

The background of the slide is a photograph of a cleanroom environment. Two people wearing white protective suits, hoods, and face masks are visible. One person is in the foreground, looking towards the camera, while another is slightly behind and to the right. Large, purple, stylized letters "EUV" are visible on the left side of the image, partially obscured by the cleanroom equipment.

Developing cost-effective actinic solutions for EUV lithography

ESOL, Inc.

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본 자료의 무단 전제 및 배포를 금지하며, 출력과 수정을 금지하고 무단 배포 및 전제시 만, 형사상의 책임을 질 수 있습니다.

Contents

- I Company Overview
- II ESOL EUV Source R&D
- III HHG(High Harmonic Generation) Source
 - Laser-like coherent source
 - High brightness source
 - High spectral brightness source
 - HHG-Based EUV mask defect review system
- V Summary



ESOL was established in 2018 with the goal of providing customers with the world's best EUV solution based on innovative technology.

EUV is a key technology leading the manufacturing of semiconductors with the highest performance. ESOL will provide customers with innovative technology that is ahead of the times based on its excellent understanding of lithography and mask technology.

Timeline

- '19. Jun EUV HHG Source development
- '20. Dec EUV Pellicle T/R tool development
- '21. Mar EUV defect review tool development
- '21. May Demonstration world first stand-alone EUV Interference Lithography system
- '21. Nov. Delivery of 1st EUV pellicle T/R tool
- '21. Dec. Delivery of EUV metrology module
- '22. Oct Delivery of 1st EUV mask review tool

High understanding of lithography and production

- Experts in EUV and photomask
- Understanding of semiconductor production



Global top tier EUV technology with mass production level



- World's 4th company of EUV production tool maker
- The world's 2nd company that makes its own EUV source

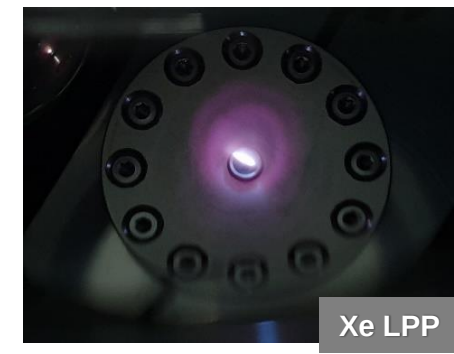
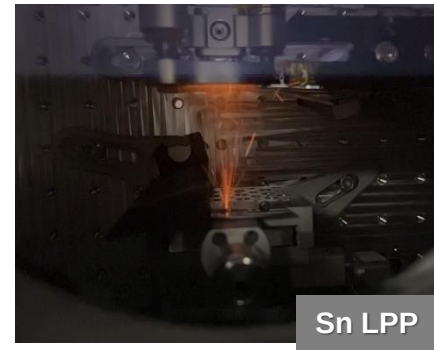
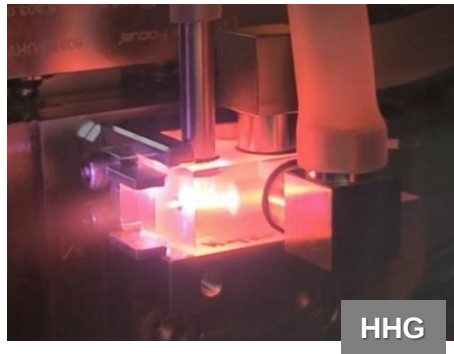
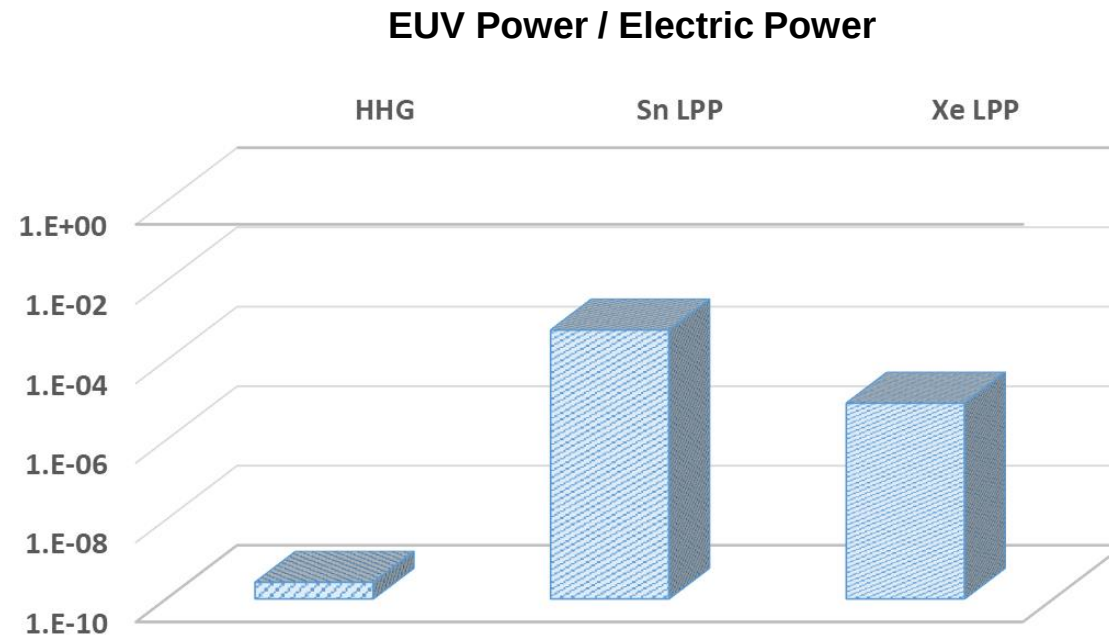
Finding cost effective way as a customer perspective



- Provide the best price competitive EUV equipment
- Designing the industry's lowest maintenance cost

ESOL EUV Source R&D

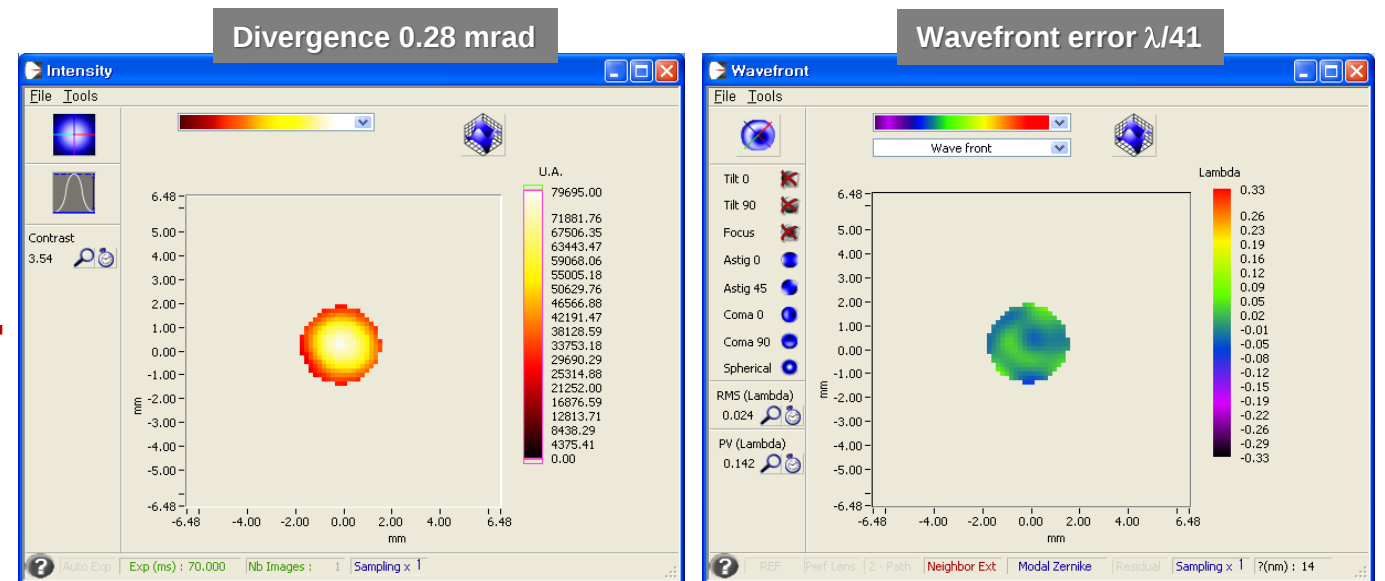
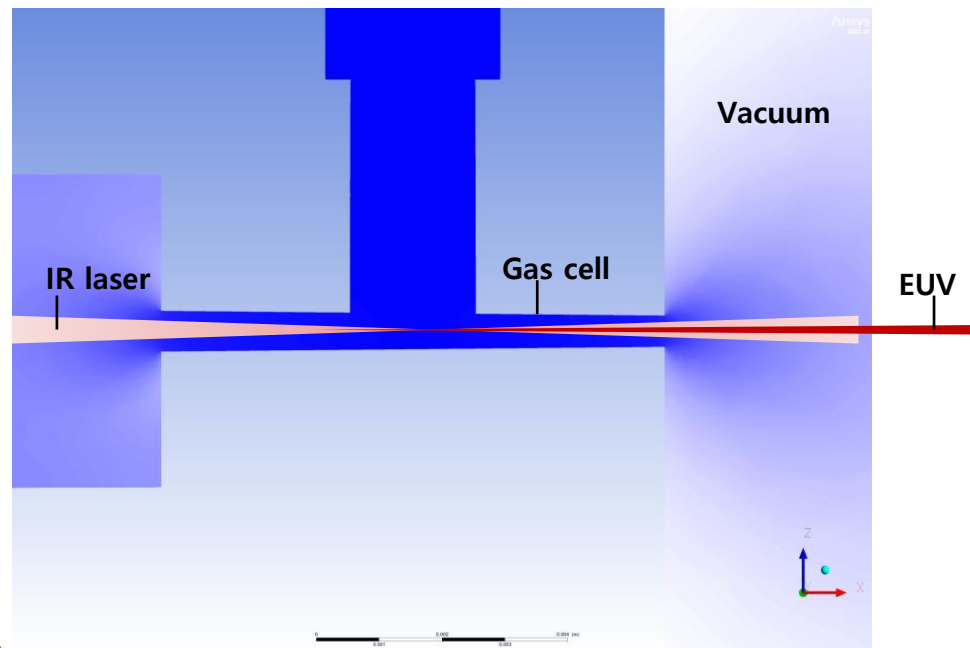
- Based on our test results, the most efficient EUV source is the Sn LPP. However, ...



Laser-Like Coherent Source

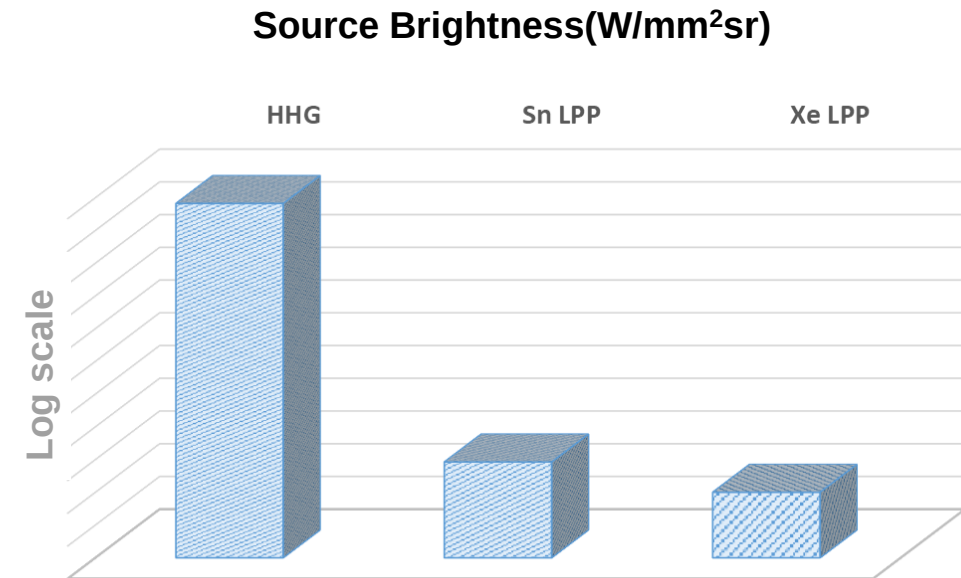
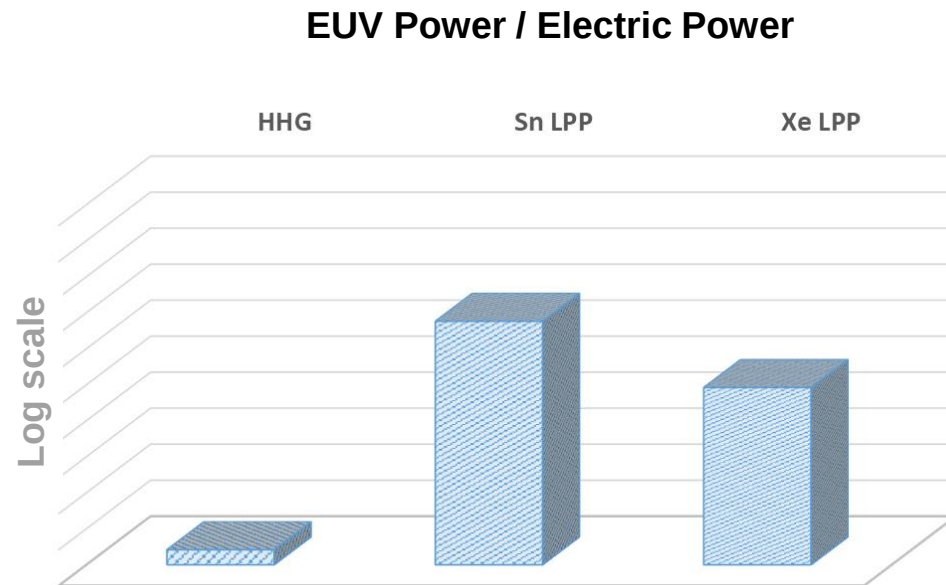
- The coherent EUV source, HHG, has the highest brightness due to its low divergence and small source size.

FST



High Brightness Source

- In the case of an EUV mask review system, where the image size is small and NA0.33/4 is being emulated, the etendue is reduced.
- A high-brightness EUV source like HHG is effective in this application.

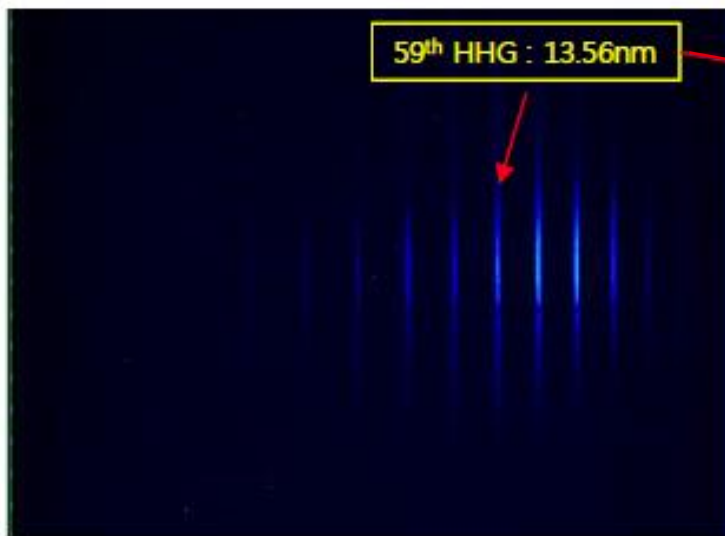


High Spectral Brightness Source

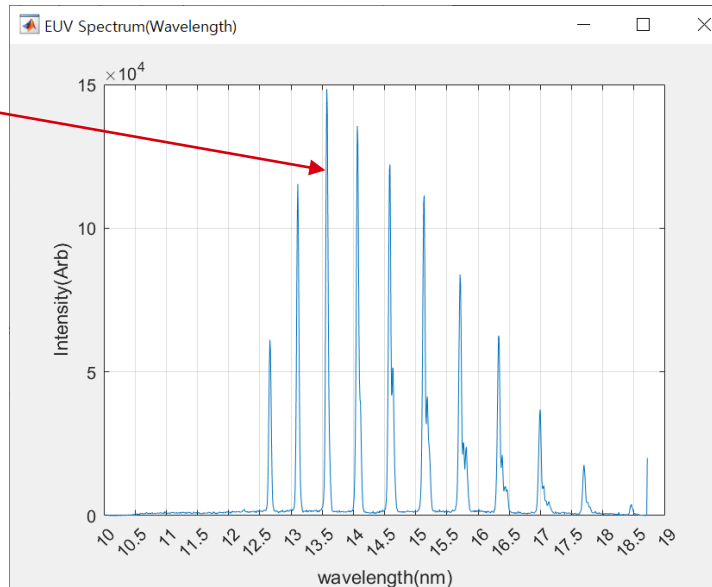
- The spectral width of an HHG source is less than 1/10 of that of Sn or Xe plasma.
- In conclusion, for review systems that employ diffractive optics, where increased chromatic aberration due to spectral width is concern, and require high brightness, and HHG source is well-suited.

FST

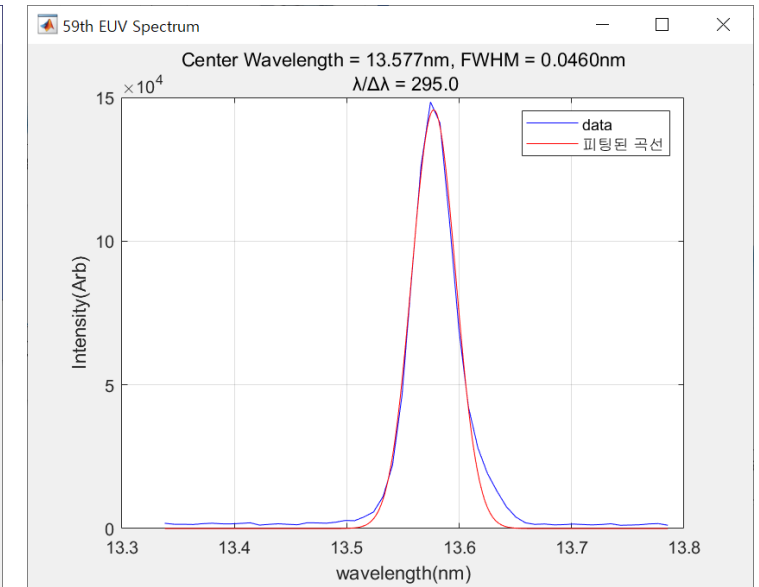
HHG spectrum@ CCD



Wavelength calibrated line spectrum



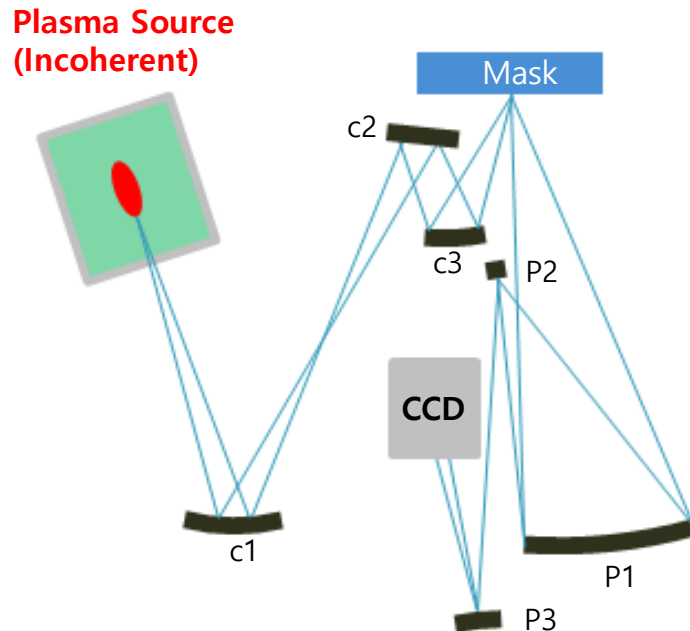
Singe harmonic spectrum



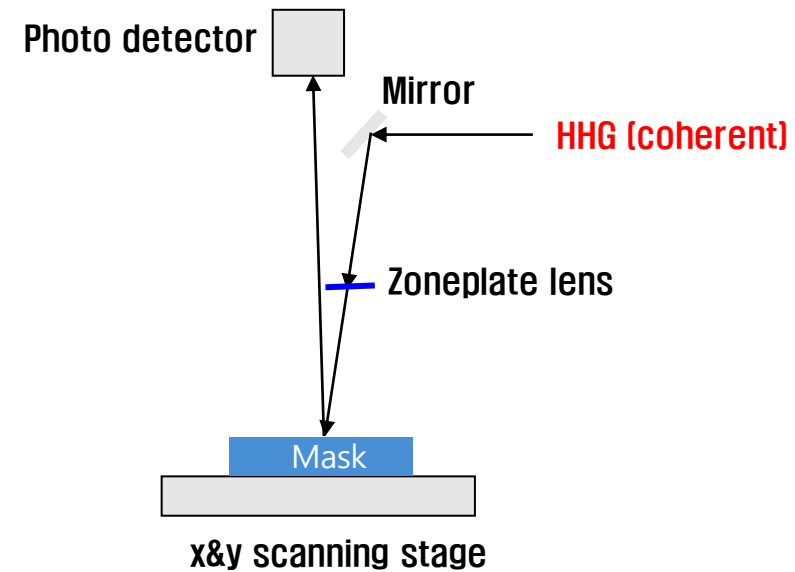
HHG-Based EUV Mask Review System(1/3)

- The application of a low divergence HHG simplifies the condenser optics.
- The implementation of a narrow bandwidth HHG and a Zoneplate lens simplifies the imaging optics.

Conventional System

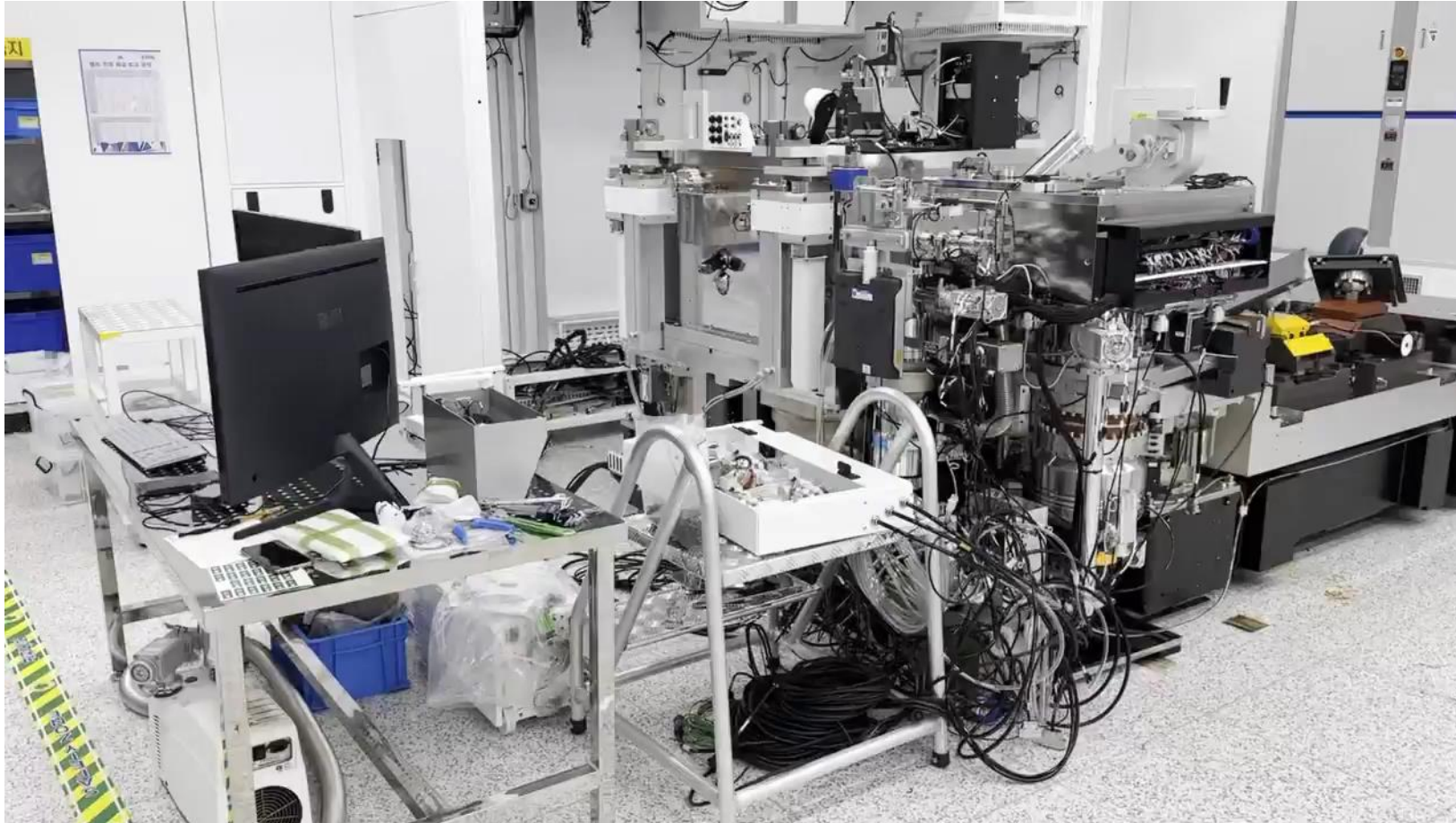


ESOL SREM(Scanning Reflection EUV Microscope)



HHG-Based EUV Mask Review System(2/3)

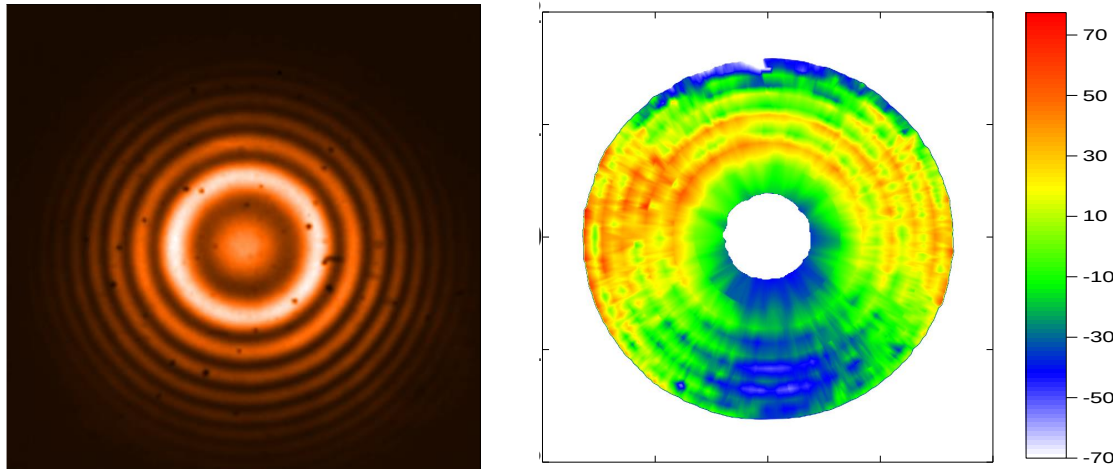
- Images before and after installation of EUV source in SREM



HHG-Based EUV Mask Review System(3/3)

- It took 20 years from the fundamental research of HHG to its application in mass production system.

Coherence and wavefront error measurement
study of HHG in 2003



*Measured HHG's Interferogram

WFE $\sim \lambda/36$ at FWHM

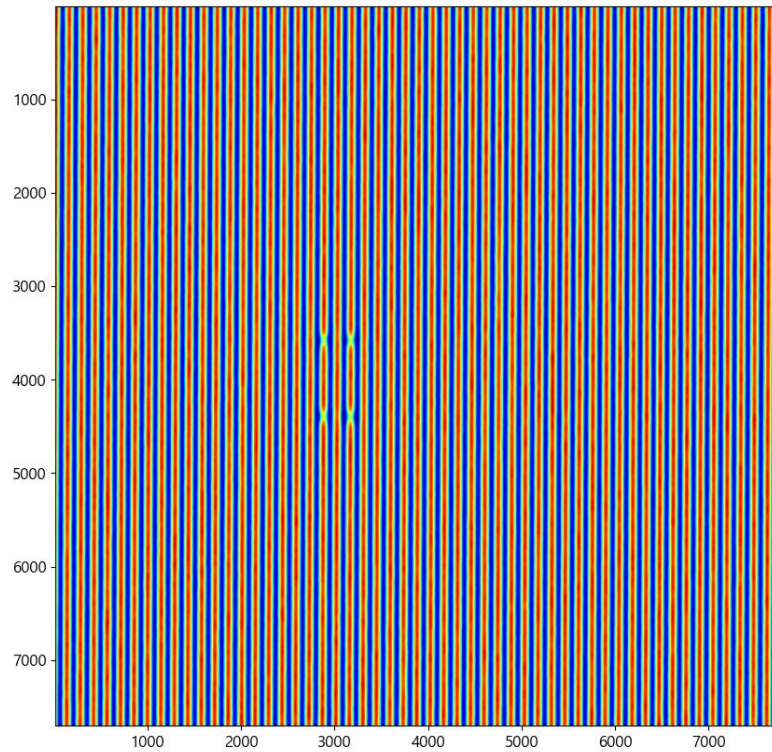
*Source D. G. Lee, et. al., Optics Lett. **28**, 480 (2003)

HHG-based EUV mask review system
implemented in a mass production fab. in 2023

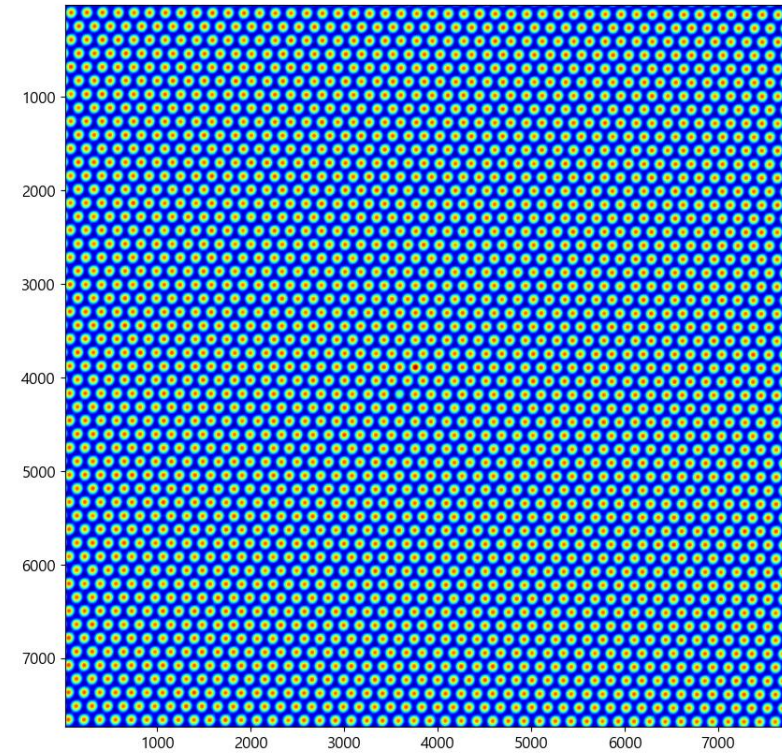


SREM Performance: No Field Aberration

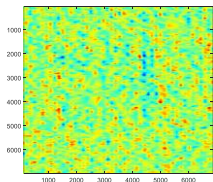
Half pitch 72 nm L/S Pattern (8 μm FOV)



Half pitch 80 nm C/H Pattern (8 μm FOV)



Contrast map

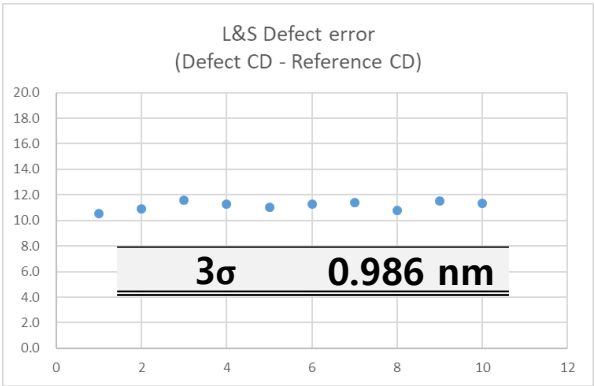
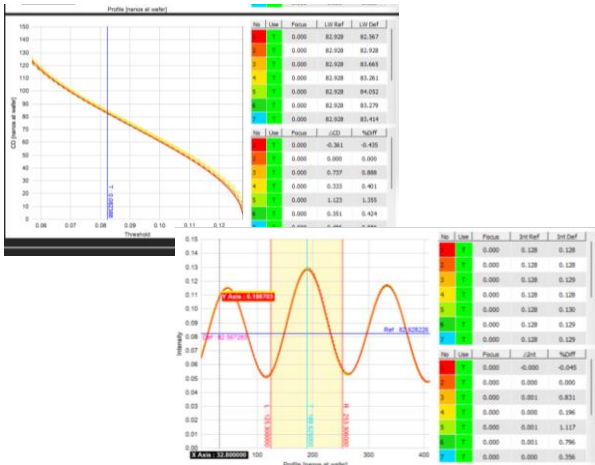
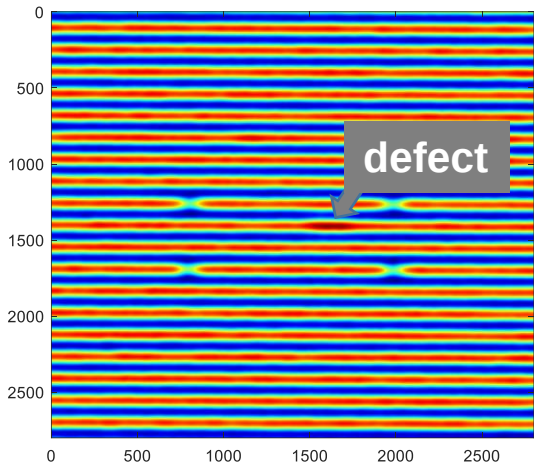


Contrast 3σ (%)

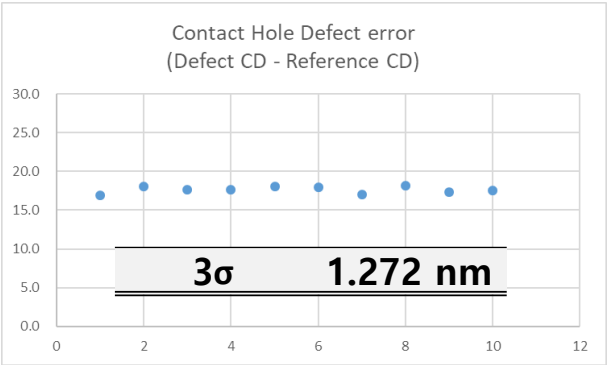
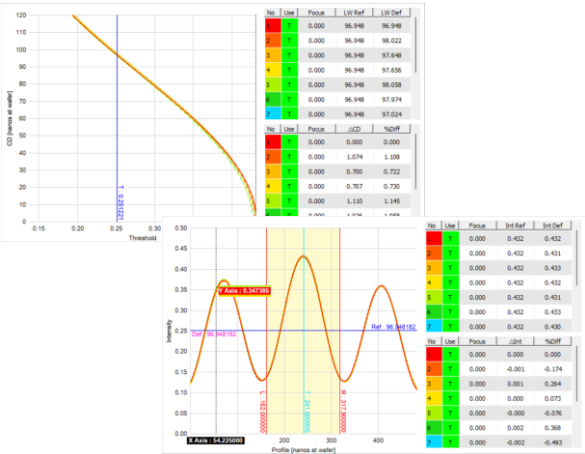
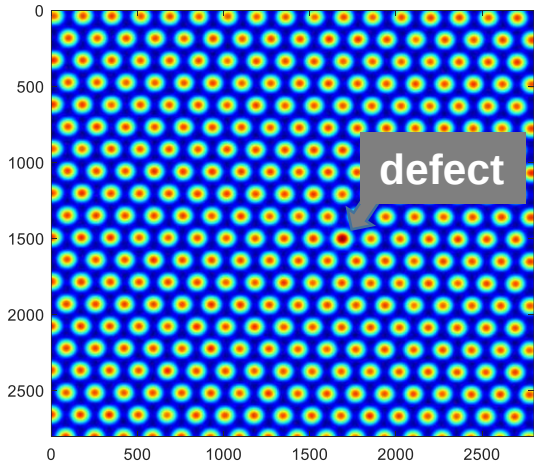
1.3094

SREM Performance: Good CD Repeatability

HP72 nm Horizontal L/S



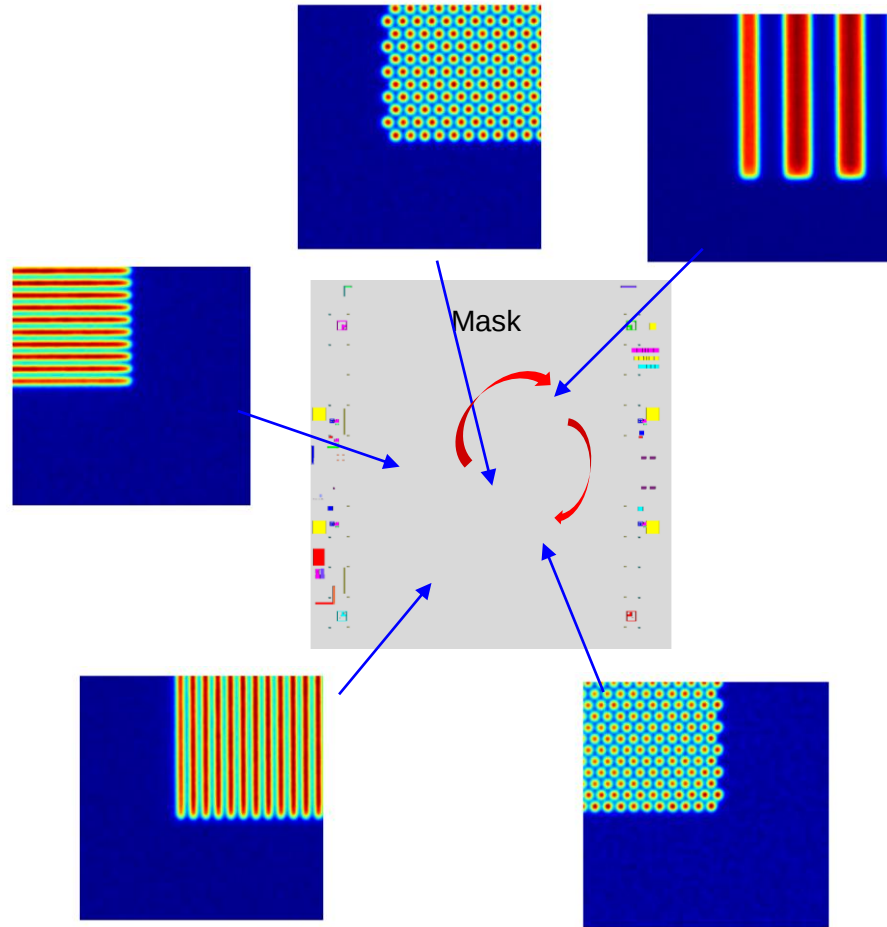
HP80 nm contact Hole



* Defect error: Defect CD - Reference CD

SREM Performance: Good Stage Position Repeatability And Accuracy

Stage position Repeatability Test

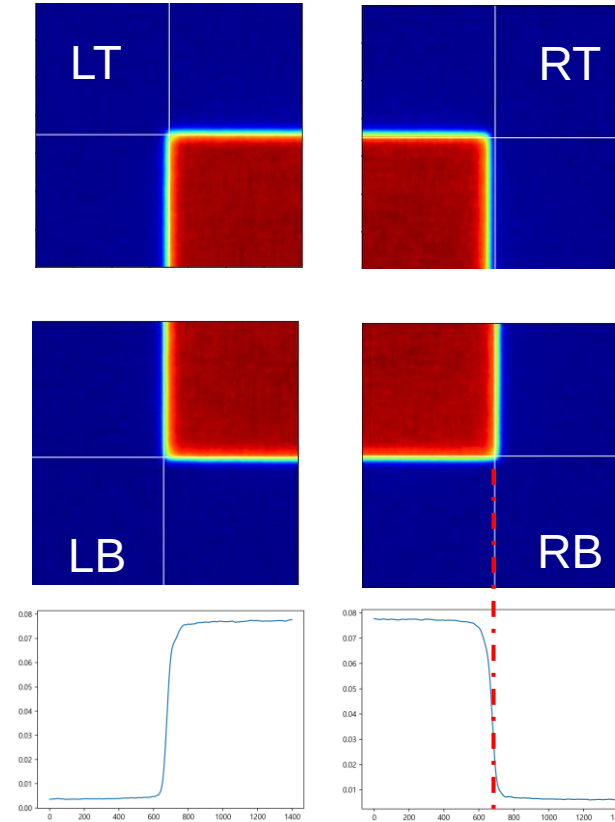


→ Max X shift: < 20.00 nm

→ Max Y shift: < 10.00 nm

Stage position Accuracy Test

Align key image



→ Max X shift: < 50.00 nm

→ Max Y shift: < 60.00 nm

SREM330 And FREM550 Specifications

Major Item	SREM330 (2022 Yr.)	FREM550 (2024 Yr.)	Note
Throughput (sec/image)	< 3 @ 1-um FOV < 9 @ 2-um FOV < 20 @ 3-um FOV	< 4 @ 1-um FOV < 6 @ 2-um FOV < 8 @ 3-um FOV	6 sec/images corresponds to 85 sites/hr. Each site consists of 7 through-focus splits
CD Reproducibility	< 1.5 nm	< 1.0 nm	The reference is a 72 nm L/S pattern
Scanner NA Emulation	0.33	0.33-0.55	For FREM550, it is capable of switching between 0.33 and 0.55
Flexible Illuminator	Hard aperture type (5 seconds to replace)	Physical flex ray (30 x 20 pixels)	When implementing physical flex ray, there are no throughput losses
Uptime	> 90%	> 95%	Uptime = 1- loss (loss includes PM, BM, Down, and other factors)
Annular Maintenance Cost	< 5%	< 5%	The percentage refers to the price of the tool

Summary

- ESOL was established in 2018 and recently delivered the EUV pellicle T/R tool in 2021 and the EUV mask review tool in 2022 to their respective customers.
- Through various quality validations of sources, HHG has demonstrated that despite its low power, it possesses high brightness, making it the most suitable EUV source for actinic review tools.
- The actinic review tool utilizing HHG source, with the application of Zoneplate lens, has a low manufacturing cost. However, the performance of the tool has become a cost-effective solution that meets all the current customer requirements.

 **ESOL**