Performance of Bandwidth Tuning Laser for Focus Drilling

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Gigaphoton Inc.
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  - Tuning range
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  - Spectrum Stability

- Influence to other Key Performances
  - BP/BD/Pointing/Energy stability

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# ArF Model & Specifications

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<td>65 nm</td>
<td>GT40A</td>
<td>higher throughput</td>
<td>45</td>
<td>11.25</td>
<td>4000</td>
<td>&lt;0.5</td>
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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

Laser spectra broadening

DOF enhancement

Chromatic aberrations

Focus shift
Simulation of DOF by bandwidth tuning

- **DOF can be expanded by tuning spectrum bandwidth**

![Graph showing normalized intensity and exposure latitude vs. relative wavelength and depth of focus for different bandwidths.]
Configuration for the function

- **Bandwidth tuning**
  - Newly developed LNM is implemented

- **Metrology and Control**
  - Existing hardware can be useful
  - No need to upgrade
# Upgradability

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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

- Convoluted 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**

- **E95: 0.3 pm**
- **CBW: 0.7 pm**
- **CBW: 1.0 pm**
- **CBW: 1.7 pm**

*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

![Graph of CBW setpoint vs. measured CBW by external spectrometer]

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

* Performance were measured using 3 different LNM
Spectrum stability (short term)

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

* Measured external spectrometer
Spectrum stability (middle term: Gas Life)

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

* Measured external spectrometer
Bandwidth Tuning time

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

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

Bandwidth can be tuned within several seconds

- Low influence to Lithography throughput

* Tuning time were measured 5 times at each condition
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**Beam Profile stability**

- High stability of Beam Profile size
  - Stable illumination uniformity will be expected at any bandwidth
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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- 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.