Integration of Stand-Alone Coherent Scattering Microscope with Femto Second Laser based EUV Source

Hanyang University

Jae uk Lee[1], Sangsul Lee[1], Jonggul Doh[1], Seongchul Hong[1] , Dong Gun Lee[2]
Jinho Ahn[1*]

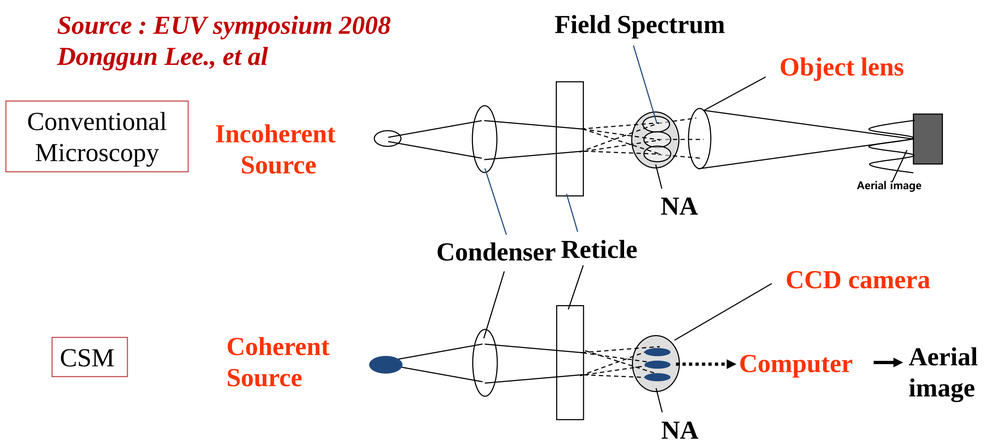
[1] Department of Materials Science and Engineering, Hanyang University
[2] Photomask Team, Semiconductor R&D Center, Samsung Electronics Co., LTD

Introduction

In this paper, we present the stand-alone EUV coherent scattering microscope (CSM) equipped with fs (femto second) laser-based EUV source for inspection of EUV mask. This fs laser-based EUV source with small footprints can be easily installed in a fab line, and also has many advantages in comparison with the synchrotron beam.

The repeatability of mask CD (critical dimension) measurement has been investigated using stand-alone EUV CSM. Mask CD changes caused by carbon contamination and H-V (horizontal –vertical) CD bias with 88nm, 100nm, 128nm half-pitch L/S patterns were also investigated.

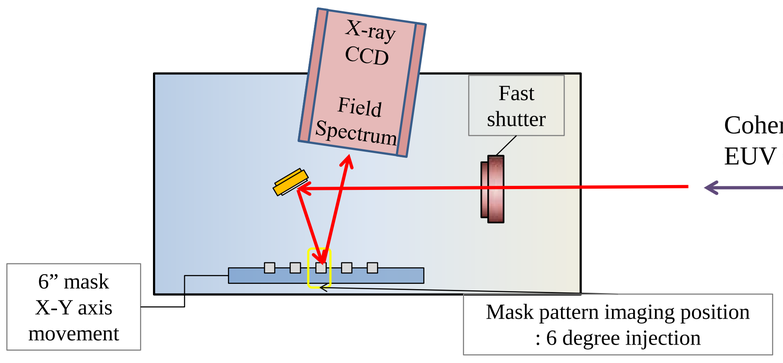
Source : EUV symposium 2008 Donggun Lee., et al

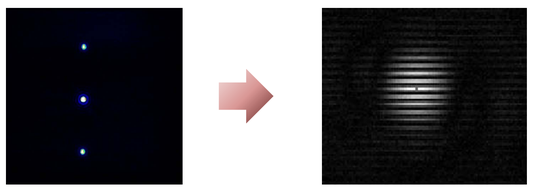


EUV CSM system

Stand-alone EUV CSM

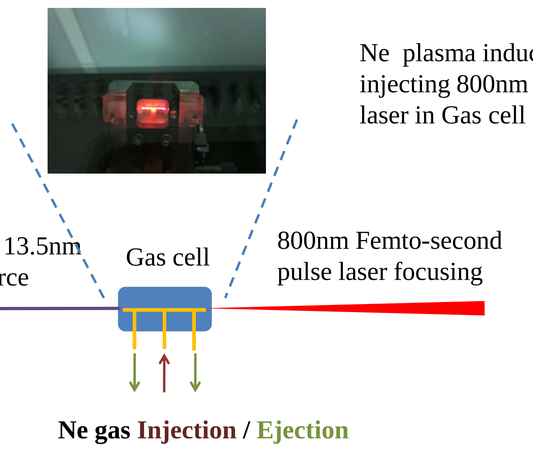
- Schematic of Coherent Scattering Microscope
- CCD camera capture a field spectrum from EUV mask as L/S or contact-hole pattern





Field spectrum — Reconstructed aerial image

Femto-second laser based EUV source

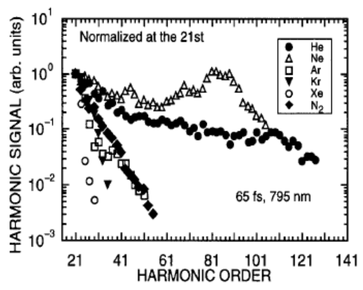


- High harmonic generation (HHG) using fs high-peak pulse laser
- 59th harmonic(13.5nm) were generated by focusing 800nm fs pulse laser

Femto-second laser based EUV source

EUV source specification

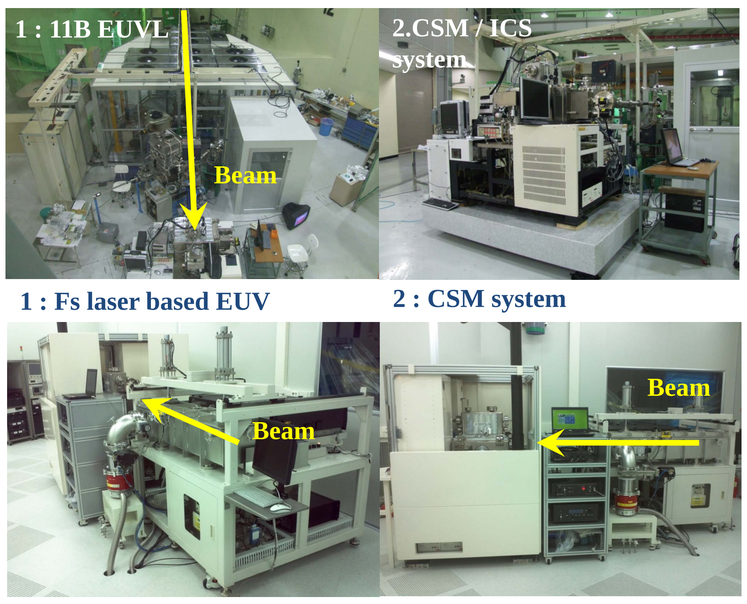
EUV source	Specification
Wave length	13.5nm ± 0.5nm
Average power	20nW ~ 40nW (η = 5.5 x 10^{-9}~ 1.1 x 10^{-8})
Pulse Repetition rate	1 kHz
Pulse duration	< 50 fs
Divergence angle	< 0.5mrad
$\lambda/\Delta\lambda$	> 280
Energy stability	< 3%
Beam size	< 30um



Source : Appl. Phys. Lett 1999, M. Kakehata

- The maximum energy achieved to date around the 13 nm wavelength region with Ne gas (~59th)

Synchrotron beam vs. Femto-second laser based EUV source



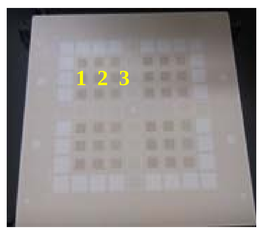
- Fs laser has a smaller footprint than synchrotron, so can be easily installed in a fab line
- Fs laser based EUV source has good coherence enough for imaging performance (divergence < 0.5mrad, $\lambda/\Delta\lambda$ > 280)

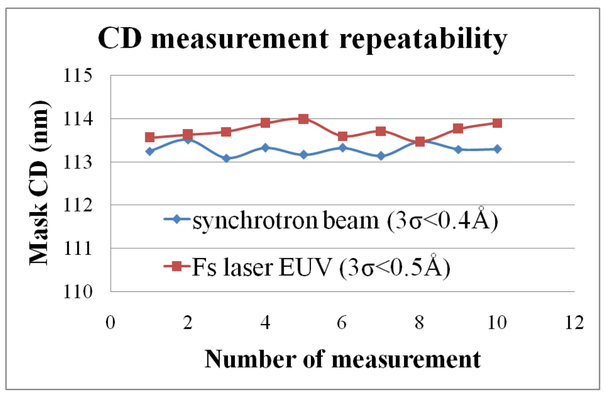
CSM performance

CSM repeatability test

- EUV test mask fabrication
  - carbon contamination
  - CD measurement

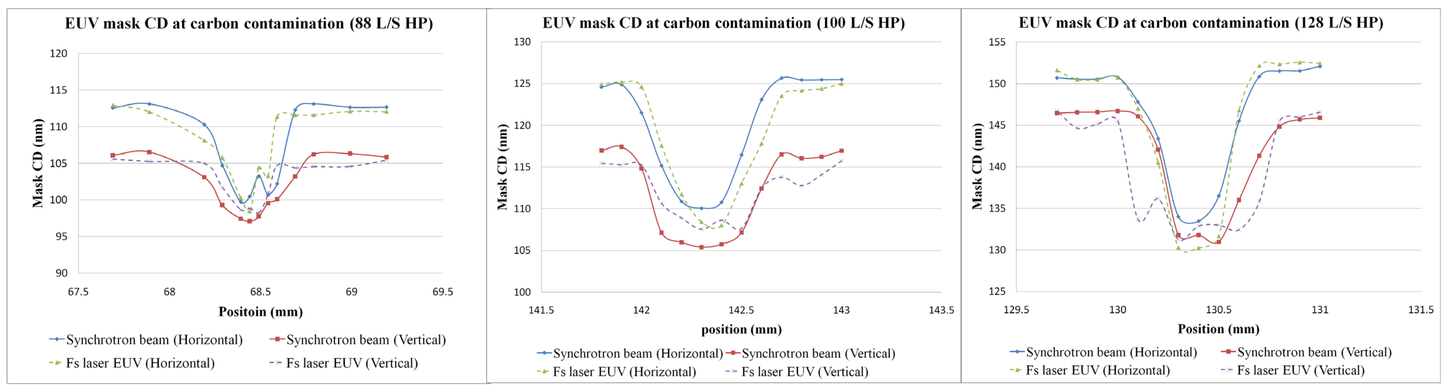
	Pitch	Exp time
1	88nm L/S	3hr
2	100nm L/S	3hr
3	128nm L/S	3hr

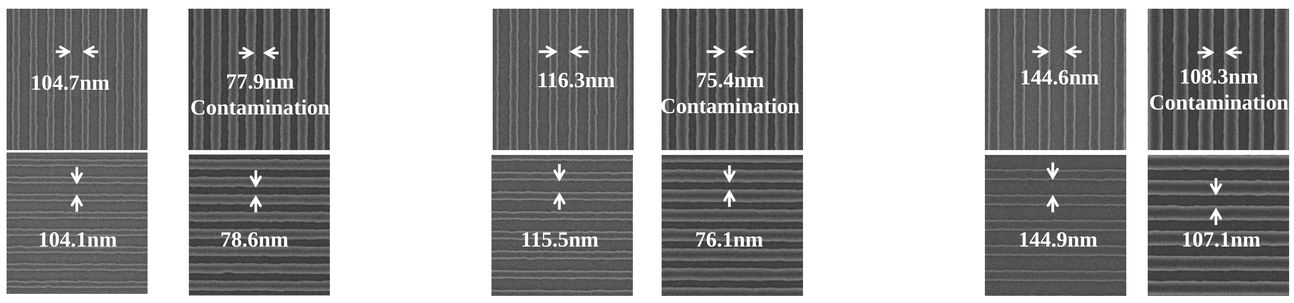




Impact of carbon contamination

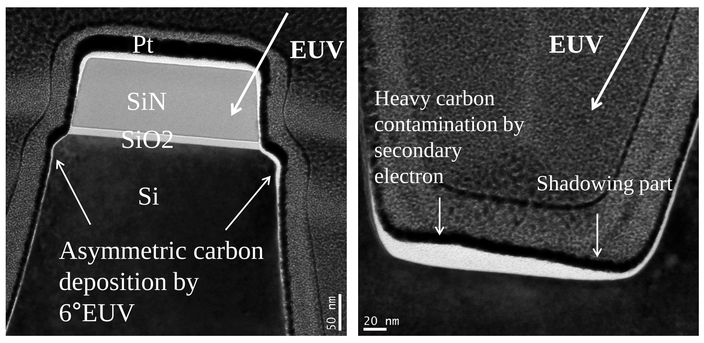
EUV mask CD measurement



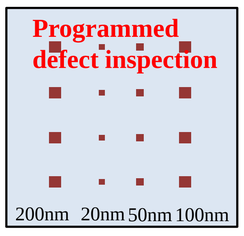


L/S Pattern Half Pitch	88nm			100nm			128nm		
Measurement tool	Fs laser EUV	Synchrotron	CD-SEM	Fs laser EUV	Synchrotron	CD-SEM	Fs laser EUV	Synchrotron	CD-SEM
Average CD (Horizontal)	111.8	112.8	104.7	124.2	125.3	116.3	151.6	151.5	144.6
Contaminated zone (Horizontal)	100.1	102.5	77.9	109.9	110.5	75.4	132.2	134.1	108.3
CD difference (Horizontal)	11.7	10.3	26.8	14.3	14.9	40.8	19.4	17.3	36.3
Average CD (Vertical)	105.1	106.0	104.1	115.8	116.3	115.5	144.8	145.9	144.9
Contaminated zone (Vertical)	99.0	98.1	78.6	108.5	106.0	76.1	131.9	133.0	107.1
CD difference (Vertical)	6.1	8.0	25.5	7.3	10.3	39.4	12.9	12.8	37.8
H-V bias	6.7	6.8	0.6	8.5	9.0	0.8	6.8	5.6	-0.3

Asymmetric carbon deposition



- CSM can measure CD and aerial image including shadowing fact

Conclusion amd Future work

- Femto Second Laser based EUV source was successfully integrated with Coherent Scattering Microscope (CSM).
- 13.5nm wavelength with good coherence was obtained through HHG with fs laser..
- This small fs laser based EUV source is suitable to use for inspection tool.
- Actinic inspection results by CSM were compared with CD-SEM results, and reasonable data was obtained.
- The programmed defect (especially buried defects) will be inspected using CSM.
- It will be studied to prevent a damages of EUV mirror in fs laser based EUV source.