



Inspection solutions for EUV-mask defectivity applications

For 22nm EUV

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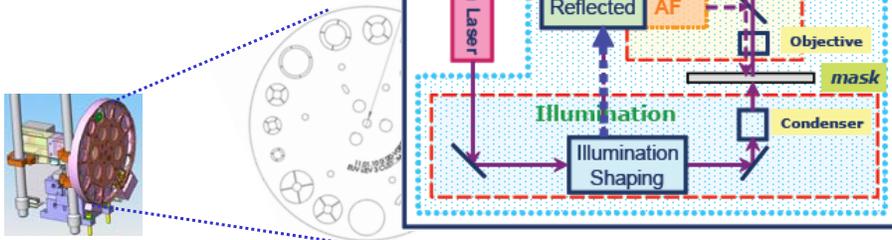
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EUV Mask Inspection Challenges and solutions

- Patterned mask inspection application by DUV optics:
 - Sub wavelength pattern, near resolution limits
 - Thick, highly polarizing mask
 - Very small sub-wavelength defect
- Mask inspection solutions on 193nm inspector
 - Highest resolution
 - Optimal polarization
 - Illumination shaping

Aera3™, designed for EUV masks

- Based on Aera2 platform
- High-Resolution optics channel
- Reflected mode for EUV masks
- New AF tracking mode
- Circular polarization for balanced detection
- Illumination shaping control for contrast enhancements



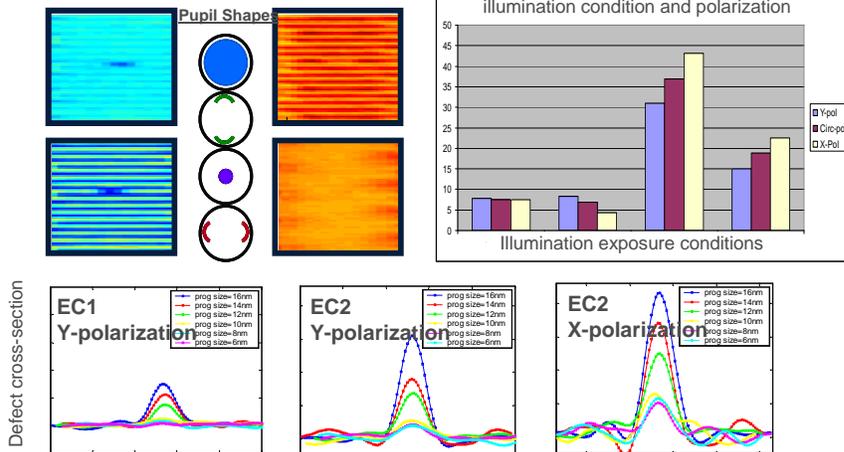
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Using RET Illumination Modes for Detection

L/S 1:1 32nm CD



Aera mask inspection system tested for EUV 32nmHP node early learning

Verdene et al, SPIE 7638-141; (2010)

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32nm L/S Detection Sensitivity – Continuous Improvement Path

- 1st inspection: Aera3 before EUV improvements
 - Larger pixel size, focus mapping
- 2nd inspection: Aera3 with EUV improvements
 - Small pixel size
 - Default illumination-polarization scheme
- 3rd inspection: Aera3 with EUV improvements and optimized illumination
 - Optimal illumination-polarization combination

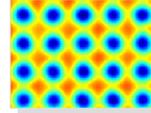
| Size Type | 16 | 14 | 12 | 10 | 8 | 6 | 4 | 2 |
|-----------|----|----|----|----|----|----|----|----|
| A | | | | | | | | |
| B | 48 | 32 | 22 | <8 | | | | |
| C | 48 | 28 | ? | ? | <8 | | | |
| D | | 32 | 28 | 20 | 10 | | | |
| E | | | | 54 | 44 | 36 | 28 | 14 |
| F | | | | 48 | 40 | 36 | 28 | 20 |
| G | | | | 36 | 26 | 20 | 18 | |
| H | | | | 20 | 22 | 16 | 10 | |

Optimized illumination dramatically improves detection sensitivity

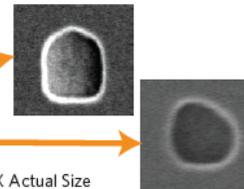
Mangan et al, SPIE 7748-89; (2010)



Patterned Mask Inspection 32nmHP 1:1 Contacts



| Size Type | 30 | 28 | 26 | 24 | 22 | 20 | 18 | 16 | 14 | 12 | 10 | 8 | 6 | 4 | 2 |
|-------------|-----|-----|----|----|----|----|----|----|----|----|----|----|----|----|---|
| Undersize | | | | | | | | | | | | | | | |
| A Surface | 100 | 100 | 84 | 70 | 72 | 58 | 50 | 42 | 36 | | | | | | |
| B Bridge | 86 | 82 | 78 | 74 | 64 | 54 | 52 | 44 | 34 | | | | | | |
| C Pinhole | | | | | | | | | | 34 | 30 | 22 | 20 | | |
| D Cut | 62 | 58 | 50 | 54 | 46 | 42 | 40 | 36 | 34 | | | | | | |
| E Extension | 88 | 68 | 62 | | | | | | | 34 | 28 | 24 | 16 | 12 | |
| F | | | | | | | | | | | | | | | |



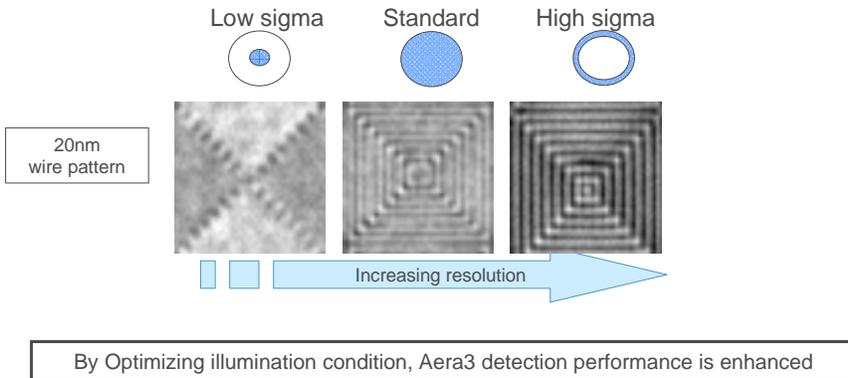
CD 128
CD 208
CD 240

Detection lines extend below 30nm
CD defects measured down to 12nm, compact defects down to 18nm



Aera3 for EUV – Featuring Flexible Illumination

- Aera3 supports flexible illumination conditions.
 - Used to maximize contrast on EUV masks
- Different patterns may develop differently in different illuminations:



Optimized illumination allows extending sensitivities

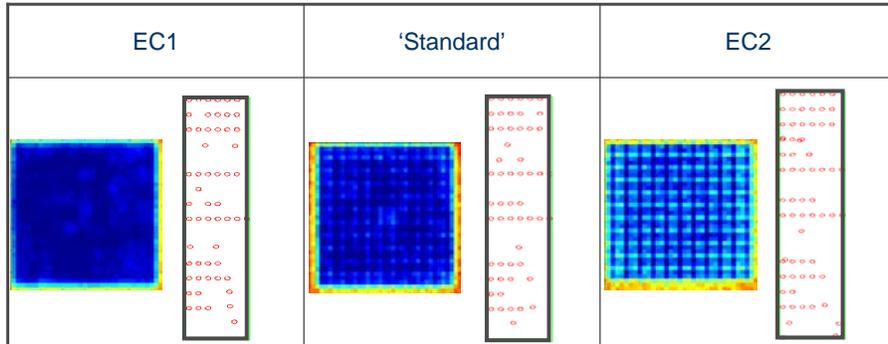
| Semi-iso 20nm | | | | | | | | Semi-iso 17nm | | | | | | | |
|---------------|-----------|------|------|-----------|------|------|------|---------------|------|-----------|------|------|------|------|--|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | 1 | 2 | 3 | 4 | 5 | 6 | |
| T | 50.7 | 39.4 | 25.3 | no defect | | | | | T | 42.2 | | | | | |
| S | 39.4 | 29.6 | 25.6 | 50.7 | 33.8 | 25.3 | 11.3 | S | | | 78.8 | | | 22.5 | |
| R | 29.6 | 26.5 | 42.2 | 19.7 | 8.4 | | | R | | | | 22.5 | | | |
| Q | no defect | | | | | | | | Q | no defect | | | | | |
| P | no defect | | | | | | | | P | no defect | | | | | |
| O | no defect | | | | | | | | O | no defect | | | | | |
| N | no defect | | | | | | | | N | no defect | | | | | |
| M | no defect | | | | | | | | M | no defect | | | | | |
| L | 42.2 | 36.6 | 28.2 | 28.2 | 22.5 | 11.3 | 11.3 | L | | | | 16.9 | | | |
| K | 49.8 | 36 | 27.6 | 24.5 | 18.3 | 10.7 | 4.2 | K | | | | 25.6 | 12.9 | | |
| J | 45.3 | 37.7 | 28.2 | 25.3 | 20.3 | 13.5 | 8.7 | J | | | | 19.1 | 13.8 | | |
| I | 33.8 | 33.8 | 25.3 | 25.3 | 19.7 | 11.3 | | I | | | 19.7 | | | | |
| H | 38.8 | 36 | 28.4 | 20.8 | 16.9 | 12.4 | 6.5 | H | | | | | 11.3 | | |
| G | 38 | 32.7 | 29.8 | 24.2 | 16 | 9.3 | 3.7 | G | | | | 22.5 | 11.5 | | |
| F | 16.9 | 11.3 | 5.6 | | | | | F | 19.7 | | | | | | |
| E | 22 | 12.9 | 8.4 | | | | | E | 25.3 | | | | | | |
| D | 18.9 | 13.2 | 8.4 | | | | | D | 19.7 | | | | | | |
| C | 14.4 | 11.3 | 8.4 | | | | | C | 11.3 | | | | | | |
| B | 22.5 | 20.3 | 11.8 | 8.4 | | | | B | 19.7 | | | | | | |
| A | 22 | 18.3 | 15.5 | 9 | 8.4 | | | A | 19.7 | | | | | | |

FA count < 40 FA count < 10

100% capture rate
Partial Detection

Detection of 20nm defects is achievable down to 20nm features

Optimized illumination allows extending sensitivities CON layer 20nm,



Optimal EC (defect detection): Non standard - EC2

Aera3 for Early Learning 22nmHP EUV Masks inspection

Imaging

- DUV optics resolution supports 20nm CD and below
- Contrast is maximized by RET-like illumination shaping technology

Inspection

- Non standard illumination provides enhanced detection and superior resolution

Defect types and sizing

- Sensitivity down to 20nm defects sensitivity on compact pattern defects

Aera3 mask inspection – a learning tool for EUV 22nmHP challenges



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