2014 EUVL Workshop

EUVL Activities in China

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Activities only refer to published papers

June 25, 2014

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

Research Organization

Chinese Academy of Sciences:

CIOMP

SIOM

IMECAS

AOE

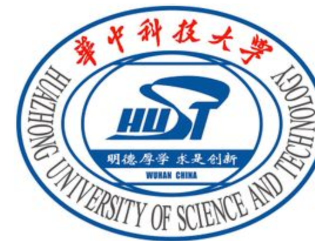
…

Universities:

BIT

HIT

TJU



HUST

…

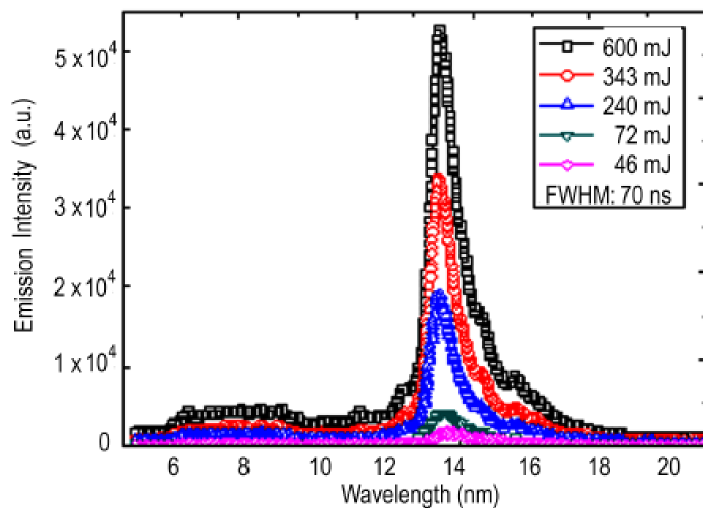
2014 Activities Update

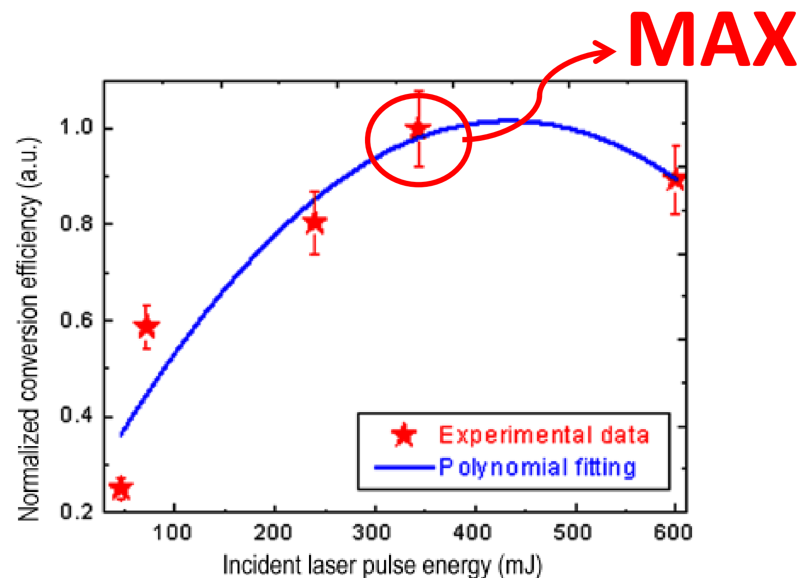
- ✓ Source
- ✓ Mask
- ✓ Optical Design
- ✓ Multilayers
- ✓ Metrology
- ✓ Contamination Control
- ✓ Simulation

2014 Activities Update

1. Source (Basic Research)

Spectral Efficiency of EUV Emission from CO_2 Laser-Produced Tin Plasma





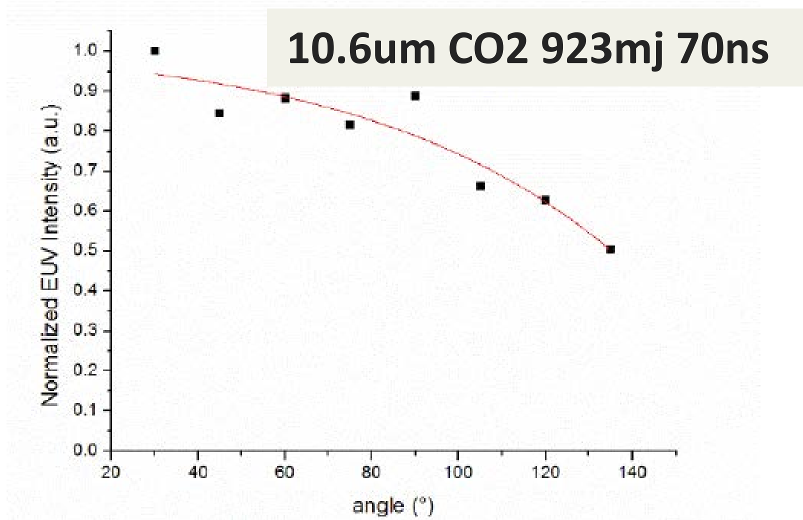
Activities in Huazhong University of Science and Tech

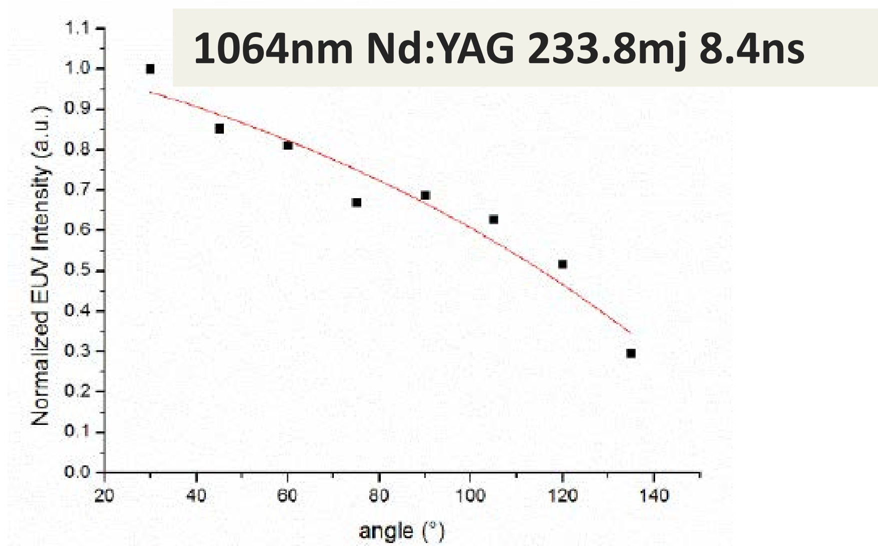
Ref. Plasma Science and Technology, 2013

Supported by NSFC…

2014 Activities Update

Emission properties of Tin droplets LPP sources





Activities in Huazhong University of Science and Tech

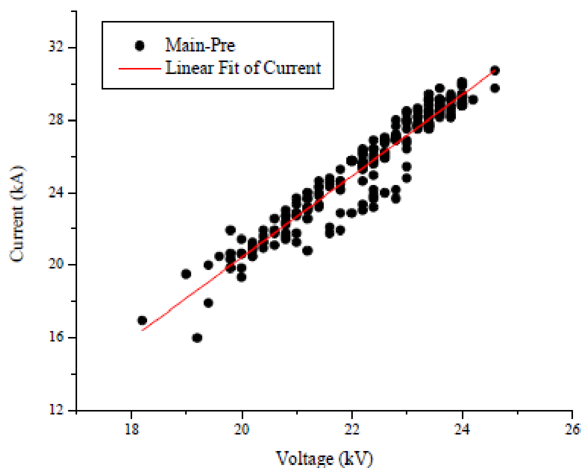
Ref.Proc.SPIE 90481V, 2014

Supported by NSFC & NSTMP

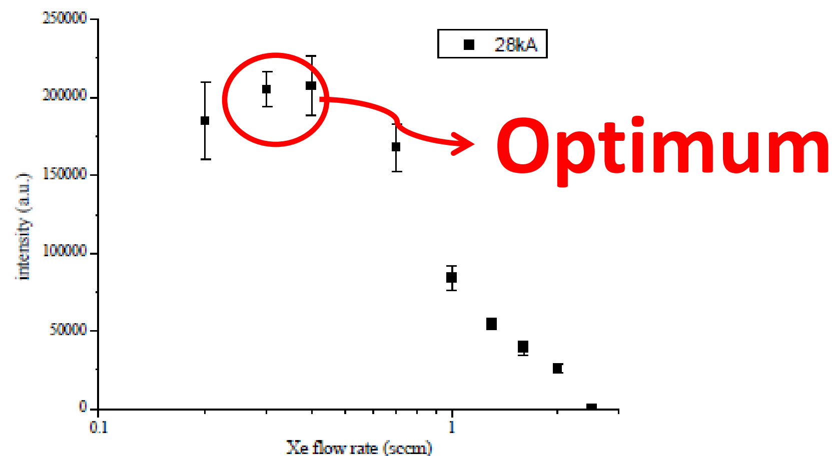
2014 Activities Update

Influence of Pre-pulse Power on Xe Capillary Discharge EUV Source

main-voltage and the current when discharging by the main-pre-pulse



13.5nm (2% bandwidth) emission and the flow rate of Xe



Activities in Harbin Institute of Technology (HIT)

"Ref. Plasma Science and Technology, 2013

Supported by NSFC&NSTMP

2014 Activities Update

Activities in SIOM

“Modulation of the Langmuir Oscillation on the plasma radiation by Rabi oscillation ”

Ref. EUVL workshop, 2014

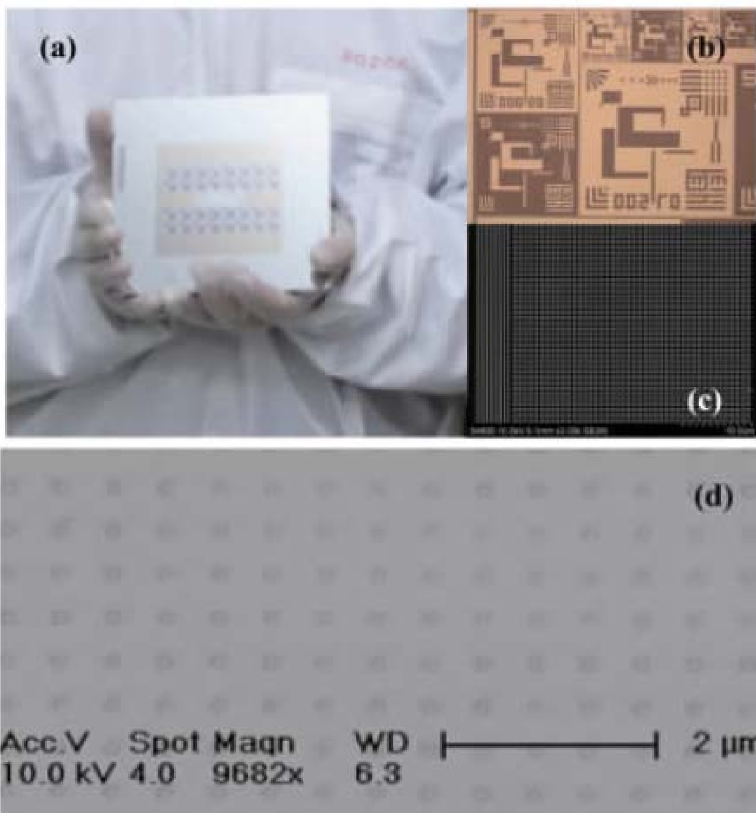
“EUV Radiation Characteristics of Xe Cluster Ensemble Irradiated by Nanosecond and Femtosecond Lasers ”

Ref. EUVL workshop, 2014

2014 Activities Update

2. Mask

Integrated Development of EUVL Mask at 32nm node



Mask CD < 100 nm
Mask CD Accuracy <20 nm

Activities in IMCAS

Ref. Acta. Optica Sinica, 2013

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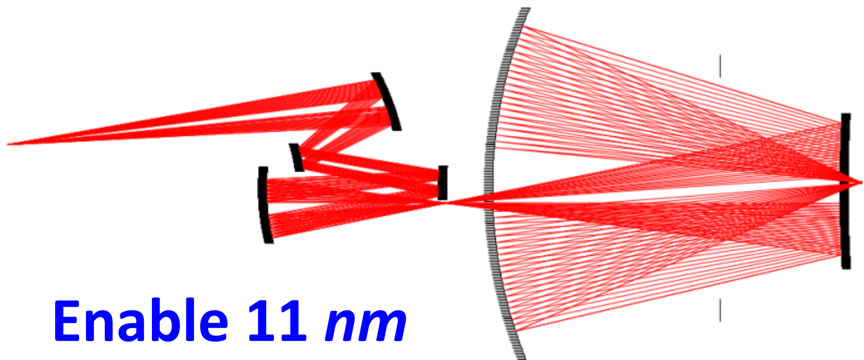
2014 Update (Basic Research)

3. Optical Design (New Requirements)

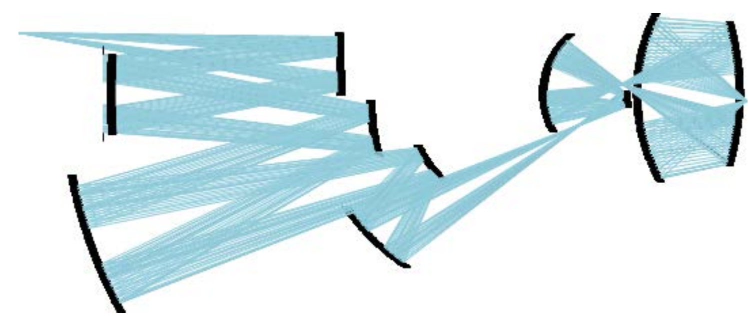
Design of High-NA Projection Objective

6M obscured objective **NA0.5**

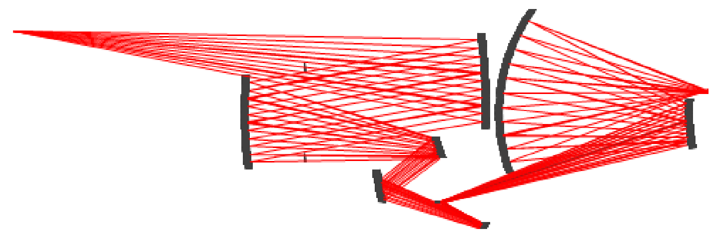


Enable 11 *nm*

10M obscured objective **NA0.75**



8M unobscured objective **NA0.45**



Activities in Beijing Institute of Technology (BIT)

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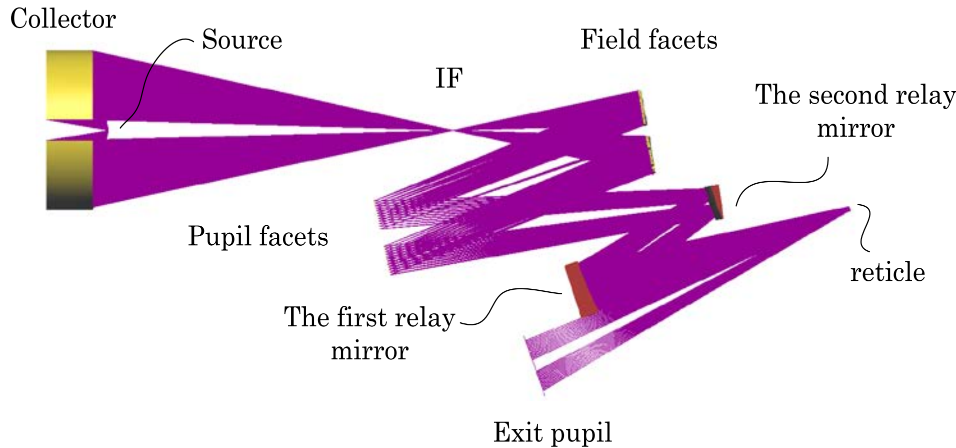
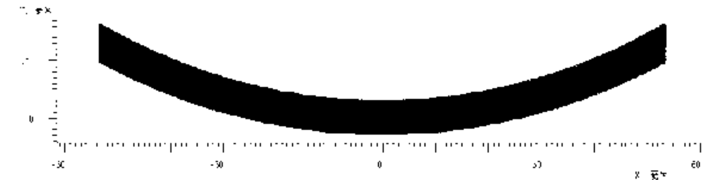
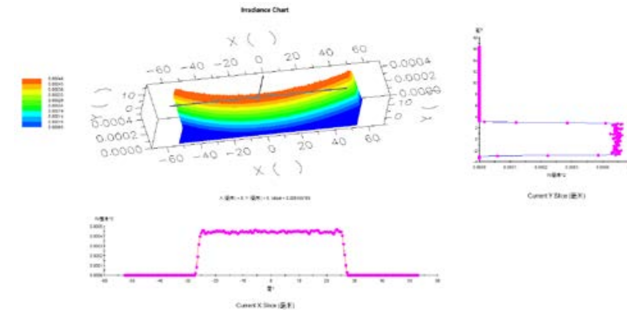
Ref. Proc. SPIE 90482F 2014, Appl. Opt. 52(29) 2014 ,EUVL workshop 2014

2014 Update (Basic Research)

Design of EUV illuminator







	90-degree dipole illumination	45-degree quadrupole illumination	annular illumination
Pupil facets			
Exit pupil			

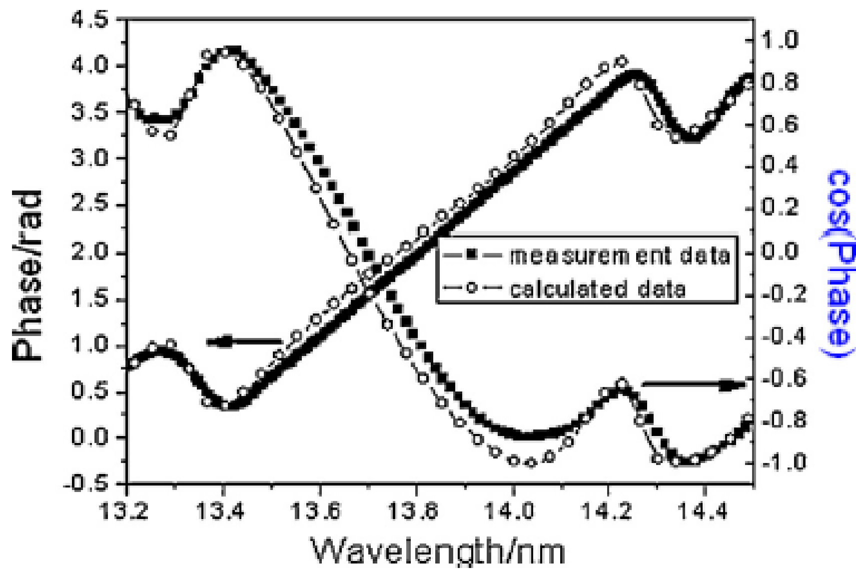
Illumination uniformity is better than 2.5%. **Submitted to Appl. Opt.**

Activities in (BIT)
Supported by NSTMP & MOE

2014 Update (Basic Research)

4.Multilayers (Basic Research)

"Reflective phase shift measurement of the Mo/Si multilayer mirror in extreme ultraviolet region"



Activities in Tongji University

Supported by NSFC, NSTMP…

Ref. Optik 124 (2013) 5003-5006

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

2014 Activities Update

5.Metrology

Activities in (BIT)

Wavefront Metrology

Design of PS/PDI system for — **Visible** / **EUV**

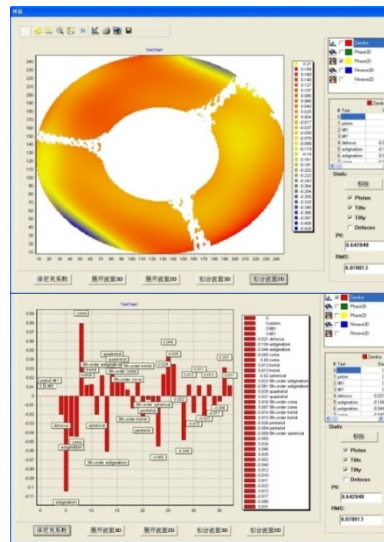
PS/PDI system @632.8nm has completed!

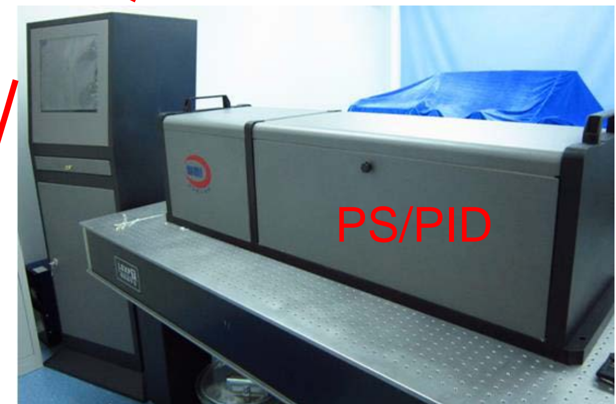
- Absolute accuracy 5 nm rms
- Repeatability 0.55 nm rms

Supported by NSTMP & MOE

New progress

- Measurement objectives with different NA （0.2 ~ 0.4）
- Automatic calibration and measurement



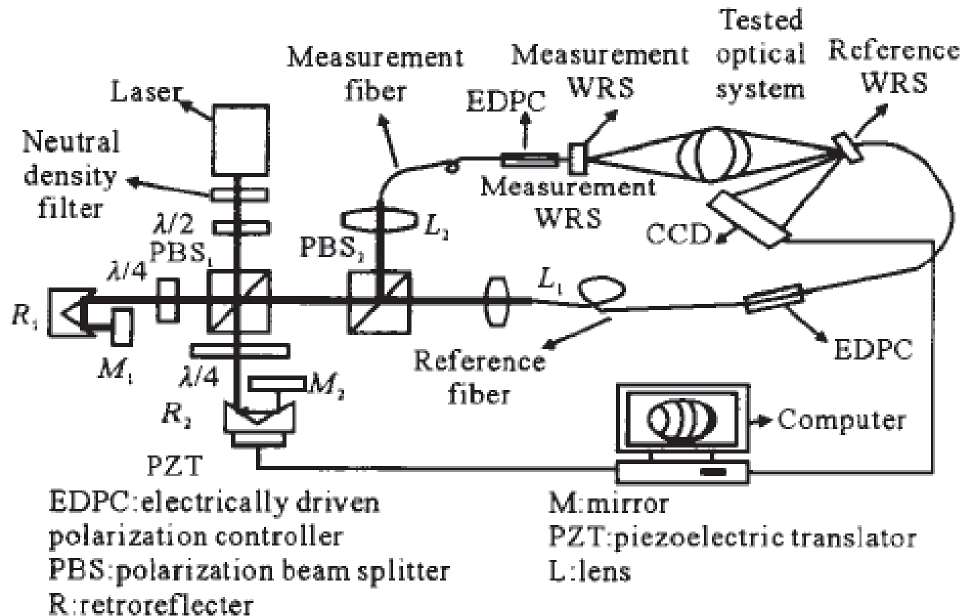


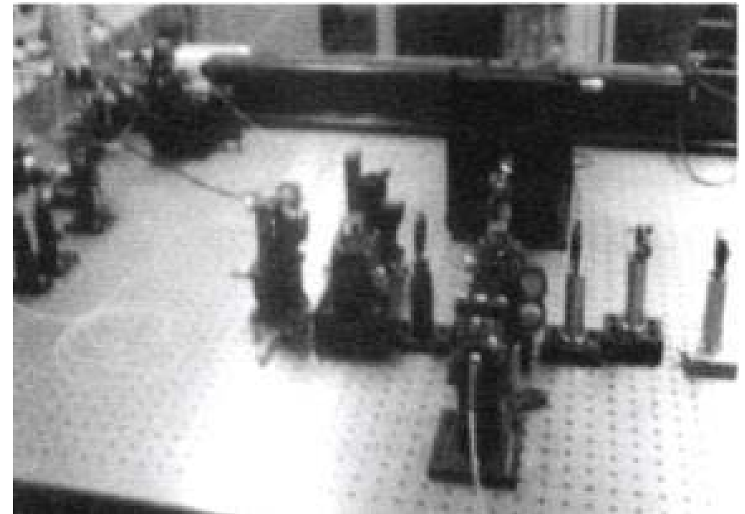
2014 Activities Update

Activities in CIOMP

Visible PS/PDI Repeatability improved.

Repeatability: 1/4000 λ rms (λ=632.8nm)





Ref. Infrared and Laser Engineering, Chinese Journal of Lasers, 28(2012).

2014 Activities Update

Activities in Institute of Optics and Electronics

"Calibration of the system error in pinhole diffracted interferometer"

PDI System error 0.009λ(λ=632.8nm)

Ref. Acta. Optica Sinica, 2013

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

"Carbon Contamination Modeling on Extreme Ultraviolet Optic Surface" Ref. Acta. Optica Sinica, 2013

"Simulation Model of Surface Carbon Deposition Contamination Under Extreme Ultraviolet Radiation" Ref. Acta. Optica Sinica, 2014

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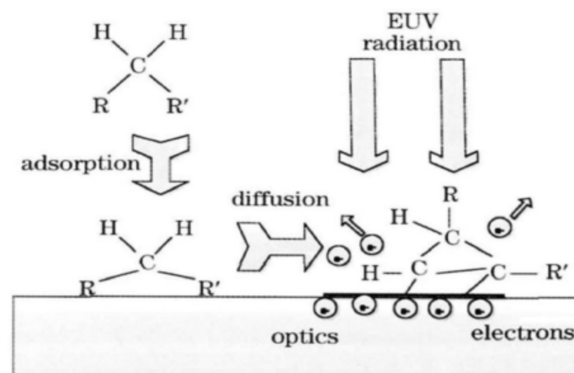
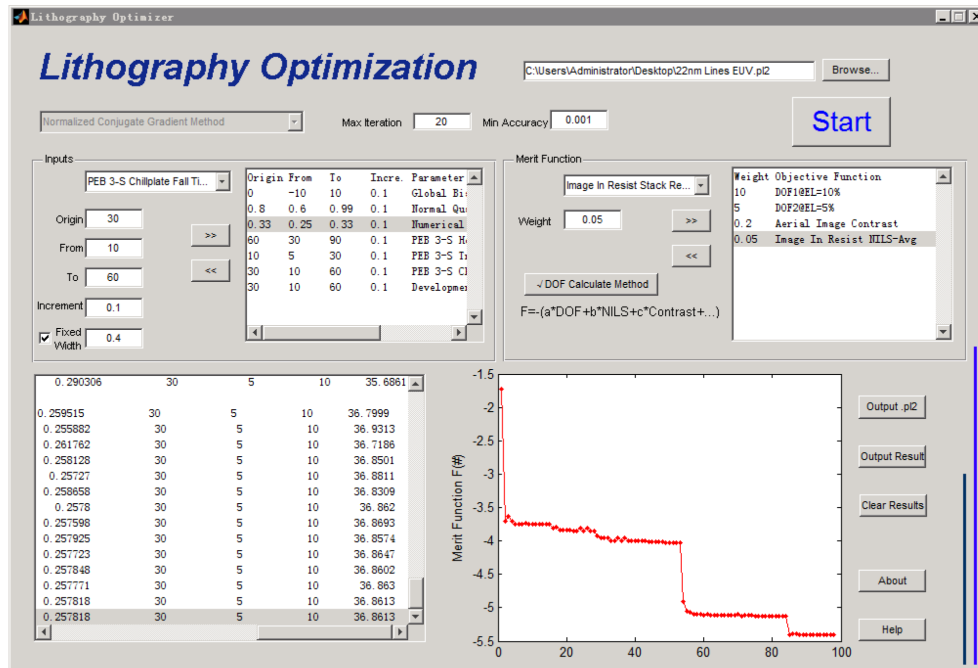
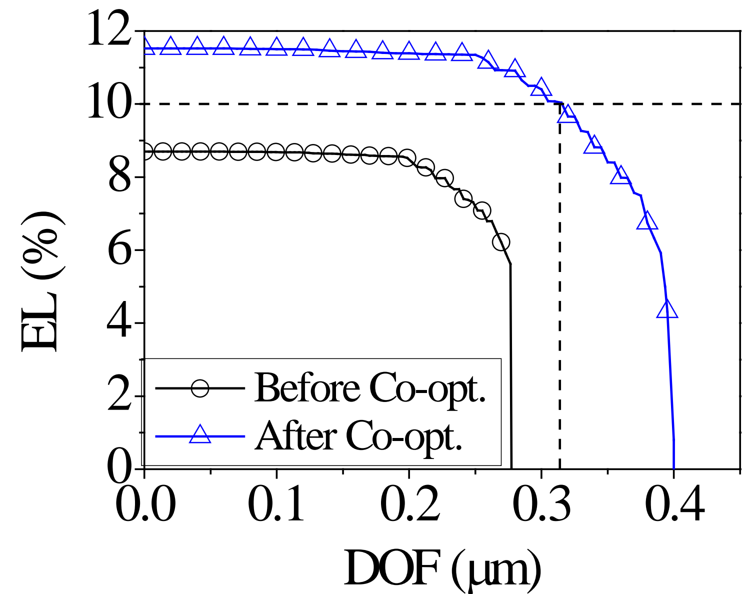


2014 Update (Basic Research)

7. Simulation

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





Activities in (BIT)

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Abbreviations for Research Organization

AOE	**Academy of Opto-electronics**
SIOM	**Shanghai Institute of Optics and Fine Mechanics**
CIOMP	**Changchun Institute of Optics, Fine Mechanics and Physics**
IMECAS	**Institute of Microelectronics**
BIT	**Beijing Institute of Technology**
HIT	**Harbin Institute of Technology**
TJU	**Tongji University**
HUST	**Huazhong University of Science and Technology**

More activities will be shown in the future!

Thank you for your attention !