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# Reliable High Power Injection Locked 6kHz 60W Laser for ArF Immersion Lithography

Hidenori Watanabe, Shigeo Komae, Satoshi Tanaka\*,  
Ryoichi Nohdomi, Taku Yamazaki, Hiroaki Nakarai,  
Junichi Fujimoto, Takashi Matsunaga\*\*,  
Takashi Saito, Kouji Kakizaki\* and Hakaru Mizoguchi

Gigaphoton Inc., Ushio Inc.\*, Komatsu Ltd.\*\*  
E-mail: [hidenori\\_watanabe@gigaphoton.com](mailto:hidenori_watanabe@gigaphoton.com)

# Introduction

Reliable high power 193nm ArF light source is desired for the successive growth of ArF-immersion technology.

In 2006, Gigaphoton released high power injection locked GT60A, 6kHz/60W/0.5pm (E95) laser system, to meet the demands of semiconductor markets.

In this poster, we report

1. Key technologies for reliable mass production GT laser systems
2. GT60A high durability performance test results up to 20 billion pulses

# Technology nodes and required performance for ArF light sources

Technology Node (typical)	Main driver	Requirement for ArF Laser light source
32 nm	Double patterning Double exposure Higher throughput	6kHz/90W/0.35pm(E95)
45 nm	Higher NA	6kHz/60W/0.35pm(E95)
50 nm	Higher throughput Higher NA	6kHz/60W/0.50pm(E95)
65 nm	Higher throughput	4kHz/45W/0.50pm(E95)

Higher laser power  
Narrower spectral bandwidth

-> Higher throughput  
-> Higher NA

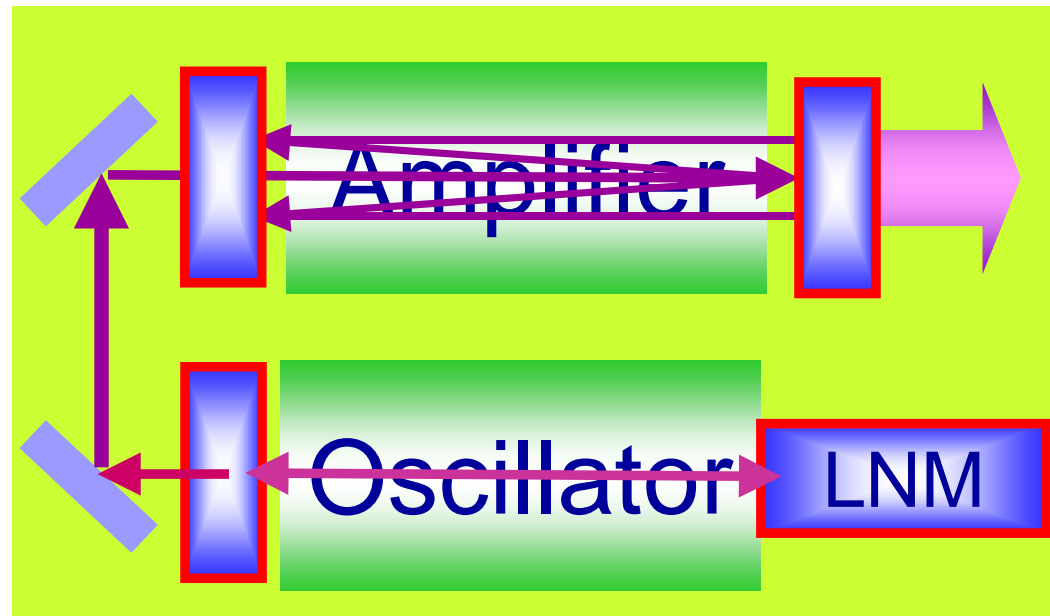
# Key technologies for reliable mass production GT laser systems

# Introduced technologies for GT models

Requirement for ArF Laser light source	Model	Introduced technologies	Platform
6kHz/60W/0.35pm(E95)	GT61A	High resolution LNM	GT common platform
6kHz/60W/0.50pm(E95)	GT60A	Strong acoustic wave damper Improvement of gas flow Higher power supply	
4kHz/45W/0.50pm(E95)	GT40A	Injection lock system	
4kHz/20W/0.75pm(E95)	G42A	G-electrode	G42A platform

All GT systems are integrated on a common and already proven GT platform

# Gigaphoton Injection lock laser system



## Merits

High efficiency  
Narrow spectral bandwidth  
Wide tolerance of synchronization timing  
Very small seed light energy  
Long pulse duration

## Benefits

-> Easy to get higher power  
-> Easy to get narrower spectrum  
-> Better stability and 2-charger system  
-> Low CoO from low optical load  
-> Low CoO from low optical load

# Major specifications of GT models

ArF model		GT40A	GT60A	GT61A
Wavelength	nm	193	193	193
Power	W	45	60	60
Pulse energy	mJ	11.25	10	10
Max. rep rate	Hz	4000	6000	6000
FWHM	pm	0.2	0.2	N.A
E95	pm	0.5	0.5	0.35
Electrical consumption	kVA	50	56	59
<b>Durability (Expected)</b>				
OSC Chamber	Bpls	13	13	20
AMP Chamber	Bpls	19	19	30
MM	Bpls	30	30	30
FM / AMP FM	Bpls	12	12	12
AMP RM	Bpls	12	12	12

# GT60A high durability performance test results up to 20 billion pulses



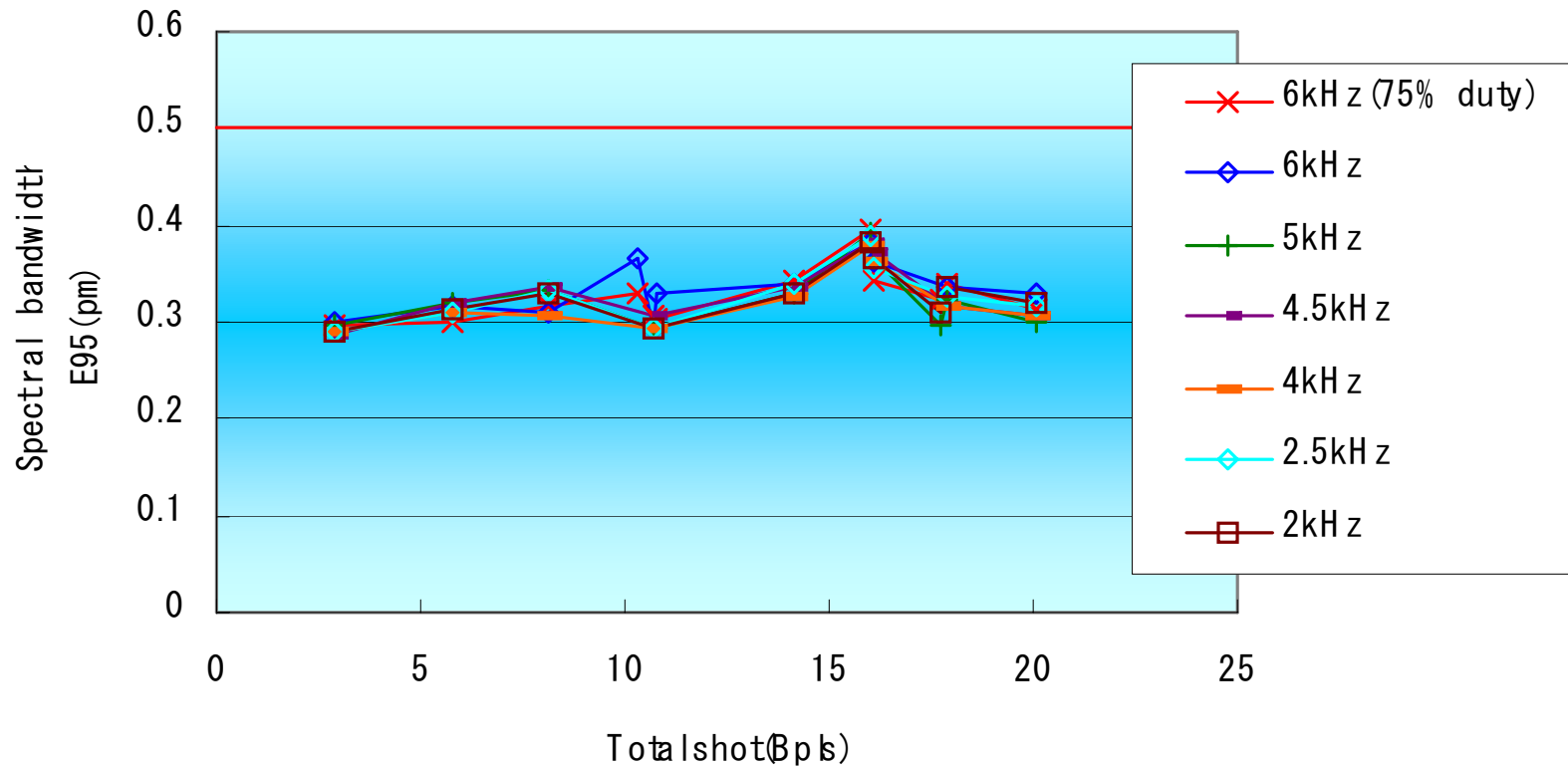
# Main durability test conditions

Pulse energy	10mJ
Repetition	6kHz
Duty cycle	75%

(maximum duty of GT60A)

- Durability Data -

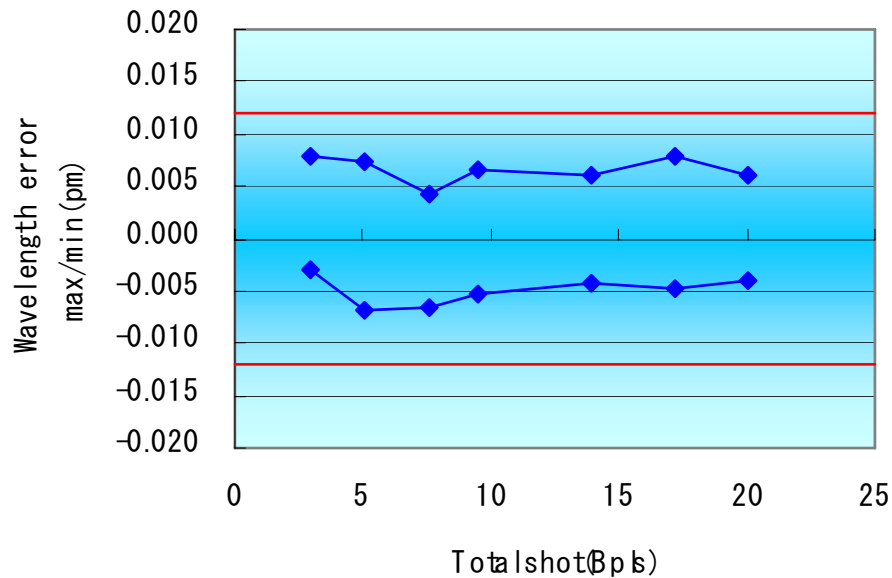
# Spectral bandwidth without bandwidth control



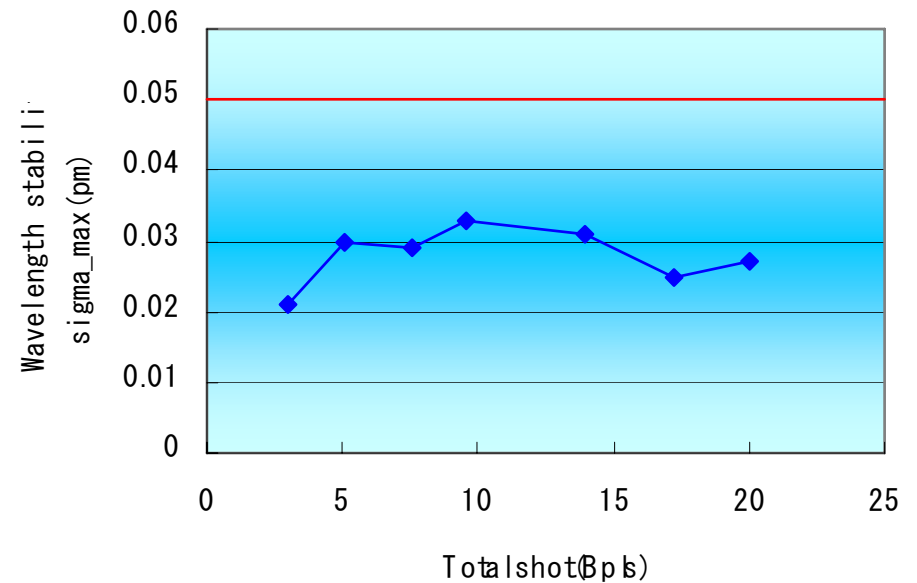
Narrow and stable spectral bandwidth until 20 Bpls  
 - Injection lock laser system

# Wavelength stability

## Wavelength error



## Wavelength sigma

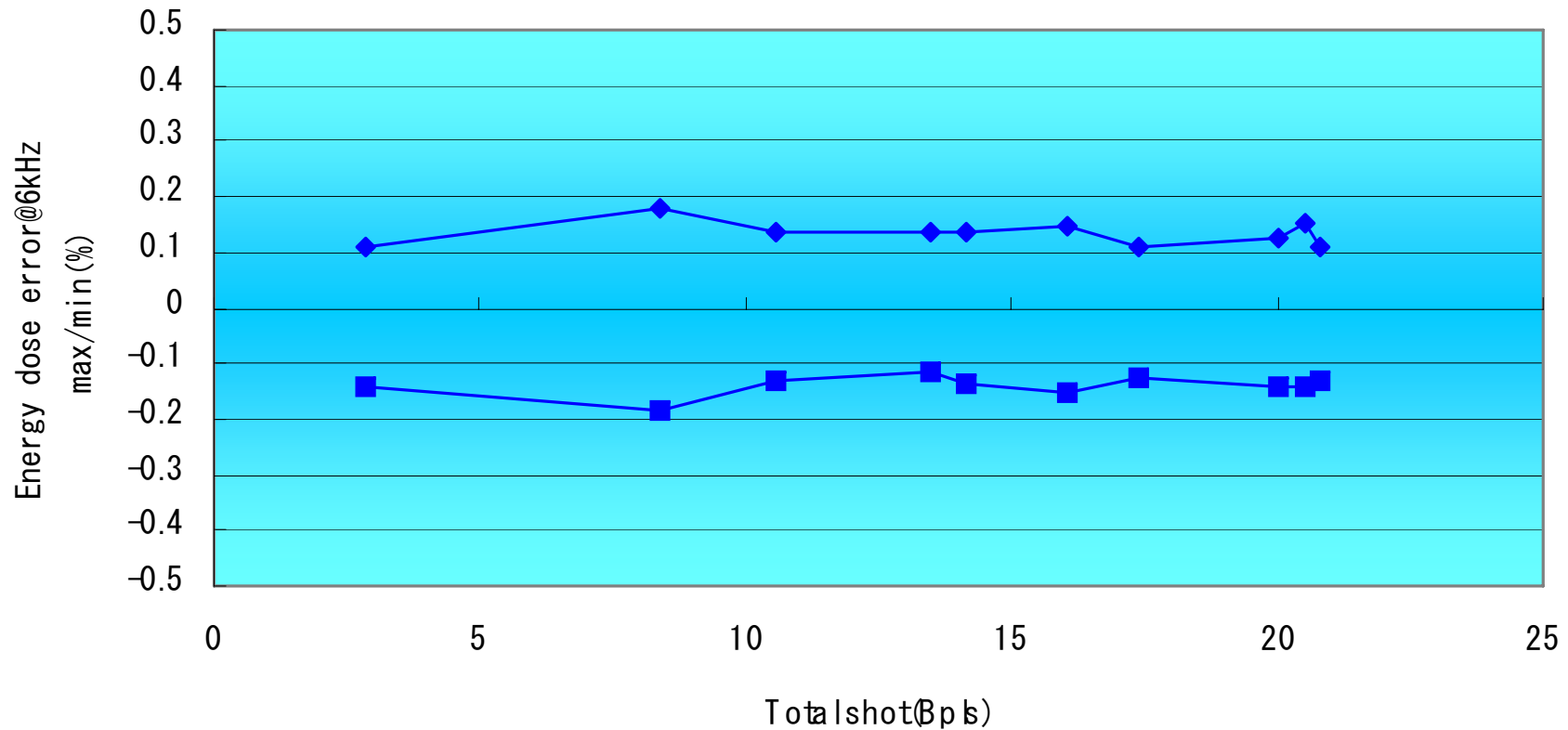


Stable wavelength stability until 20 Bpls

- Highly accurate control
- Low vibration of discharge chamber

- Durability Data -

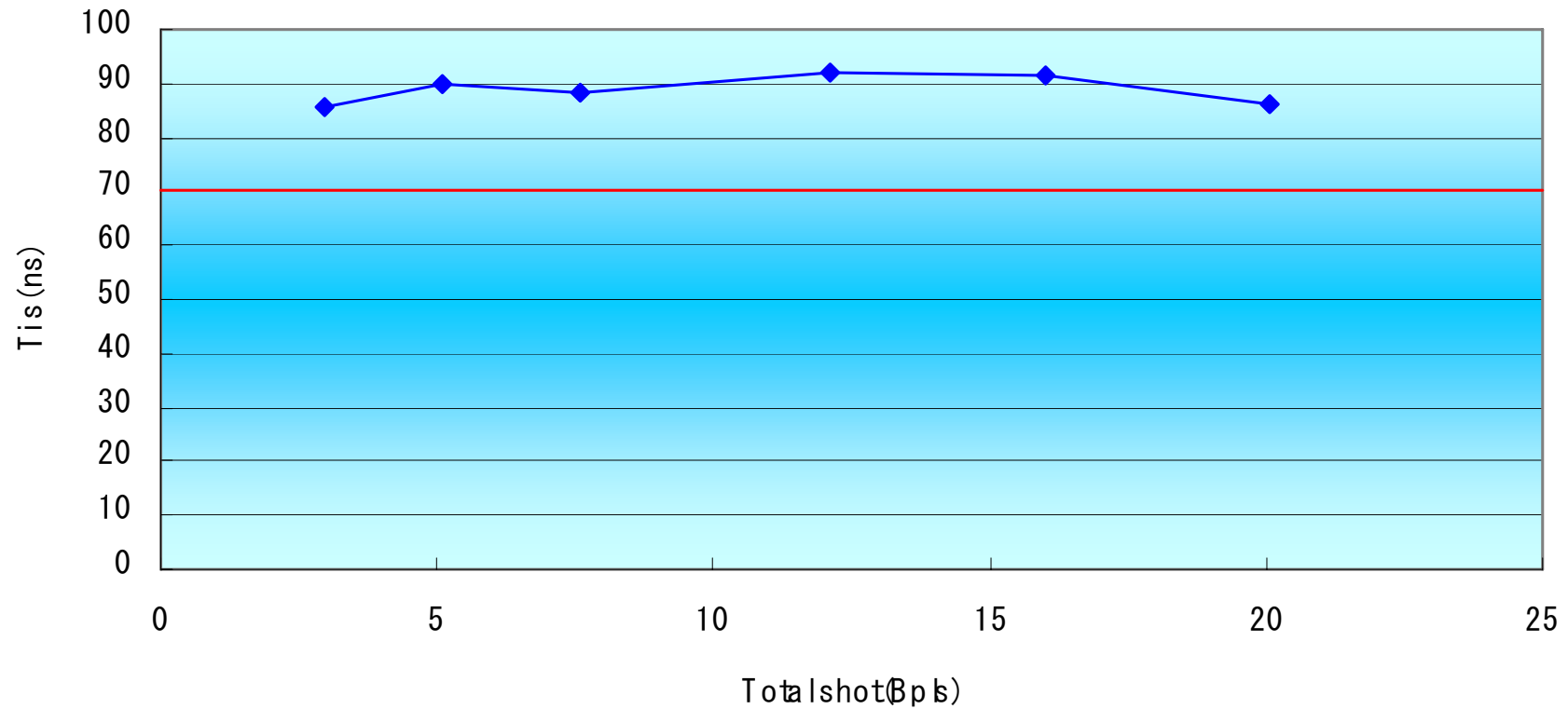
# Does stability



Stable dose stability until 20 Bpls

- Stable Discharge
- Injection lock laser system

# Pulse duration

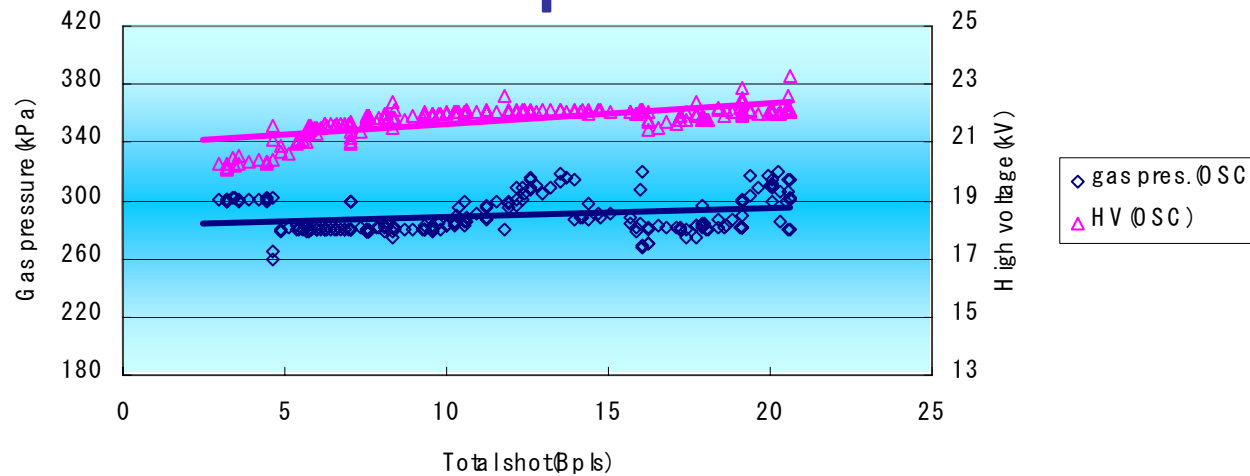


Long and stable pulse duration until 20 Bpls

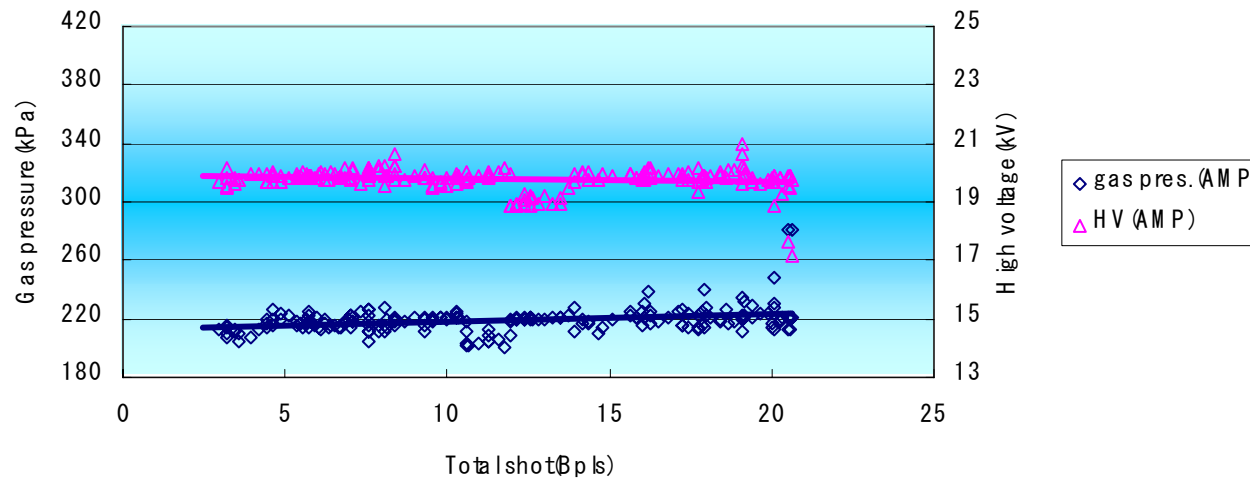
- Durability Data -

# Gas pressure and operation voltage

**OSC chamber**



**AMP chamber**



No drastic changes were observed until 20 Bpls.

# Summary

Gigaphoton has released GT60A, high power injection locked 6kHz/60W/0.5pm(E95) laser system, to meet the demands of semiconductor markets.

Performances were confirmed to be very stable up to 20 billion pulses.

- Spectral bandwidth
- Wavelength stability
- Dose stability
- Pulse duration

GT60A has demonstrated higher reliability inherited from common GT40A platform.

# Acknowledgement

This development is based on F2 laser research performed under the management of Association of Super-advanced Electronics Technologies (ASET) in the Ministry of Economy Trade and Industry (METI) program of "F2 laser lithography technology" supported by New Energy and industrial technology Development Organization (NEDO) in JAPAN.





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