ✓ GT62A-1SxE is build on reliability-proven GigaTwin platform.
- ✓ Availability >99.5%



$$\text{Availability} = \frac{[\text{Total Hour} - (\text{Scheduled Downtime} + \text{Unscheduled Downtime})]}{[\text{Total Hour}]}$$



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## Conclusion

- **Gigaphoton has developed a laser matching the lithography tool of the double patterning with consideration for the ecology.**
  - ✓ Optimized illumination power for various resist sensitive.
  - ✓ Enhanced CD variation at all power range.
  - ✓ Enhanced Overlay improves litho system.
  
- **We have confirmed the latest laser performance: GT62A-1SxE has high durability based on 'Eco-photon' concept.**
  - ✓ CoE: Gas consumption and electrical power consumption was improved.
  - ✓ CoC: High durability was proved with durability test.
  - ✓ CoD: The availability was proven in the field with GT Platform.
    - **CoO reduction can be achieved under EcoPhoton.**

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.

Thank you for your attention !

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