Development of EUV wavefront metrology system (EWMS)

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Outline

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EUV wavefront metrology methods

EUV experimental interferometer (EEI) results

Status of EUV wavefront metrology system (EWMS)

Summary

Introduction

EUV Wavefront System (EWMS) was developed by EUVA in NEDO project.

Before the development of EWMS, EUV experimental interferometer (EEI) was developed and several wavefront metrology methods were tested using EEI.

Non-EUV wavefront metrology systems installed in the factories will be used in the manufacturing of EUV lithography tools. EWMS will play an important role as a standard system of EUV wavefront metrology.

EUV wavefront metrology project outline

Project name: Development of EUV Wavefront Metrology Technology
NEDO funding project

Period: Start: January, 2002, End: March, 2006
Continuous research now underway

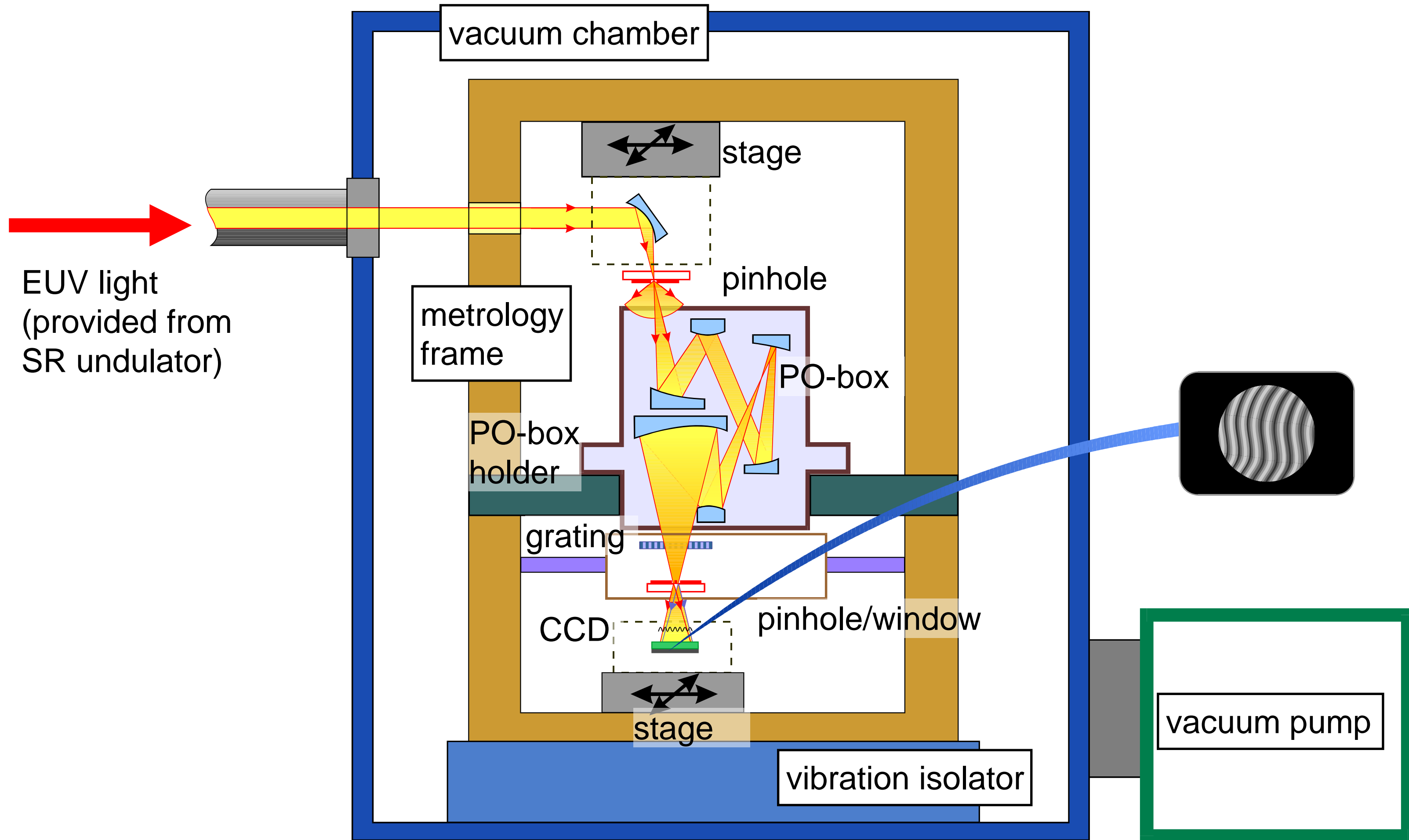
Objective: Development of EUV wavefront metrology system for high-NA (0.25)
full-field projection optics

Target: accuracy of less than 0.1nmRMS

Light source: Undulator beamline of New Subaru synchrotron radiation
source at University of Hyogo (UH)

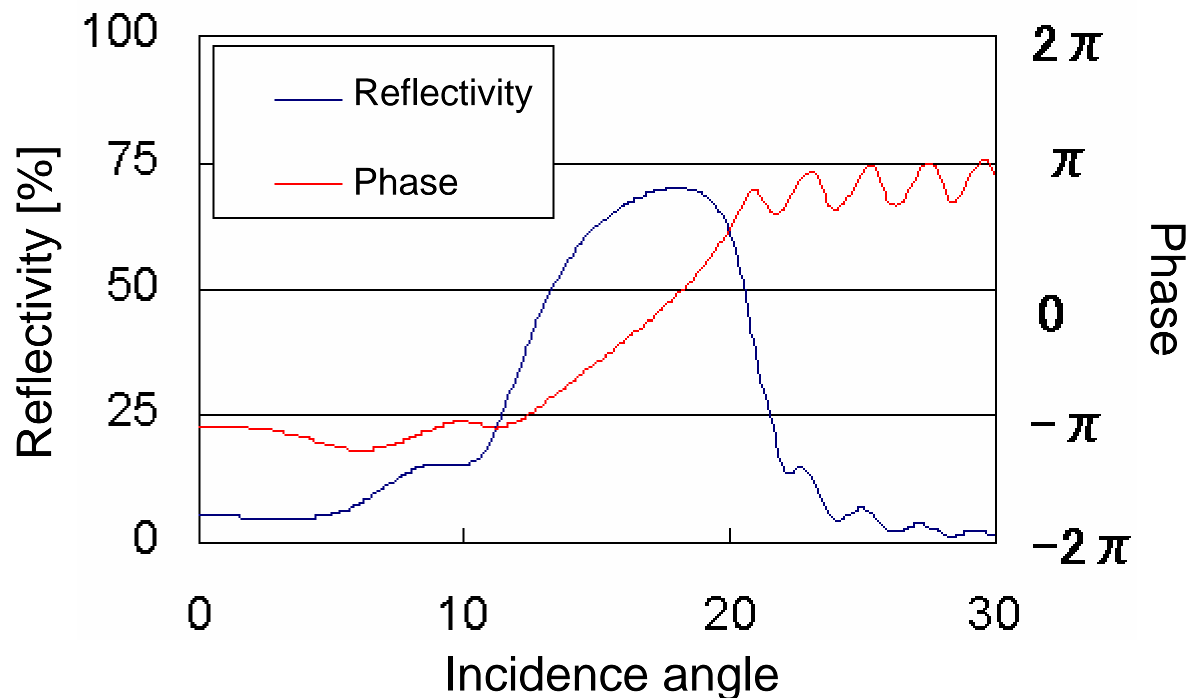
Concept of EUV wavefront metrology system (EWMS)

Goal of the project
Wavefront of high NA (0.25) full-field projection optics can be measured.



Why we need EUV wavefront metrology?

Generally reflection type optics have no chromatic aberration.
However, phase change accompanies the reflection by multilayer mirrors.
Therefore wavefront measured with non-EUV radiation is not equal to that measured with EUV radiation.
The difference is not negligible considering optical performance.
Wavefront metrology using EUV radiation is required.



Difficulties and solutions of EUV wavefront metrology

No coherence light source

Common –path type interferometer

Limitation of optical elements

Simple interferometer design using pinholes and gratings

Extremely high accuracy required

No mechanical reference surface

EUV wavefront metrology methods

Seven different type of EUV metrology methods were tested using EEI.

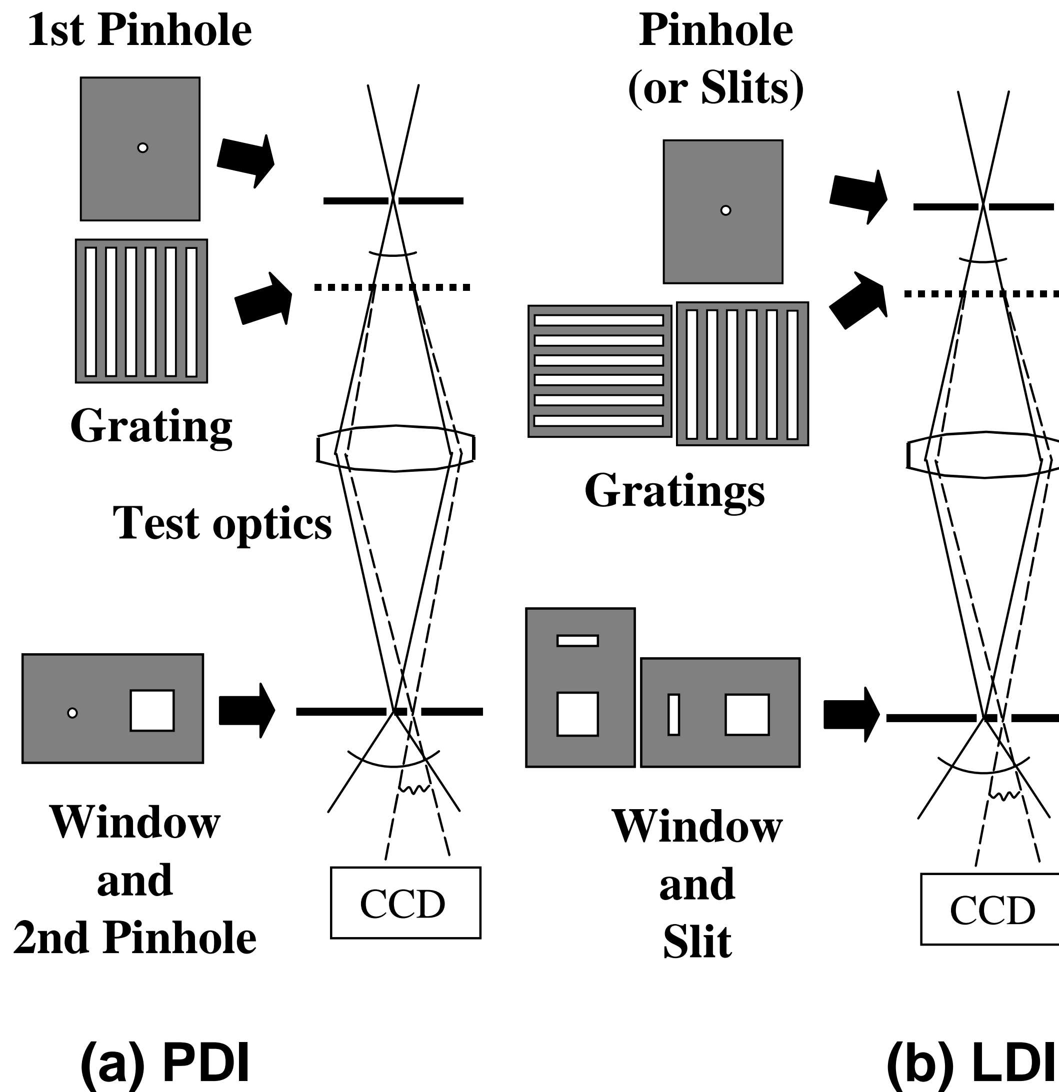
Diffraction type interferometers

- Point Diffraction Interferometer (PDI)
- Line Diffraction Interferometer (LDI)

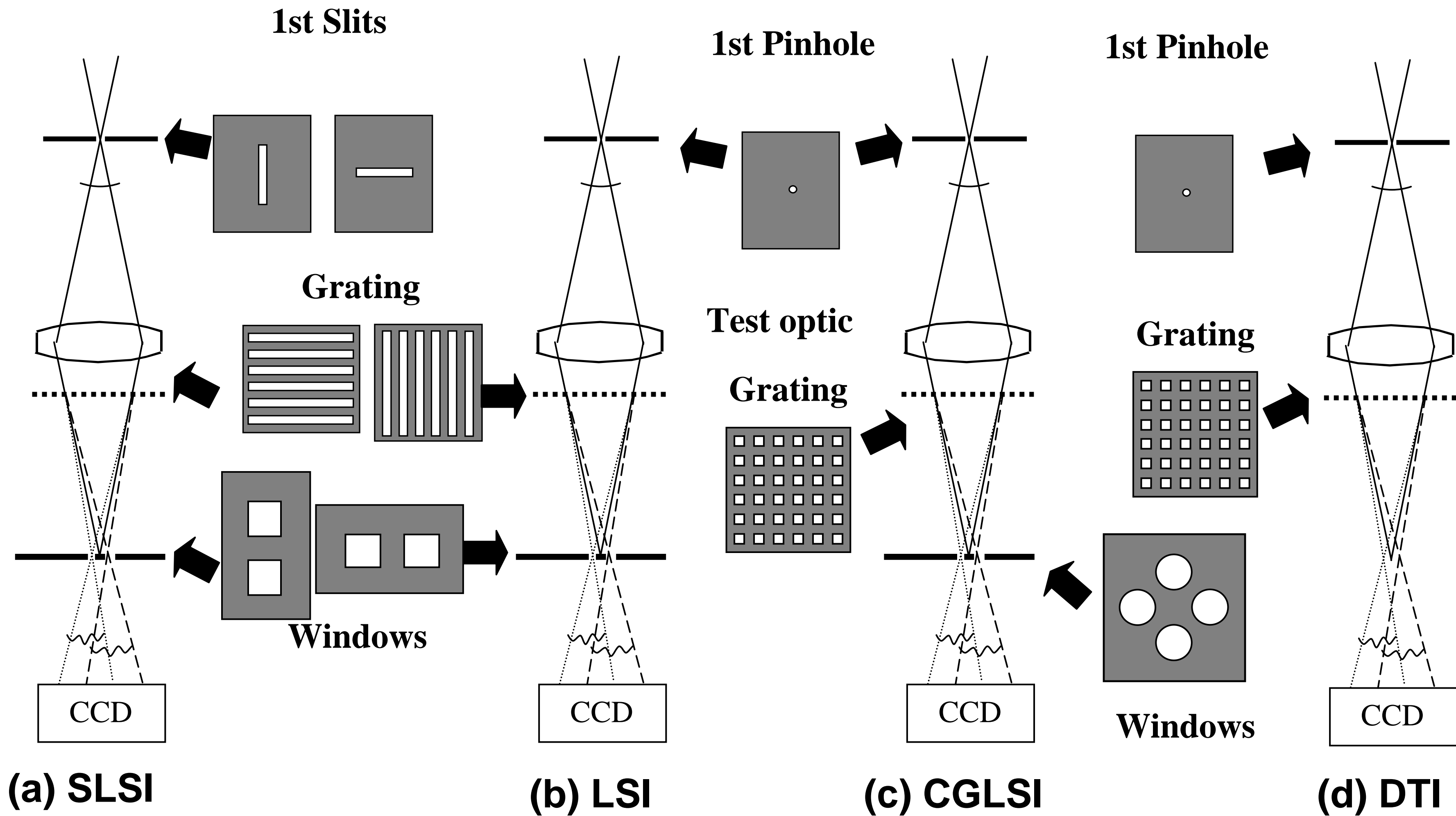
Shearing type Interferometers

- Lateral Shearing Interferometer (LDI)
- Slit Lateral Shearing Interferometer (SLDI)
- Cross-grating Lateral Shearing Interferometer (CGLSI)
- Digital Talbot Interferometer (DTI)
- Double-grating Lateral Shearing Interferometer (DLSI)

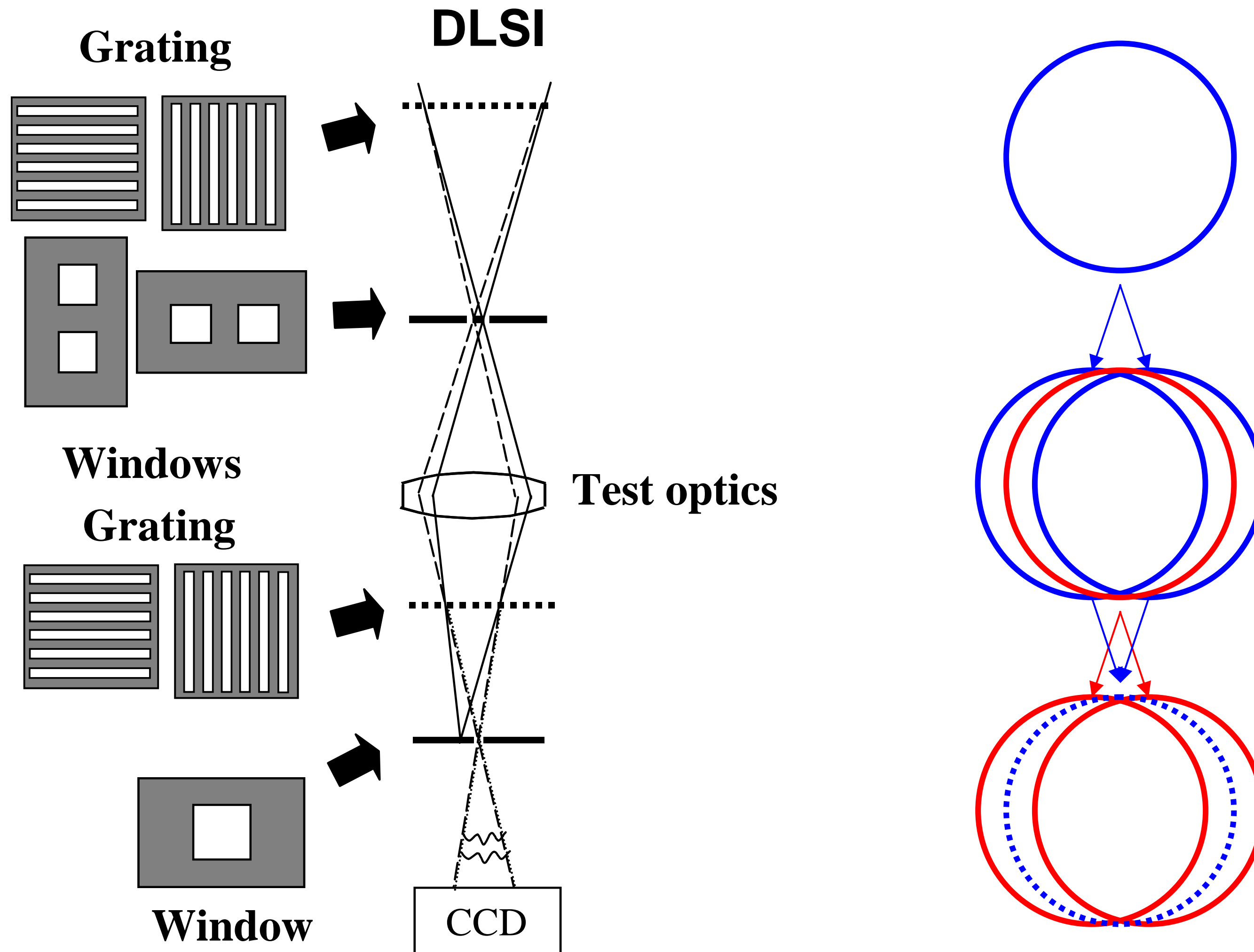
Diffraction type interferometers



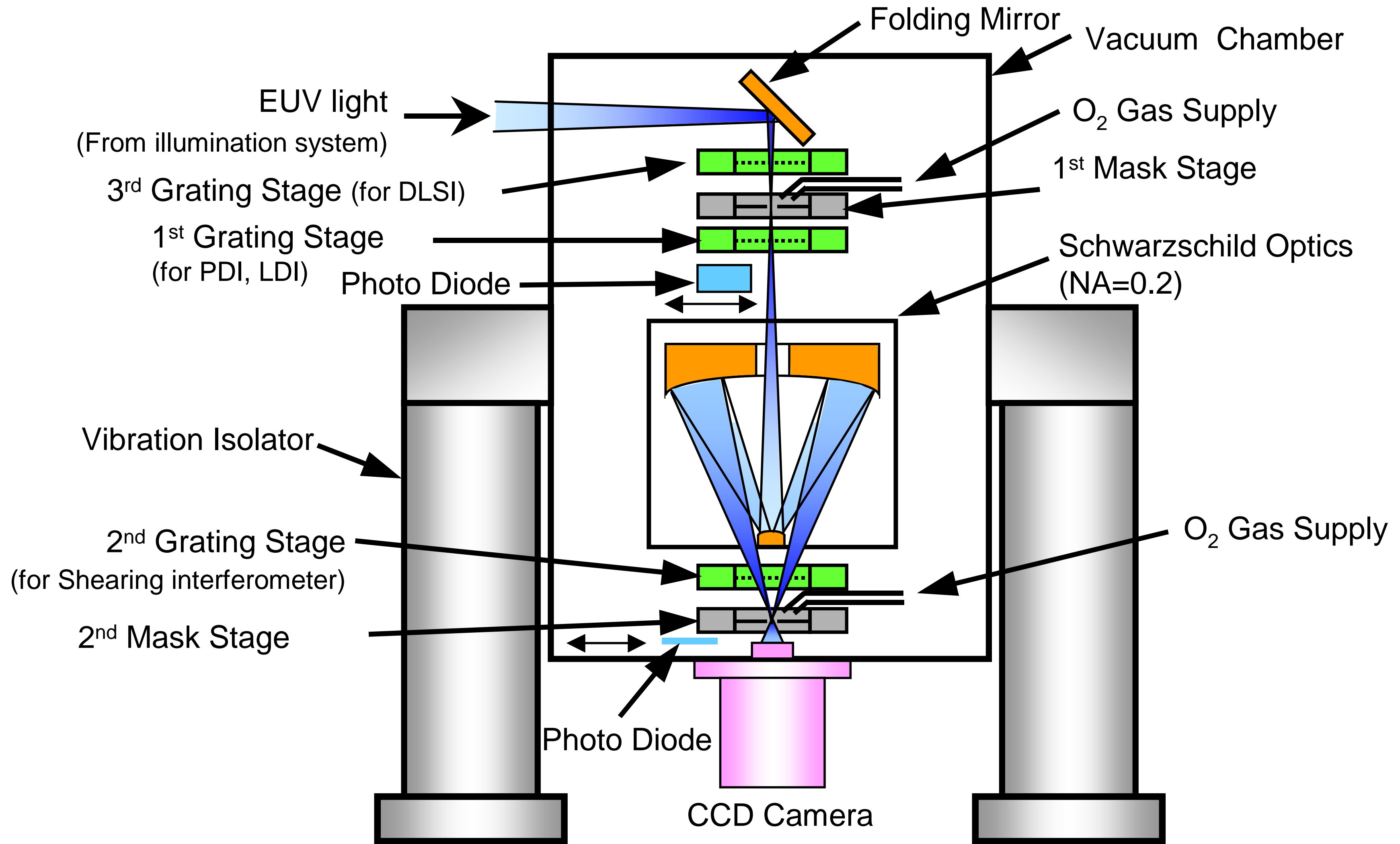
Shearing type Interferometers 1/2



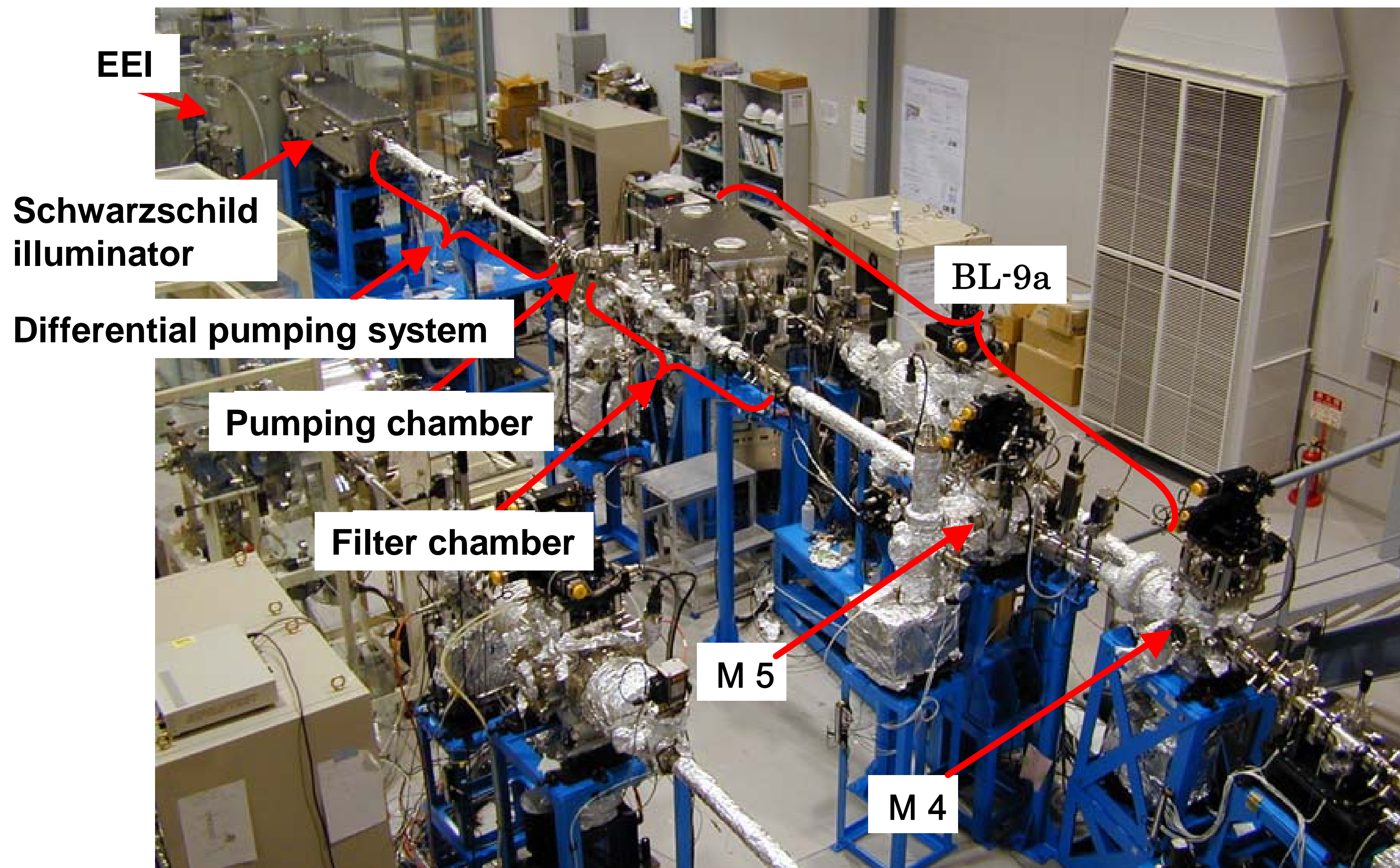
Lateral shearing Interferometer 2/2



Concept of EUV experimental interferometer (EEI)



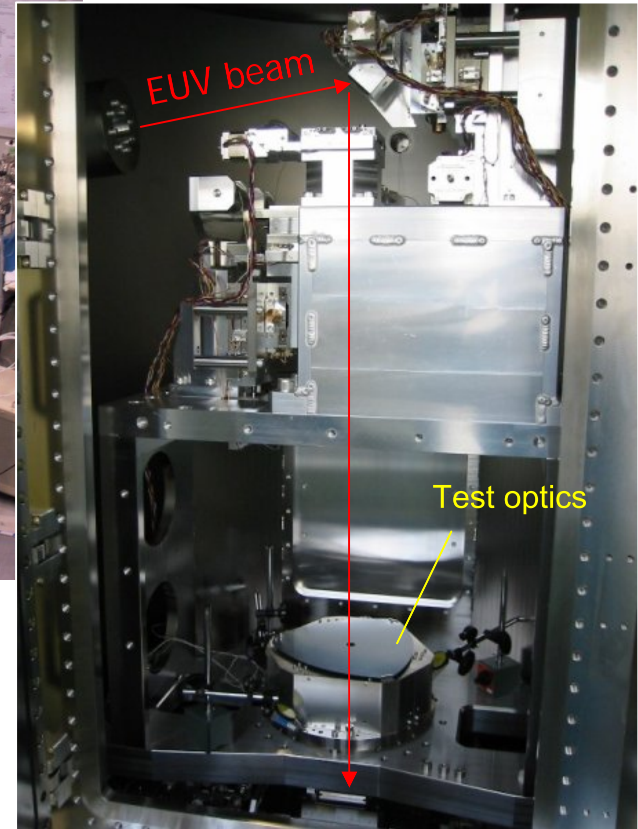
EUV wavefront metrology beam line at New Subaru



EUV experimental interferometer (EEI) at New Subaru

Clean chamber
EEI
Illuminator(NA:0.01)
EUV beamline

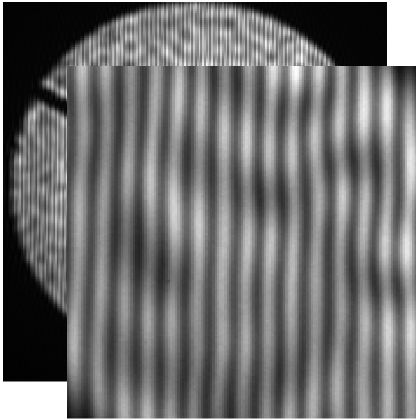
Entire view of EEI



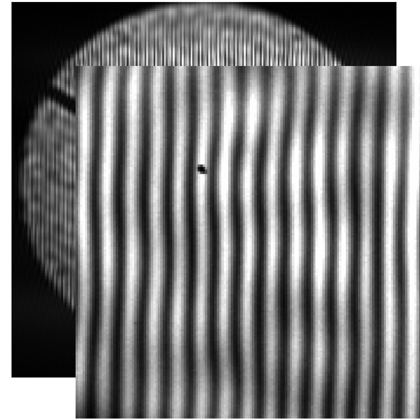
Inside of EEI

EUV interference fringes

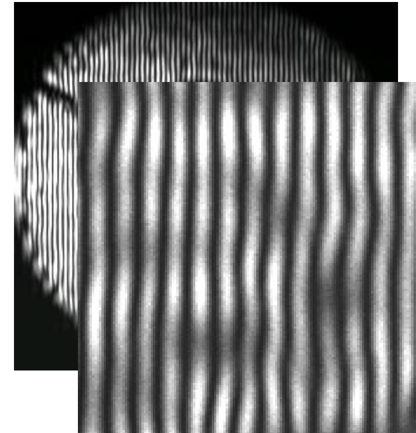
PDI



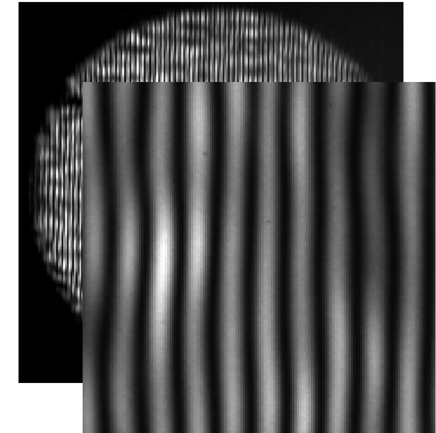
LDI



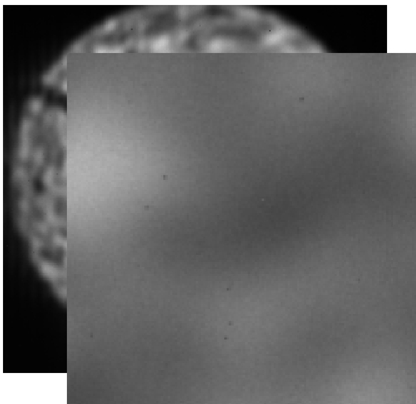
LSI



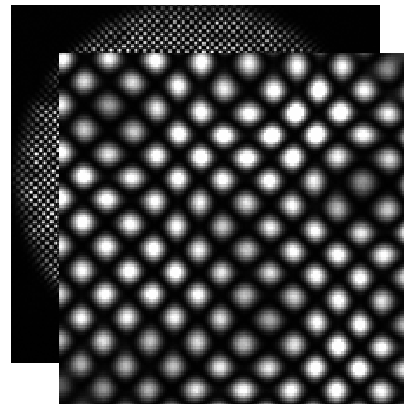
SLSI



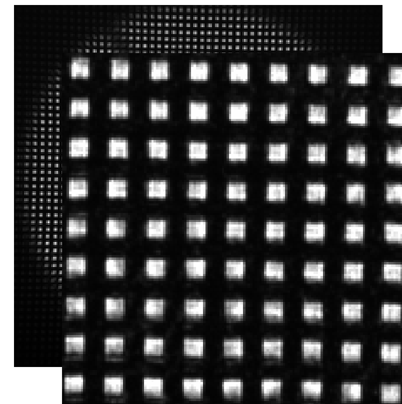
DLSI



CGLSI

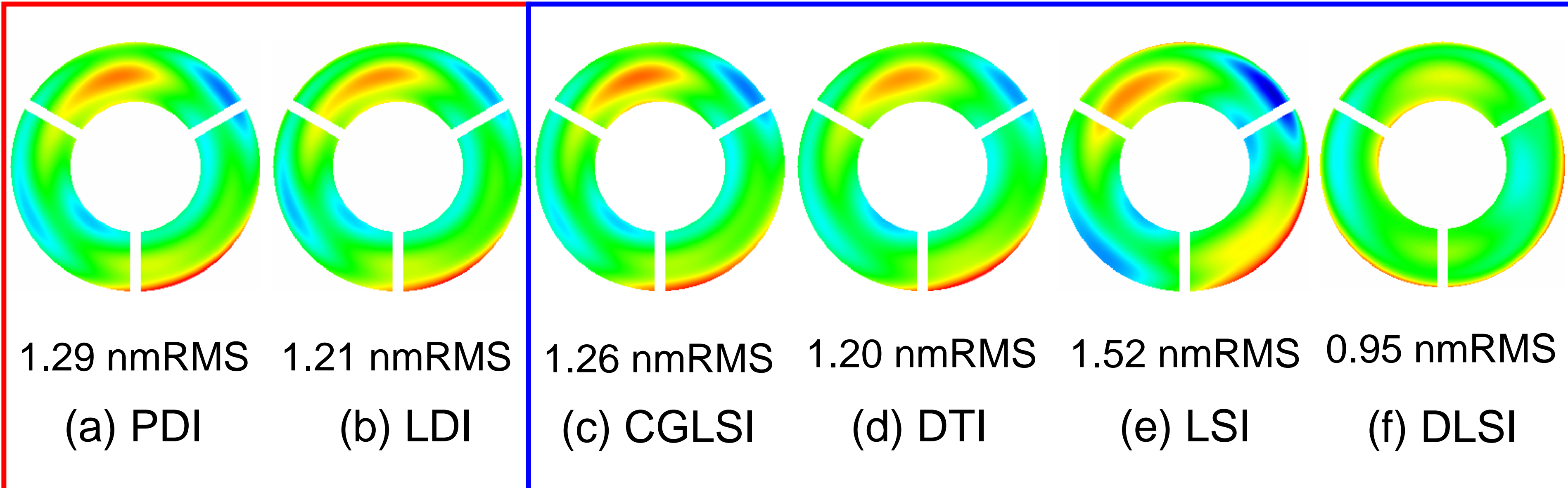


DTI



EUV interference fringes were obtained
for 7 different wavefront metrology methods.

Measured EUV wavefront using EEI



EUV wavefront was measured using 6 different metrology methods.

Good agreement between deferent metrology methods.

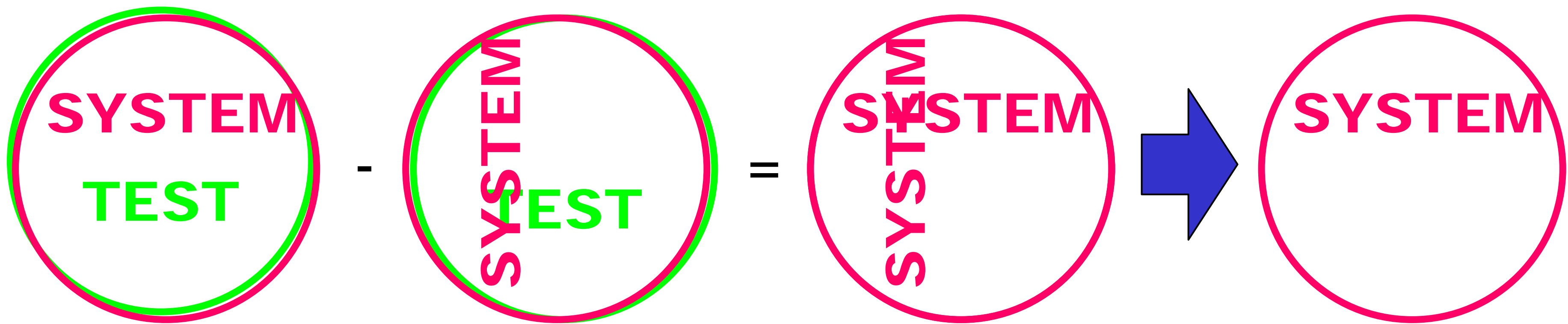
Comparison of metrology method

Method	Test result
PDI	High Accuracy, Small measurement range, Difficult operation (alignment of PH, contamination of PH)
LDI	Higher fringe contrast than PDI, Two sets of measurement in X, Y direction
LSI	Wide measurement range, Easy alignment, Two sets of measurement in X, Y direction, Difficult to measure astigmatism
SLSI	Improved LSI but no significant advantage, Two sets of measurement in X, Y direction
DLSI	Need the least photons, Two sets of measurement in X, Y direction, Difficult to measure astigmatism
CGLSI	Wide measurement range, Easy alignment, Astigmatism can be measured, Moderate accuracy
DTI	Wide measurement range, Easy alignment, Astigmatism can be measured

CGLSI was selected as a main metrology method of EWMS.

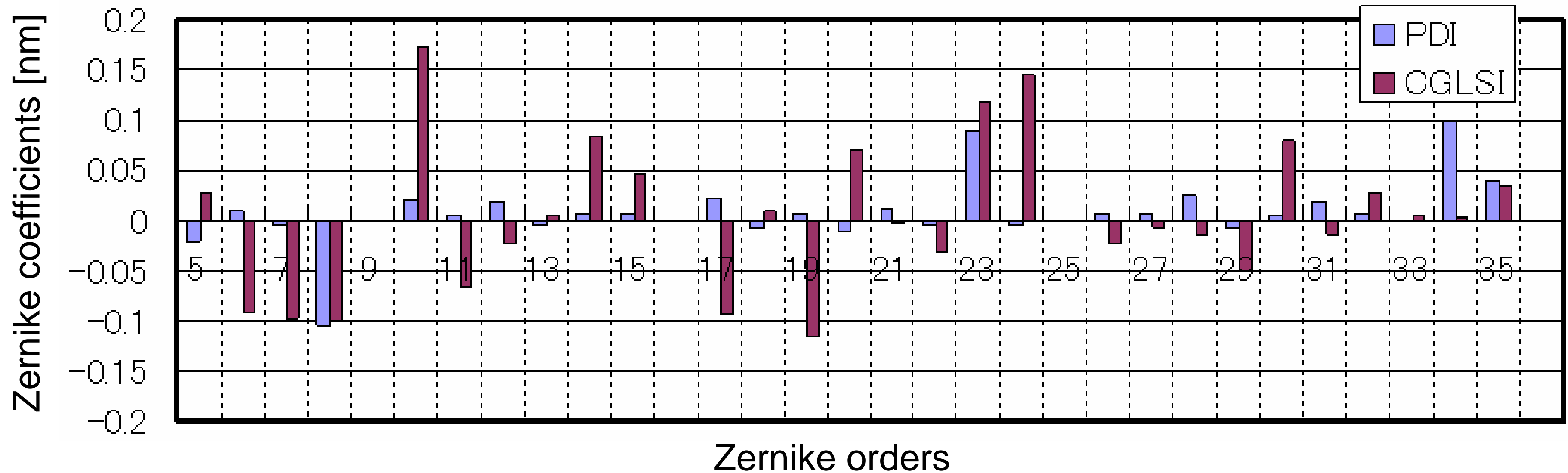
Measurement of system error (criterion of accuracy) of EEI

Measured wavefront	Rotate test optic	Remove Test wavefront	System error derivation



Measurement with rotating test optics can distinguish system error of interferometer from error of test optics.

Measured system error in PDI and CGLSI

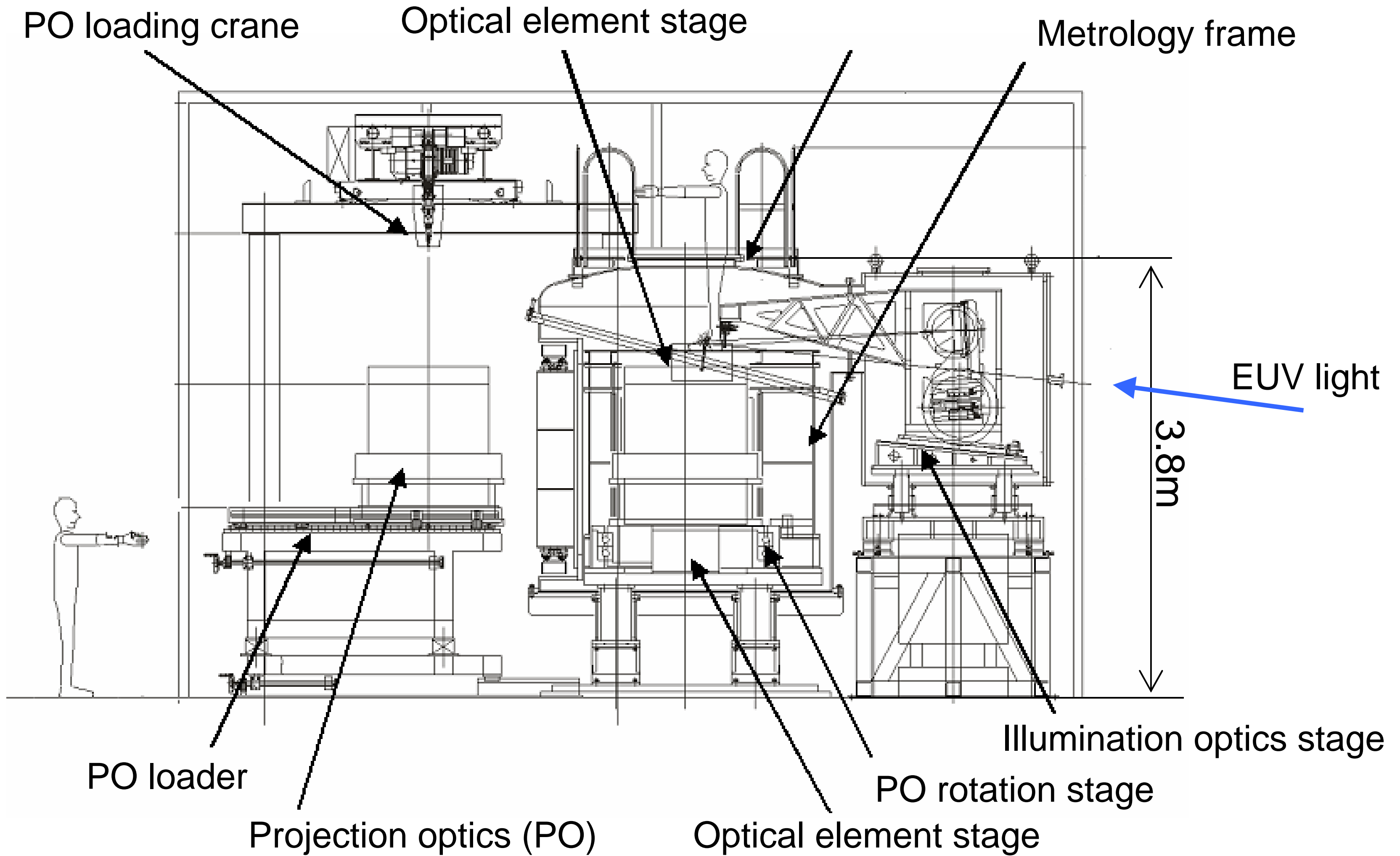


Measured system errors: 0.06nmRMS (PDI), 0.12nmRMS (CGLSI)

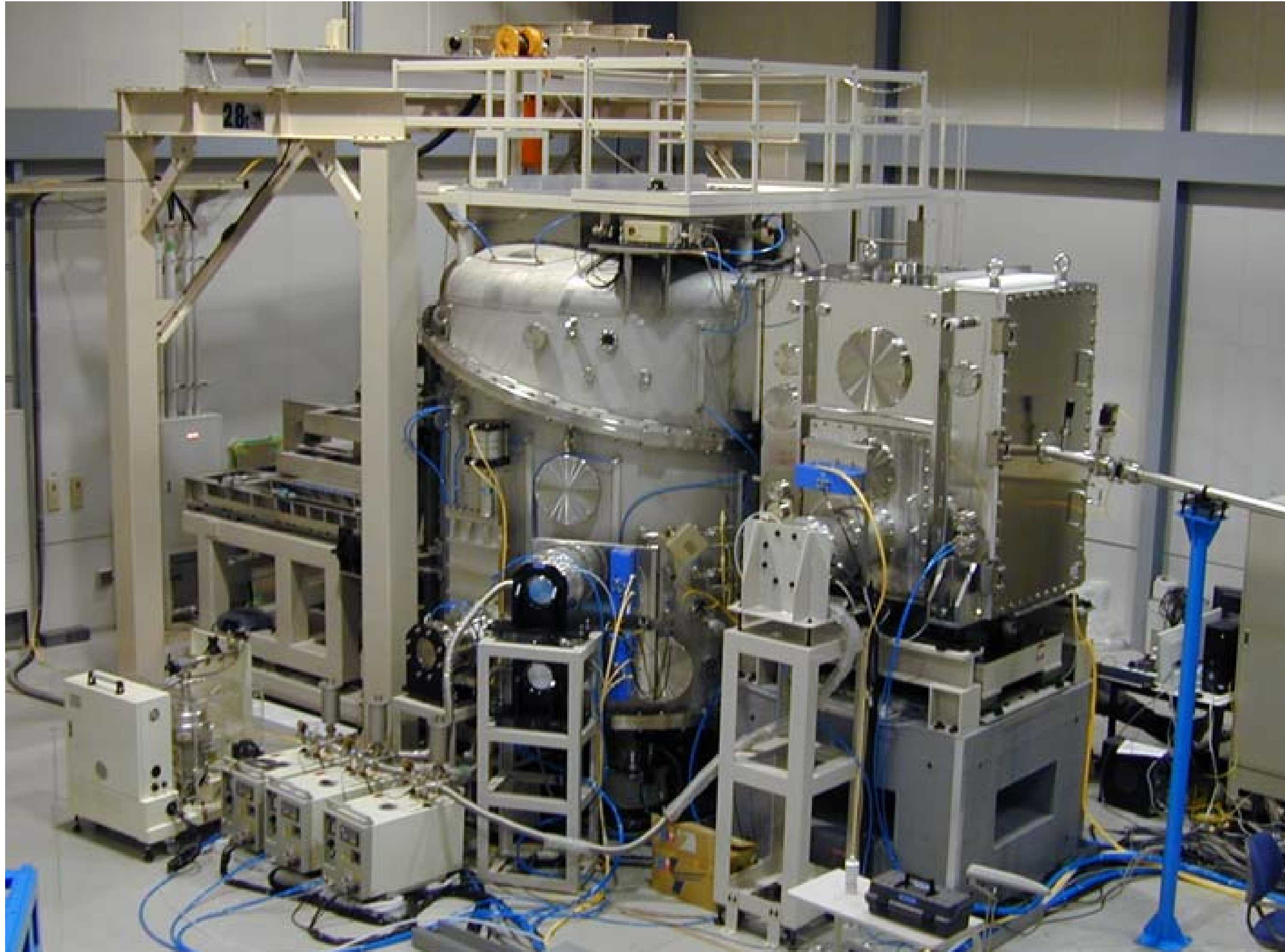
Our target accuracy (0.1nmRMS) was achieved in PDI.

CGLSI showed very good accuracy beyond our expectation.

EUV wavefront metrology system (EWMS)



Installation of EWMS at New Subaru completed



EWMS is ready to start EUV wavefront metrology

Optical elements for metrology (pinholes and gratings) for EWMS were completed.

Thermal chamber was installed.

Prototype EUV projection optics will be delivered at the end of October.

Summary

7 different EUV metrology method were tested using EEI.

Measured system error were 0.06nmRMS for PDI
and 0.12nmRMS for CGLSI.

CGLSI was selected main metrology method of EWMS.

EWMS was completed and ready to start EUV wavefront metrology.

Acknowledgment

The authors would like to thank the operation staff of New Subaru synchrotron facility for their help.

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