The study on influence of carbon contamination on imaging performance of EUV mask using CSM/ICS

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Introduction : Abstract

❖ **Development target for EUVL Beamline**
– mask contamination & inspection (@ Pohang Light Source)

1. Inspection infrastructure for mask : Actinic inspection tool @ EUV
   → **EUV CSM**
2. Protection : illumination optics and mask lifetime
   → Resist out-gassing / **EUV ICS** (In-situ Mask Contamination System)

Abstract

The life time of Mo/Si multi-layer masks is one of the critical issues to be solved for the high volume production of EUVL. Carbon contamination on the mask, which is caused by residual hydrocarbons when masks are exposed to EUV radiation, is one of the critical issues for the EUV mask life time
In this paper, we analyze the impact of carbon contamination on the imaging performance using the coherent scattering microscopy with in-situ accelerated contamination system (CSM/ICS). The CSM/ICS consists of CSM for measuring imaging properties and ICS for implementing acceleration of carbon contamination. Deposited carbon on the mask during EUV exposure can affect the mask performance, so this effect was observed by variation in CD, H-V bias, and reflectivity in combination with carbon film analysis using our system. In addition, strategies for carbon contamination mitigation including resist out-gassing effect will be discussed.

Experimental setup : 11B EUVL @ Pohang Light Source

Experimental configuration

CSM/ICS system design and manufacture @ PAL beamline

EUV Mask design and manufacture (with Samsung)

EUV **Mask acceleration** test (ICS)

In-situ analysis
(**CD measurement :: EUV CSM**)
(In-situ.....RGA / EUV reflectance)

See these poster !!

Construction of EUVL test bed @ PAL – Korea

1. EUV contamination : EUVL critical issue (reflective optics contamination)
✪ Out-gassing Test System : EUV resist out-gassing analysis
✪ICS (In-situ Contamination & analysis chamber System)
: optics contamination accelerate system, contaminate & carbon thin film thickness measurement, Optics reflectivity measurement, EUVL system cleaning study

2. EUV Mask Inspection
✪ Reflectometer : Measurement of EUV reflectance
✪CSM(Coherent Scattering Microscopy) : image reconstruct of EUV mask pattern image

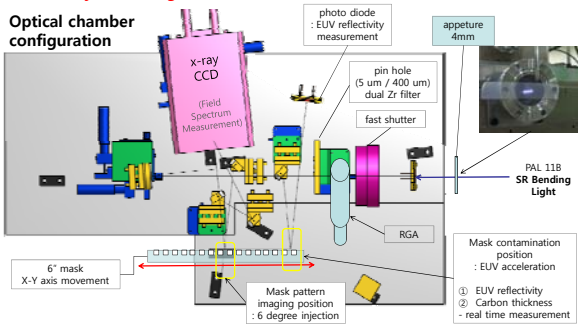
EUV CSM/ICS System →

→ Mask (MA) / MA-P21 / Application of the coherent scattering microscopy on the EUV mask fabrication
→ Reticle Contamination (RC) / RC-P01 / Analysis of compound on EUV mask surface and chamber circumstance using EUV CSM/ICS and RGA
→ Mask (MA) / MA-P09 / The suggestion of novel attenuated phase shift mask structure in Extreme Ultraviolet Lithography

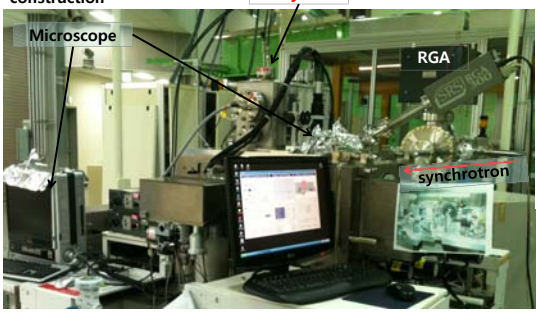
Mask Contamination/Inspection System (EUV CSM / In-situ Contamination system)

CSM/ICS system design and manufacture

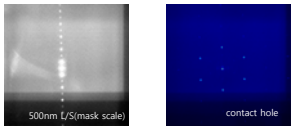
Optical chamber configuration



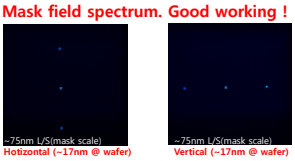
EUV CSM / ICS system construction



EUV CSM working test

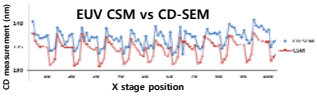


Mask field spectrum. Good working !



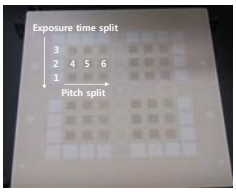
Hotizontal (~17nm @ wafer) Vertical (~17nm @ wafer)

EUV CSM vs CD-SEM



Influence of carbon contamination on imaging performance of EUV mask using CSM/ICS

Mask for contamination test

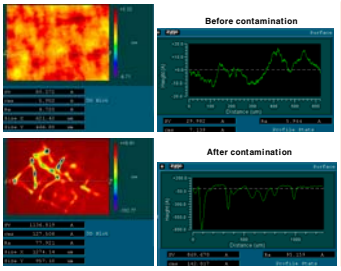


Mask condition

❖ Ru capping/MoSi ML/Qz/Cr
❖ 88/100/128nm (4X) L/S array, ML pad

	Pitch	Exp. Time
1	ML pad	3hr
2	ML pad	2hr
3	ML pad	1hr
4	88nm L/S	3hr
5	100nm L/S	3hr
6	128nm L/S	3hr

EUV contamination test (ICS) - profile of contamination area



Substrate:
Mo/Si 40pair, Ru capping

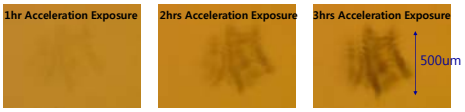
Acceleration time : 2hr
Chamber pressure:
1x 10^{-6}Torr

Profile : (optical measurement)
Zygo interferometer

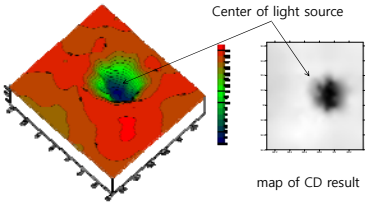
Before contamination
: rms ~5Å

After contamination
: carbon film deposition

ML pad image after EUV accelerate test

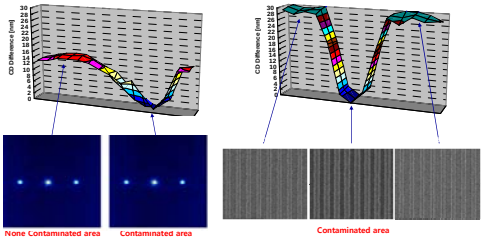


CD performance after contamination
- CD map measured by CSM



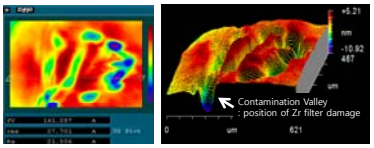
Shape of CD change is similar to light source shape.

CD Performance of CSM vs. CD SEM
- 88nm L/S, 3hr exposure
- trend of CD change is similar for both measurement tools.

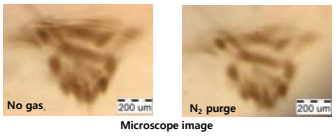


CD performance after contamination
- various chamber condition

	Gas	Exp. Time	L/S	Vacuum
1	No	3h`r	100nm L/S	2E-6 torr
2	N_2 purge	3hr	100nm L/S	2E-6 torr

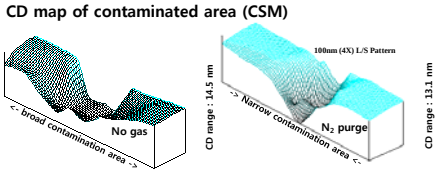


Zygo interferometer measurement after contamination (N_2 purge)



Microscope image

CD map of contaminated area (CSM)



❖ EUV CSM/ICS system will help to quantify the degree of contamination and its correlation with the mask performance.
❖CSM/ICS can analyze CD performance of mask, and will help to develop cleaning method.

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