

# High Power Injection Lock Laser Platform for ArF Immersion Lithography

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*GT development project*

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## ABSTRACT

Gigaphoton demonstrated in 1998 a 30W, 0.12pm line narrowed 157nm light source for microlithography with injection lock technology. Based on this technology, a high power laser platform for 193nm lithography has now successfully been developed. The **“Injection Lock”** technology of the new platform shows better performance than a MOPA laser system, i.e. it enables higher efficiency, higher stability and better spectral performance.

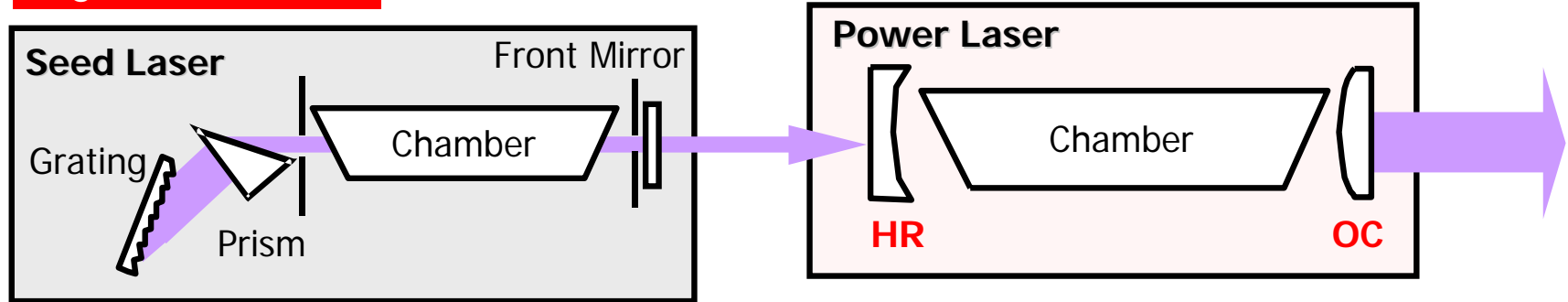
Gigaphoton will release a **60W (4000Hz, 15mJ)** high power injection lock ArF laser platform named GT40A at **4Q 2004**.

The new platform GT40A has been especially designed for dry and for ArF immersion lithography.

We present a comparison between Injection Lock and MOPA systems and introduce GT40A, the newly developed high power “Injection Lock” laser platform.

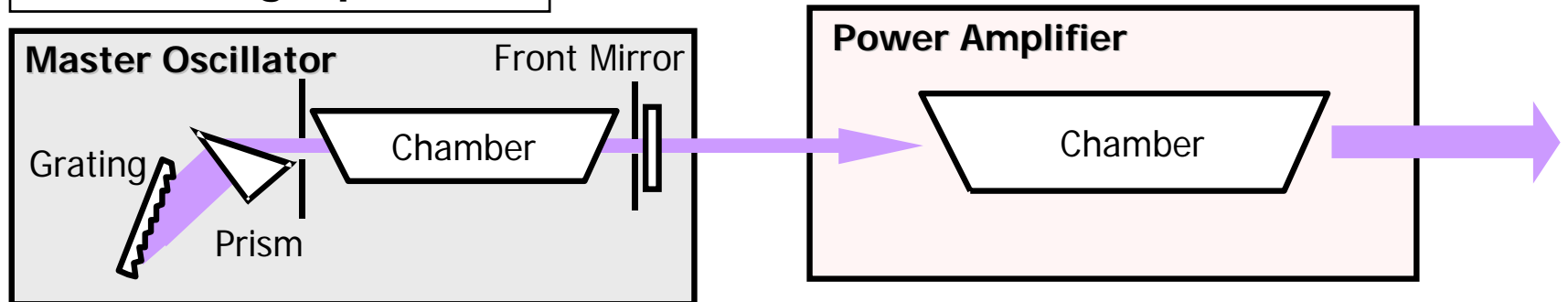
## Comparison of Injection Lock and MOPA system

### Injection Lock

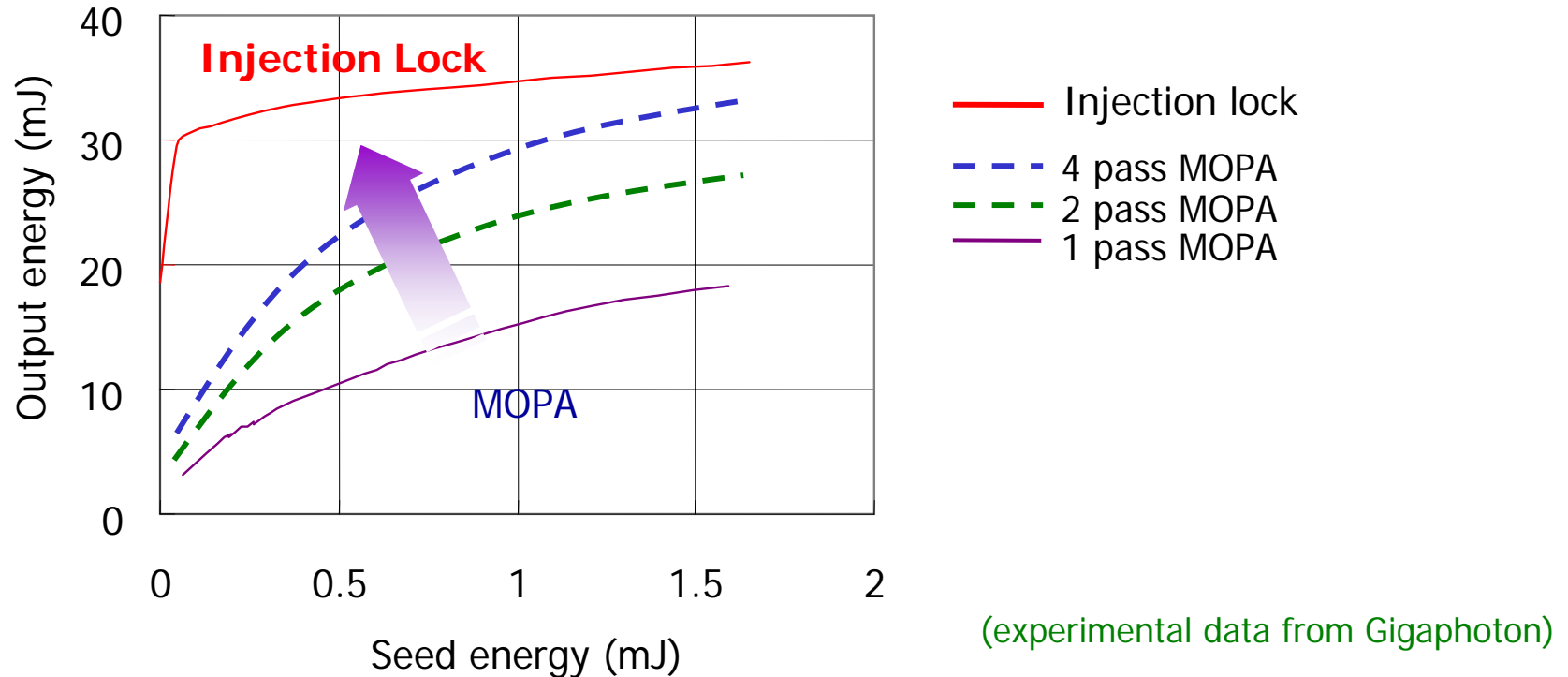


➤ Injection Lock system provides resonator to AMP -enabling high efficiency and high stability performance.

### MOPA (single pass )



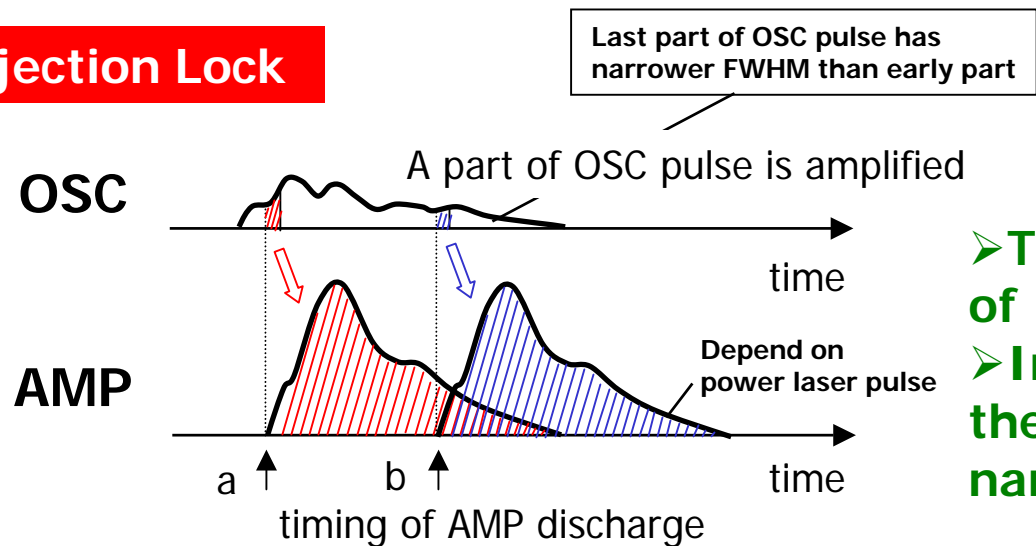
## Characteristic of Injection Lock (Energy efficiency)



➤ **Injection Lock system enabled higher power at lower OSC energy compared to MOPA.**

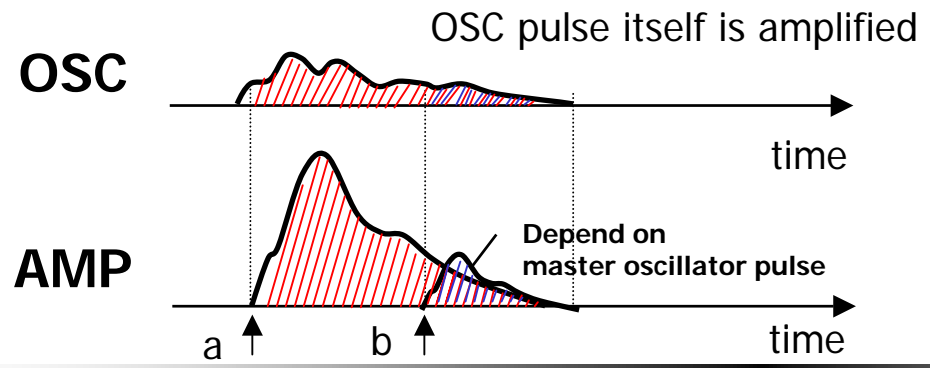
# Characteristic of Injection Lock (Timing control)

## Injection Lock



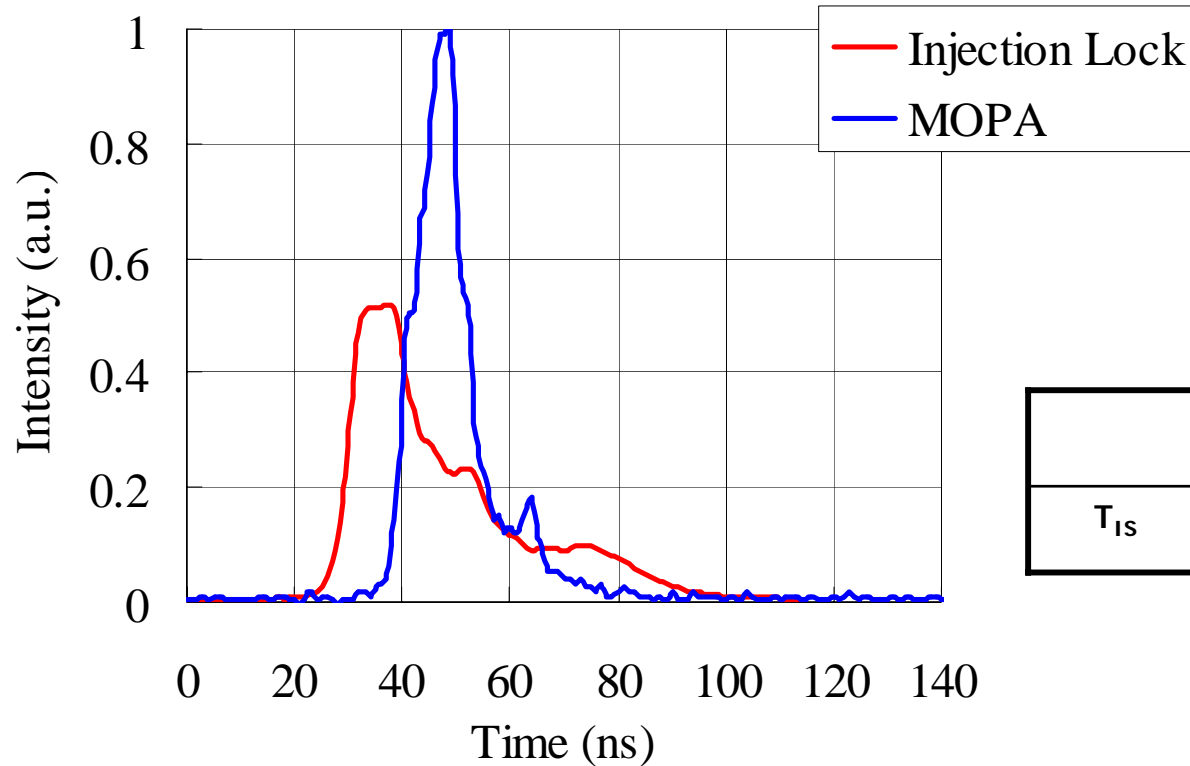
- Tolerance of timing control of Injection Lock is large.
- Injection Lock system has the potential of spectral line narrowing.

## MOPA



- Tolerance of timing control of MOPA system is small.

## Characteristic of Injection Lock (Pulse duration)

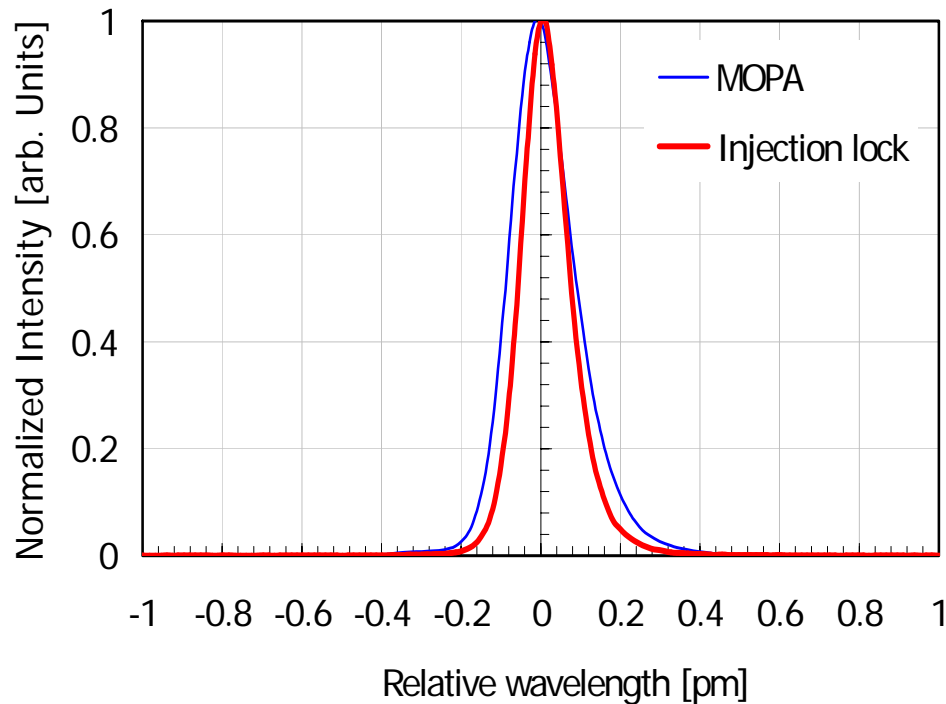


	Injection Lock	MOPA
$T_{Is}$	43 ns	21 ns

➤ Injection Lock system has a longer pulse duration than MOPA system without optical pulse stretcher.

## Characteristic of I/L system (Spectral profile)

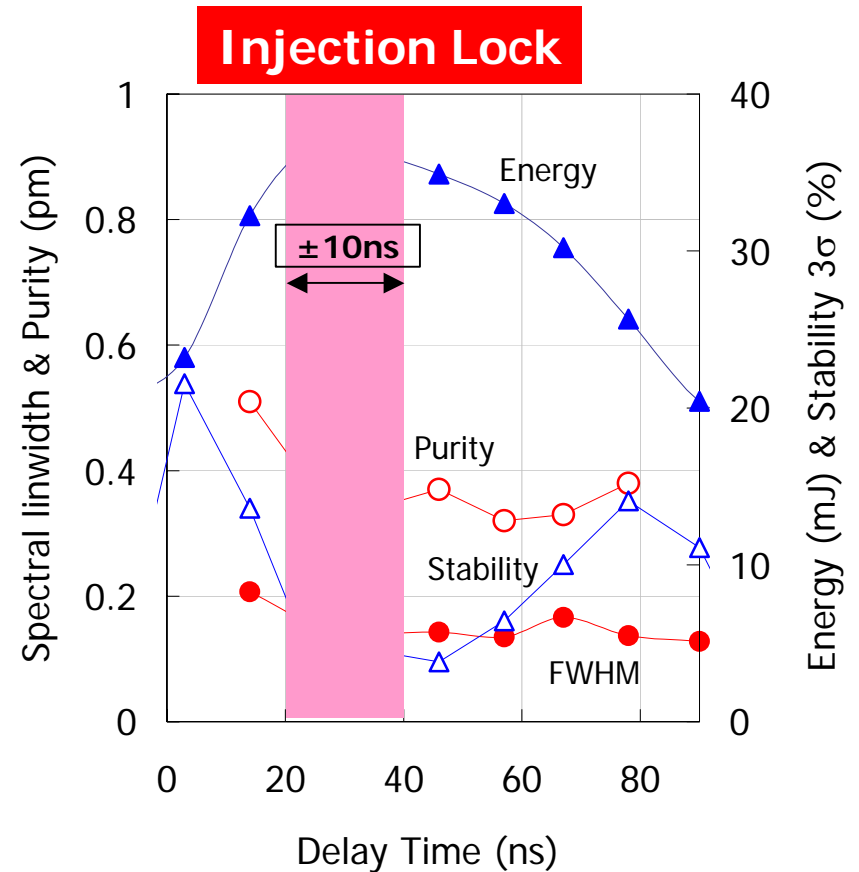
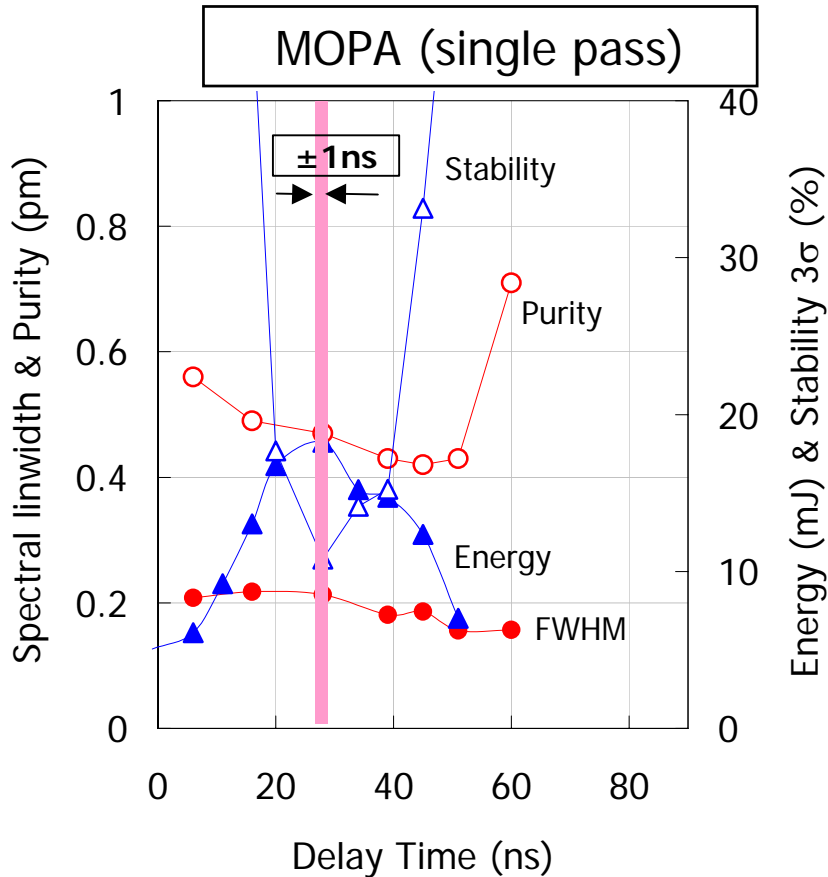
Typical Spectrum Profile of MOPA & Injection Lock



	Line Width in FWHM	Purity in E95%
MOPA	0.21 pm	0.47 pm
Injection Lock	0.13 pm	0.32 pm

- Injection Lock has narrower line width than MOPA.
- Injection Lock system has the potential of spectral line narrowing.

# Characteristic of Injection Lock (Synchronization)



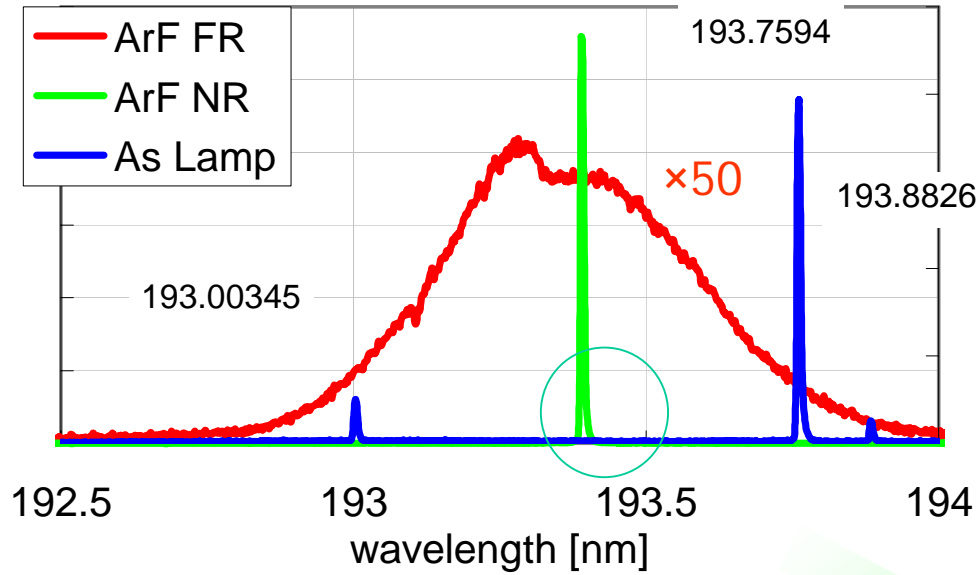
➤ Injection Lock has larger synchronization tolerance than MOPA.

## Characteristics of Gigaphoton Injection Lock System

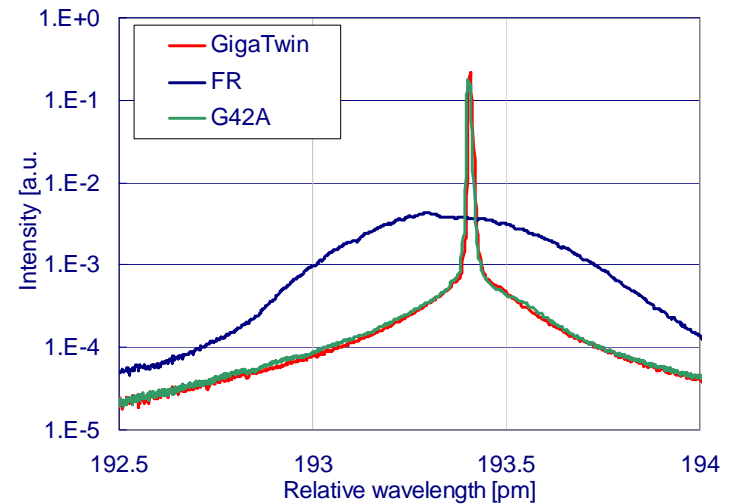
Status at 2004	Injection Lock	Conventional ( MOPA )
Efficiency	100 ☺	70 ☹
Energy stability	☺	☹
Spectrum (Bandwidth)	☺	☹
Spectrum (ASE)	☹ → ☺	☹
Coherence	☹ → ☺	☹
Synchronization	☺ +/- 10ns	☹ → ☺ +/- 2ns
Judge	Injection lock technology revives with new breakthrough technologies	Solved critical synchronization issue.

Injection Lock technology enters the lithography market with technical innovations ⇒ GT40A

# Low ASE (Amplified Spontaneous Emission) (1)

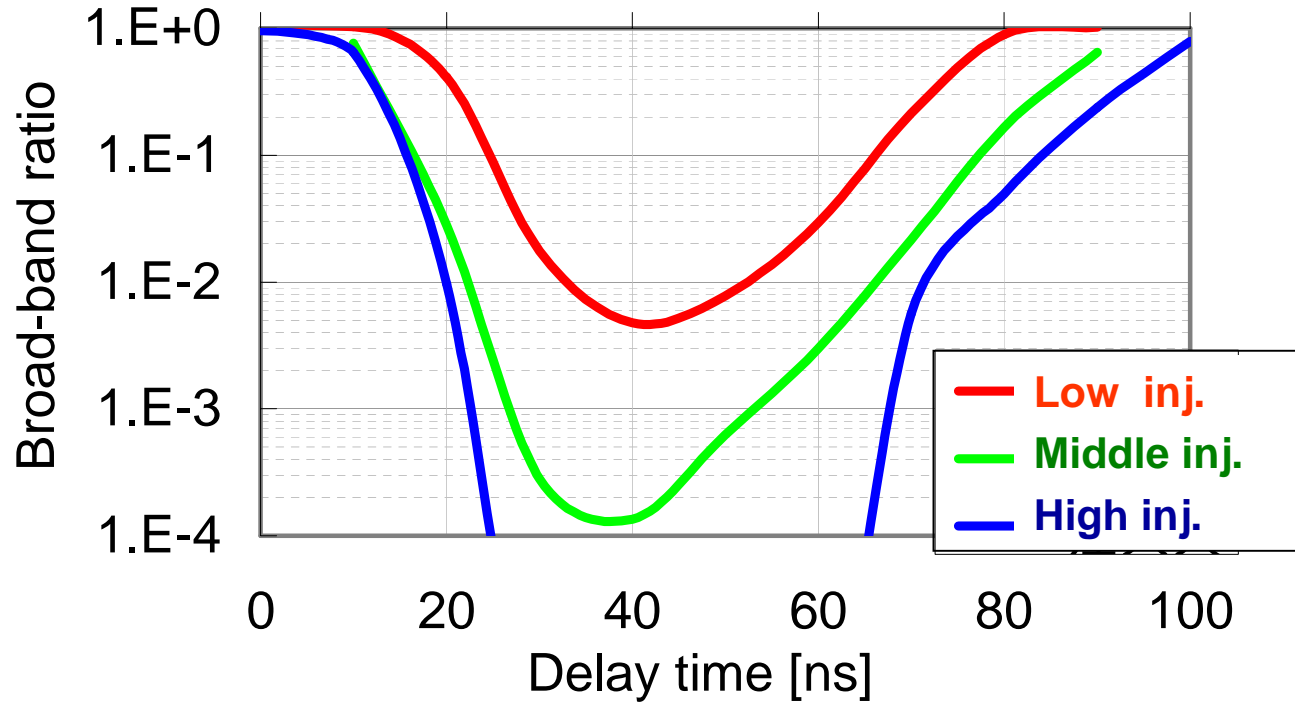


**Gigaphoton Original**



## Low ASE (2)

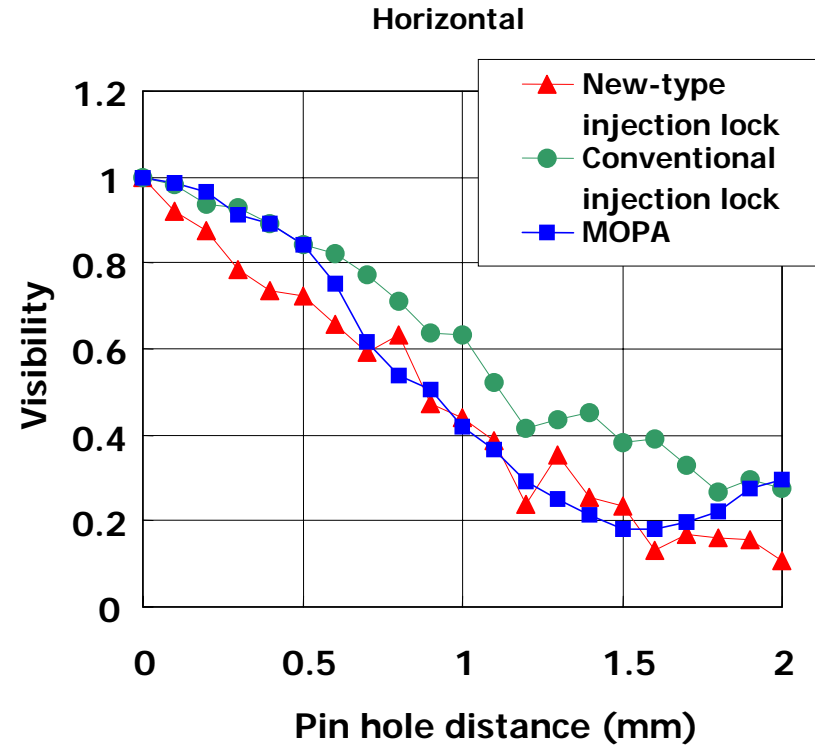
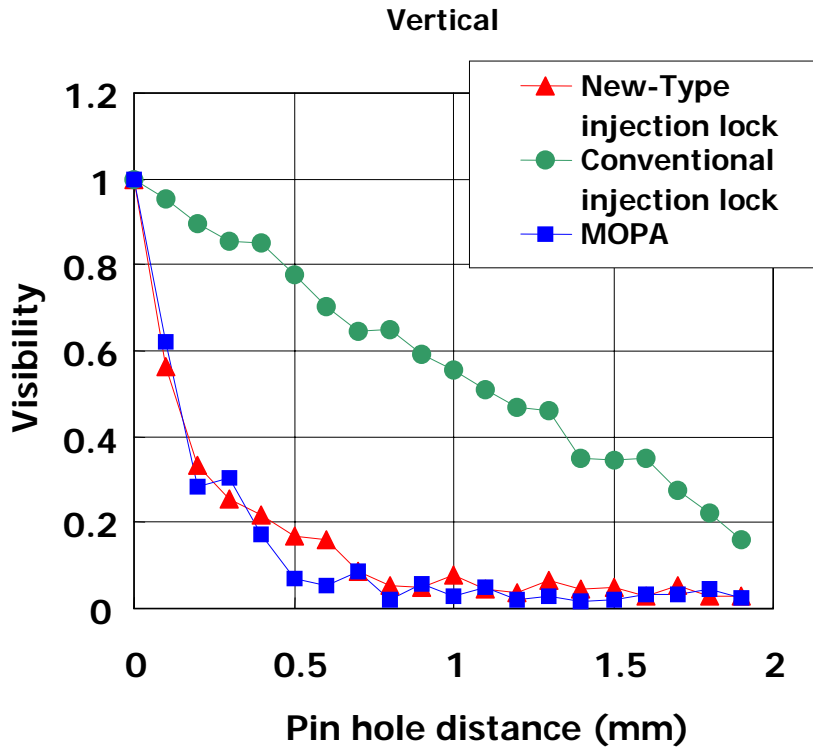
Gigaphoton Original



➤ Optimization of seeding enables low ASE (Broad-band ratio) within large time range.

# New-Type Injection Lock Technology

**Gigaphoton Original**



- New-type injection lock system has a very low broadband emission level preventing deterioration of exposure tool projection lens resolution.
- This technology solves the coherence issue.

## Design Concept of GT40A (ArF/60W)

- **Stable & Easy operation**

- Injection Lock guarantees easy operation with a wide and stable operation range. These advantages allow Stable & Easy operation.

- **Low CoO & Easy maintenance**

- High efficiency guarantees wide margins for key components, i.e. guarantees long lifetimes for key components.
- Separate operation of 2-chamber design minimizes MTTR and maintenance cost.

- **Reliability**

- Gigaphoton's durability technology supports reliable GigaTwin laser system.

# Specification of GT40A

- 65-50nm Design Rule
- 60W High power & Narrow Spectral Bandwidth



- Outlook of GT40A proto laser-

Size L2800 x W820 x H2050mm

Item	Performance
Max. Rep. Rate	4000Hz
Pulse Energy	15mJ
Max. Output Power	60W
Bandwidth (FWHM)	0.20pm
Purity (E95)	0.50pm
Availability	Q4, 2004
Chamber Life	12Bpls
LNM Life	20Bpls
MM Life	30Bpls
FM Life	30Bpls

## Conclusion

1. Injection lock system was compared with MOPA system.
  - Injection Lock has higher efficiency, higher stability and better spectral performance.
  - Gigaphoton original new cavity technologies solve coherence and ASE issues of Injection Lock system.
  - Injection Lock has potential of spectral line narrowing for ArF immersion.
2. High Power & line-narrowed "Injection Lock" ArF Laser System GT40A for Microlithography has been developed.
  - Output power of 60W at 4000 kHz repetition rate has been realized.
  - Line width below 0.20pm and E95% below 0.5 pm has been realized.
3. GT40A will be released to the market in 4Q 2004.