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

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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

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

**Higher laser power**  
**Narrower spectral bandwidth**  
-> **Higher throughput**  
-> **Higher NA**
Key technologies for reliable mass production
GT laser systems
### Introduced technologies for GT models

<table>
<thead>
<tr>
<th>Requirement for ArF Laser light source</th>
<th>Model</th>
<th>Introduced technologies</th>
<th>Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>6kHz/60W/0.35pm(E95)</td>
<td>GT61A</td>
<td>High resolution LNM</td>
<td></td>
</tr>
</tbody>
</table>
| 6kHz/60W/0.50pm(E95)                   | GT60A | Strong acoustic wave damper  
                                Improvement of gas flow                  
                                Higher power supply                      | GT common platform                       |
| 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

<table>
<thead>
<tr>
<th>ArF model</th>
<th>GT40A</th>
<th>GT60A</th>
<th>GT61A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength (nm)</td>
<td>193</td>
<td>193</td>
<td>193</td>
</tr>
<tr>
<td>Power (W)</td>
<td>45</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Pulse energy (mJ)</td>
<td>11.25</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Max. rep rate (Hz)</td>
<td>4000</td>
<td>6000</td>
<td>6000</td>
</tr>
<tr>
<td>FWHM (pm)</td>
<td>0.2</td>
<td>0.2</td>
<td>N.A.</td>
</tr>
<tr>
<td>E95 (pm)</td>
<td>0.5</td>
<td>0.5</td>
<td>0.35</td>
</tr>
<tr>
<td>Electrical consumption (kVA)</td>
<td>50</td>
<td>56</td>
<td>59</td>
</tr>
<tr>
<td>Durability (Expected)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSC Chamber (Bpls)</td>
<td>13</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>AMP Chamber (Bpls)</td>
<td>19</td>
<td>19</td>
<td>30</td>
</tr>
<tr>
<td>MM (Bpls)</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>FM / AMP FM (Bpls)</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>AMP RM (Bpls)</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>
GT60A high durability performance test results up to 20 billion pulses
- Durability Data -

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 Bpl.s

- Injection lock laser system
Wavelength stability

Stable wavelength stability until 20 BplS
- Highly accurate control
- Low vibration of discharge chamber
Does stability

Stable dose stability until 20 BplS
- Stable Discharge
- Injection lock laser system
Long and stable pulse duration until 20 Bpls
- Durability Data -

Gas pressure and operation voltage

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.