EUVL Activities in China

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Activities only refer to published papers
OUTLINE

- **Overview of EUVL in China**
  - National Research Foundation
  - Research Organization

- **2014 Activities Update**
  - Source
  - Mask
  - Optical Design
  - Multilayers
  - Metrology
  - Contamination Control
  - Simulation
National Research Foundation

- **NSFC**: National Natural Science Foundation of China.
- **NBRC**: National Basic Research Program of China.
- **NSTMP**: National Science and Technology Major Project.
- **MOE**: Ministry of Education
Chinese Academy of Sciences:

- CIOMP
- SIOM
- IMECAS
- AOE

Universities:

- BIT
- HIT
- TJU
- HUST
2014 Activities Update

✓ Source
✓ Mask
✓ Optical Design
✓ Multilayers
✓ Metrology
✓ Contamination Control
✓ Simulation
Spectral Efficiency of EUV Emission from CO\(_2\) Laser-Produced Tin Plasma

Activities in Huazhong University of Science and Tech
Ref. Plasma Science and Technology, 2013
Supported by NSFC...
Emission properties of Tin droplets LPP sources

10.6um CO2 923mj 70ns

1064nm Nd:YAG 233.8mj 8.4ns

Activities in Huazhong University of Science and Tech

Supported by NSFC & NSTMP
Influence of Pre-pulse Power on Xe Capillary Discharge EUV Source

Activities in Harbin Institute of Technology (HIT)

"Ref. Plasma Science and Technology, 2013

Supported by NSFC&NSTMP
Activities in SIOM

“Modulation of the Langmuir Oscillation on the plasma radiation by Rabi oscillation ”
Ref. EUVL workshop, 2014

“EUV Radiation Characteristics of Xe Cluster Ensemble Irradiated by Nanosecond and Femtosecond Lasers ”
Ref. EUVL workshop, 2014
2. Mask

Integrated Development of EUVL Mask at 32nm node

Mask CD < 100 nm
Mask CD Accuracy <20 nm

Activities in IMCAS

Supported by NSFC
3. Optical Design (New Requirements)

Design of High-NA Projection Objective

6M obscured objective NA0.5

Enable 11 nm

8M unobscured objective NA0.45

Activities in Beijing Institute of Technology (BIT)

10M obscured objective NA0.75

Supported by NSTMP & MOE

Design of EUV illuminator

<table>
<thead>
<tr>
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<th>90-degree dipole illumination</th>
<th>45-degree quadrupole illumination</th>
<th>Annular illumination</th>
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</thead>
<tbody>
<tr>
<td>Pupil facets</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
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<tr>
<td>Exit pupil</td>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
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</tbody>
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Illumination uniformity is better than 2.5%. Submitted to Appl. Opt.

Activities in (BIT) Supported by NSTMP & MOE

2014 Update (Basic Research)
“Reflective phase shift measurement of the Mo/Si multilayer mirror in extreme ultraviolet region”

This work gives the chance to characterize the phase shift of the EUV multilayer mirrors for EUVL.
2014 Activities Update

Activities in CIOMP

“A Novel Model for Coated System Analysis in Extreme Ultra-Violet Lithography ”

Ref. EUVL workshop, 2014

Activities in SIOM

“Simplified Model for Spectrum Simulation of Multilayer with Buried Defect in EUV Lithography ”

Ref. EUVL workshop, 2014
5. Metrology

Activities in (BIT)

Wavefront Metrology

Design of PS/PDI system for Visible EUV

PS/PDI system @632.8nm has completed!
- Absolute accuracy 5 nm rms
- Repeatability 0.55 nm rms

Supported by NSTMP & MOE

New progress
- Measurement objectives with different NA (0.2 ~ 0.4)
- Automatic calibration and measurement
2014 Activities Update

Activities in CIOMP

Visible PS/PDI Repeatability improved.

Repeatability: $1/4000 \lambda \text{ rms (}\lambda=632.8\text{nm})$

Activities in Institute of Optics and Electronics

“Calibration of the system error in pinhole diffracted interferometer”

PDI System error $0.009\lambda (\lambda = 632.8 \text{nm})$


Activities in SIOM

“Aberration measurement technique based on an analytical linear model of a through-focus aerial image”

Ref. Optics express, 2014

Lens aberration offset with an accuracy of 0.7 nm.

Supported by NSFC
6. Contamination Control

Activities in CIOMP


Supported by NSFC, NSTMP...
7. Simulation

Co-optimize the EUV Litho-tool, Process, and Mask to improve the pattern fidelity and the process window

22 nm L/S=1:1

Activities in (BIT) Supported by NSTMP
<table>
<thead>
<tr>
<th>Abbreviation</th>
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<tr>
<td>AOE</td>
<td>Academy of Opto-electronics</td>
</tr>
<tr>
<td>SIOM</td>
<td>Shanghai Institute of Optics and Fine Mechanics</td>
</tr>
<tr>
<td>CIOMP</td>
<td>Changchun Institute of Optics, Fine Mechanics and Physics</td>
</tr>
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More activities will be shown in the future!

Thank you for your attention!