Correlation between printability and visibility of defects in EUV mask blanks

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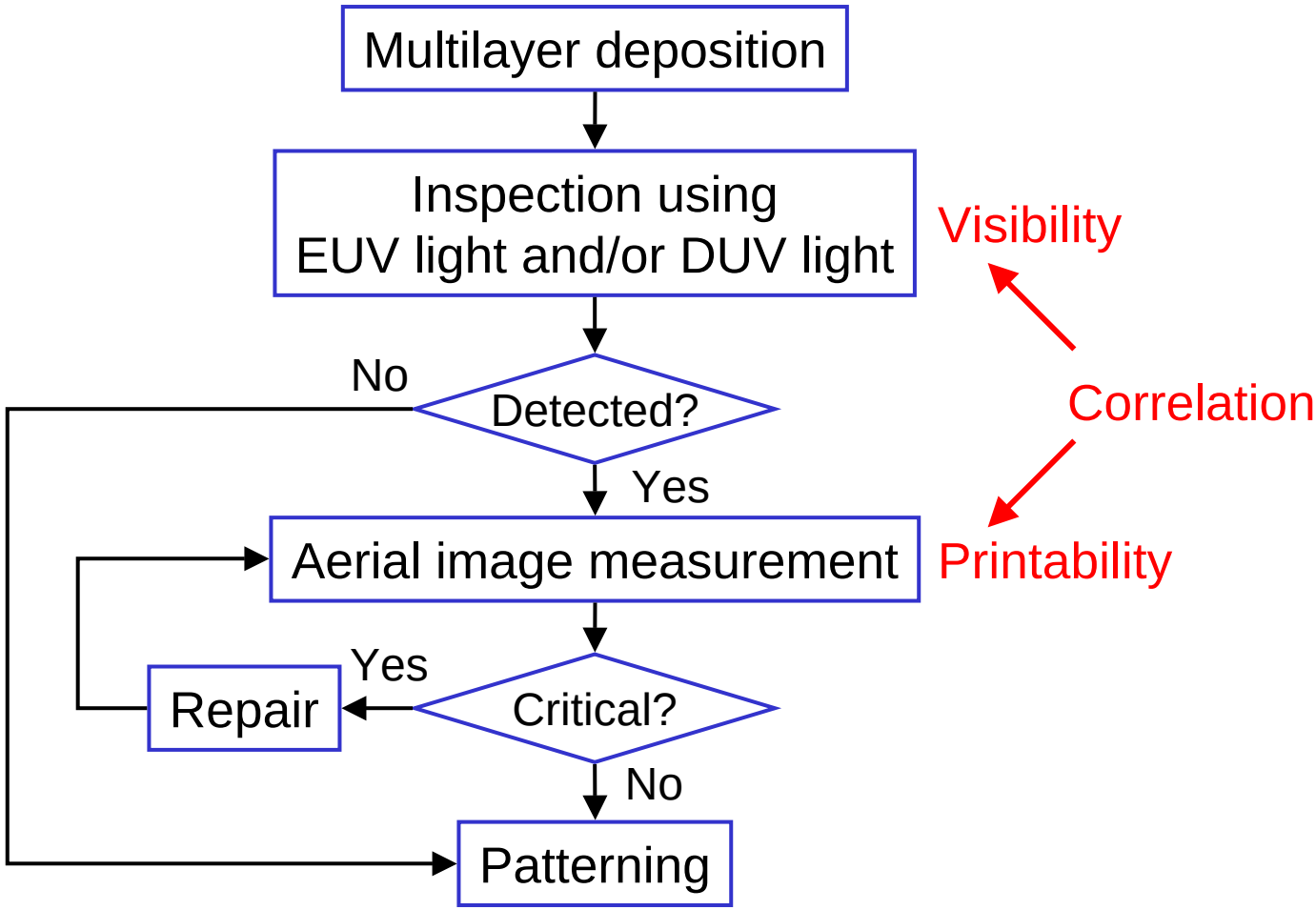
Outline

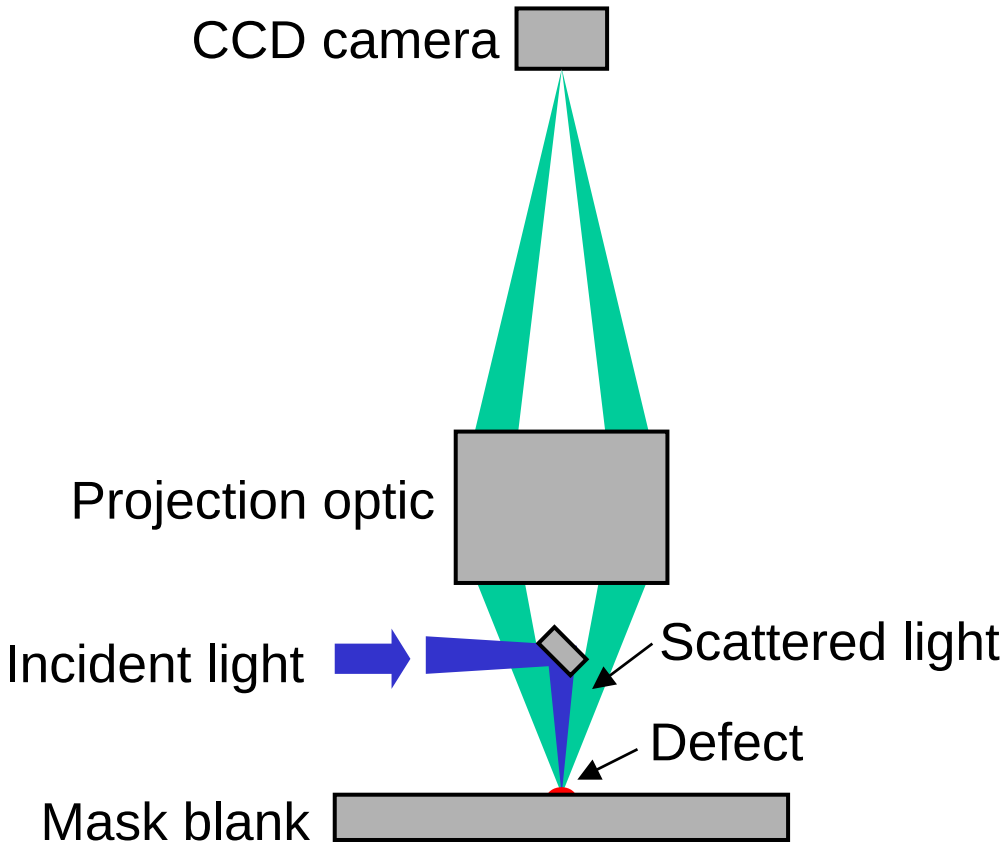
- Introduction
- Simulation method
- Results and discussion
  - ✓ Printability of isolated defects
  - ✓ Inspection by EUV dark-field imaging
  - ✓ Visibility versus printability
- Conclusion

Mask blank inspection scheme

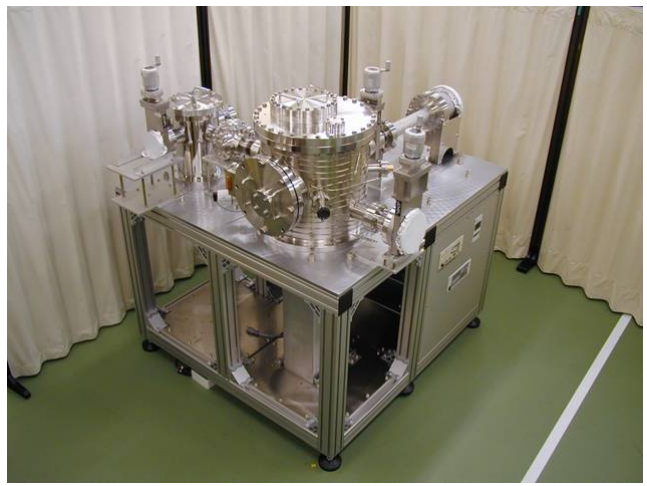


Mask blank inspection tool

- ✓ Defects are detected by EUV dark-field imaging.
- ✓ The signal is proportional to the total image intensity.



Proof-of-concept tool:
Magnification = 20
CCD pixel size = 13.5 μm



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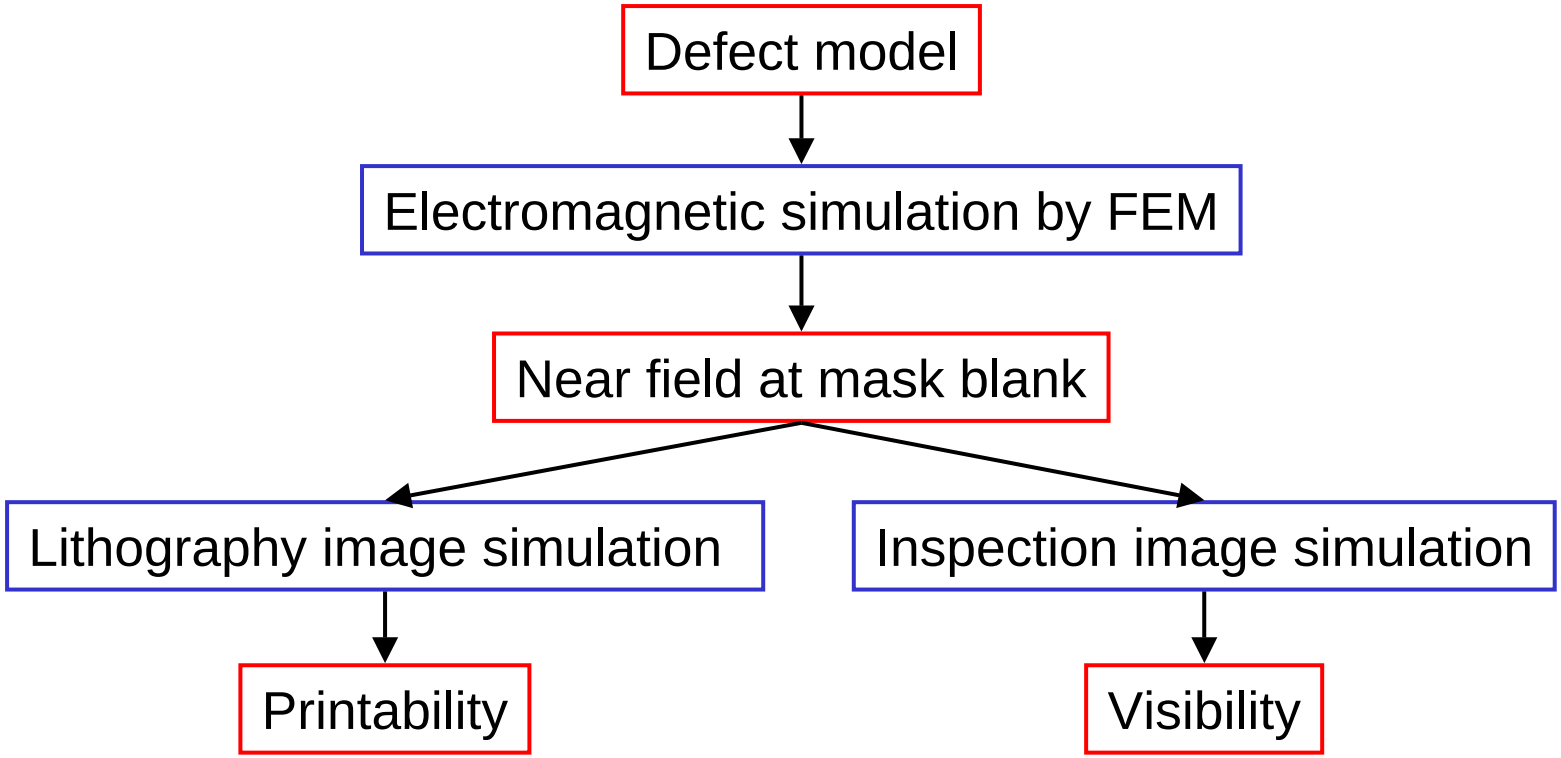
Overview of simulation



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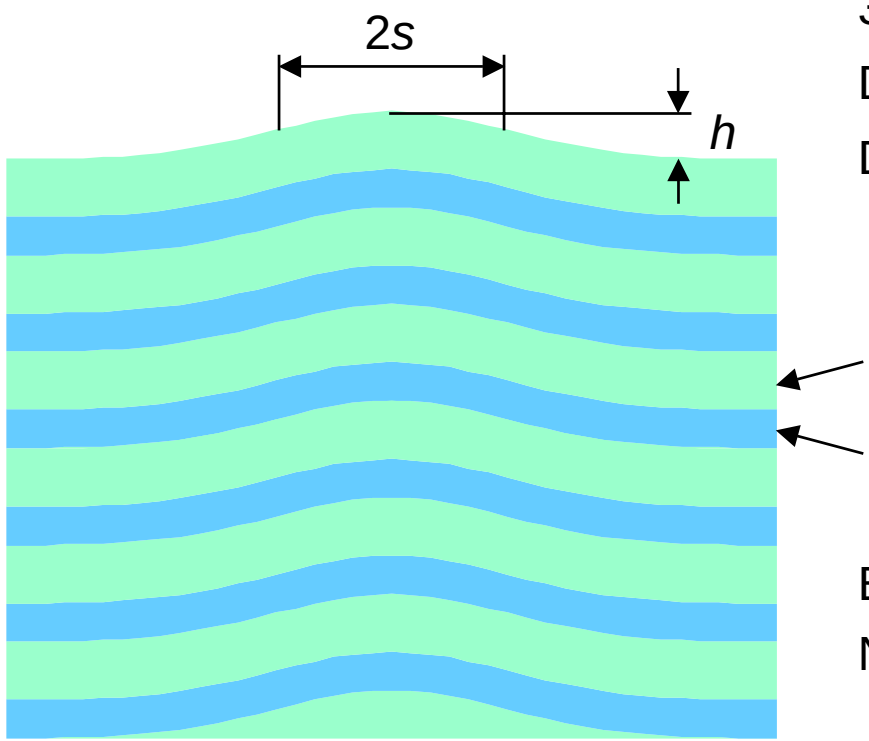
Mask blank defect model

✓ Layer profiles are identical and Gaussian-shaped.



3-D Gaussian: $z = h\exp(-\frac{x^2+y^2}{2s^2})$

Defect height = h

Defect width = $2s$ = 0.85 x FWHM

Bilayer thickness = 6.98 nm

Number of bilayers = 40

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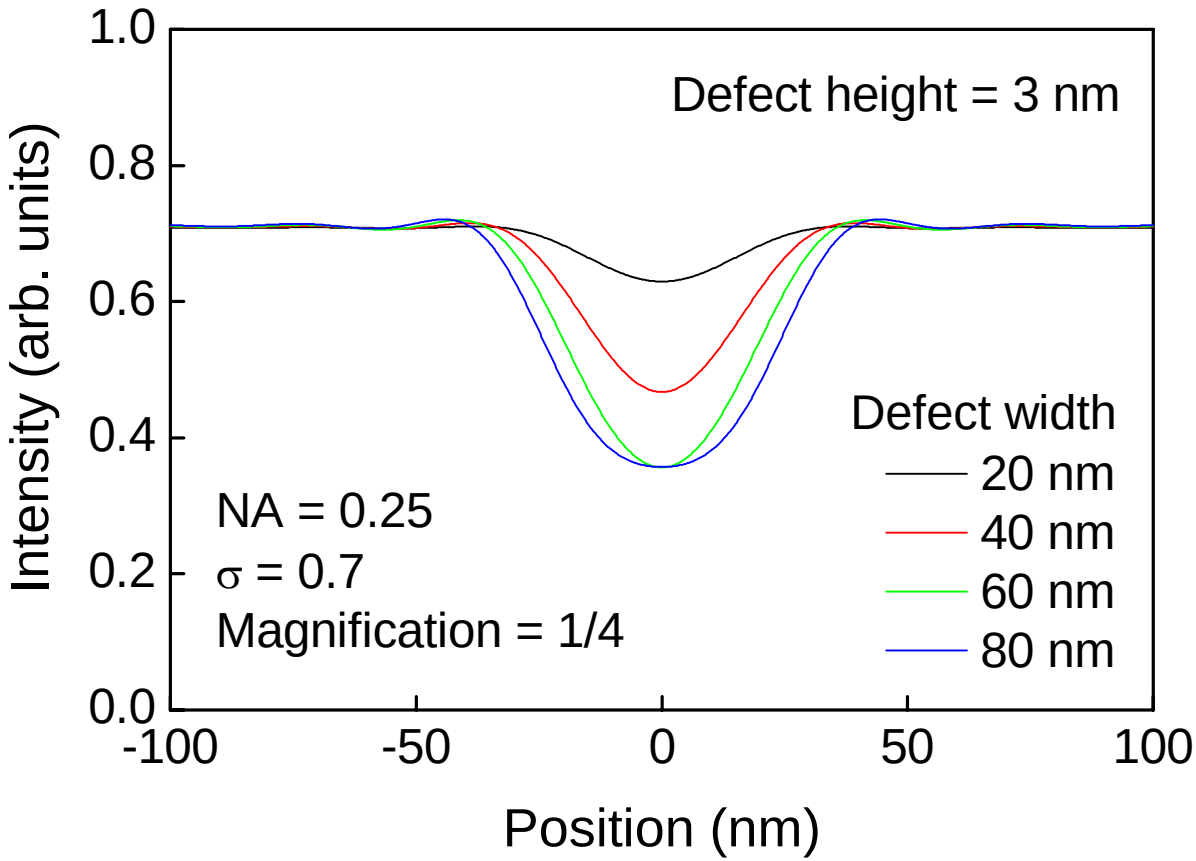
Image intensity of isolated defects



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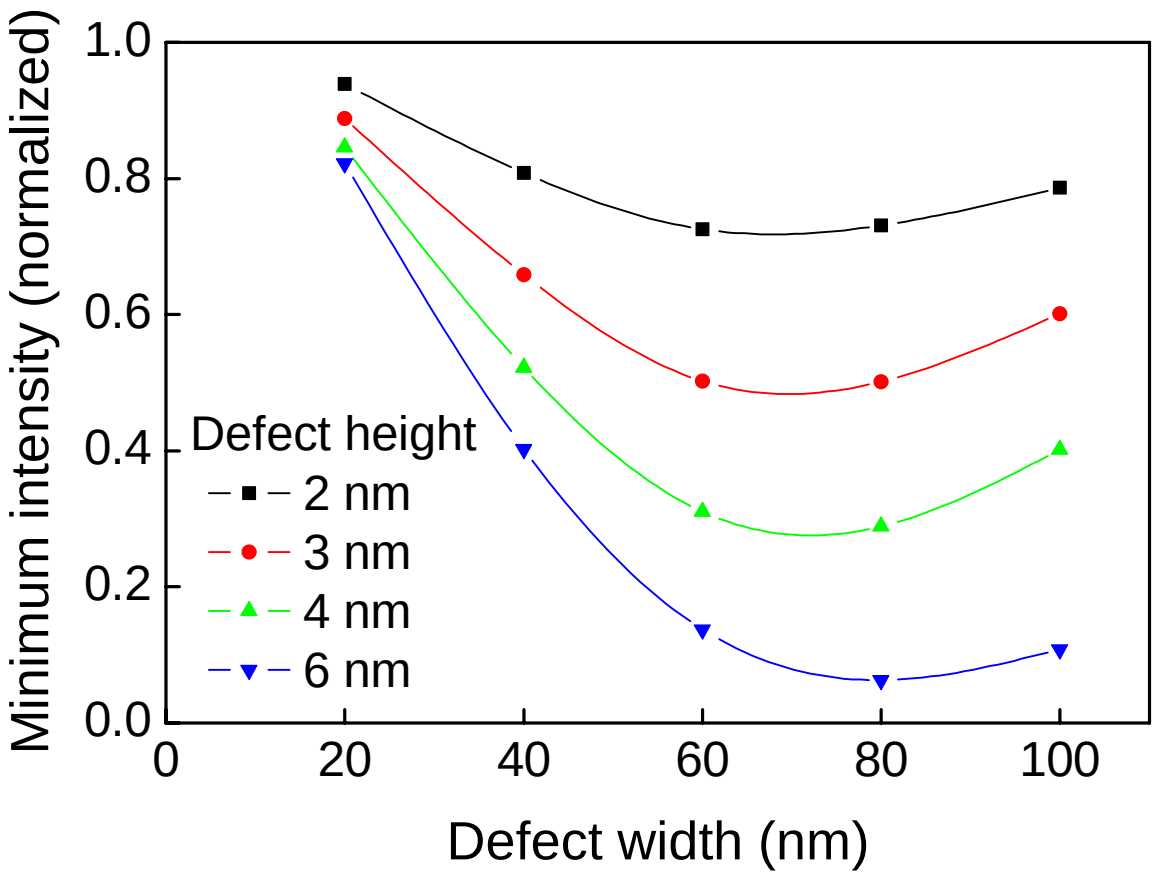
Printability vs defect size



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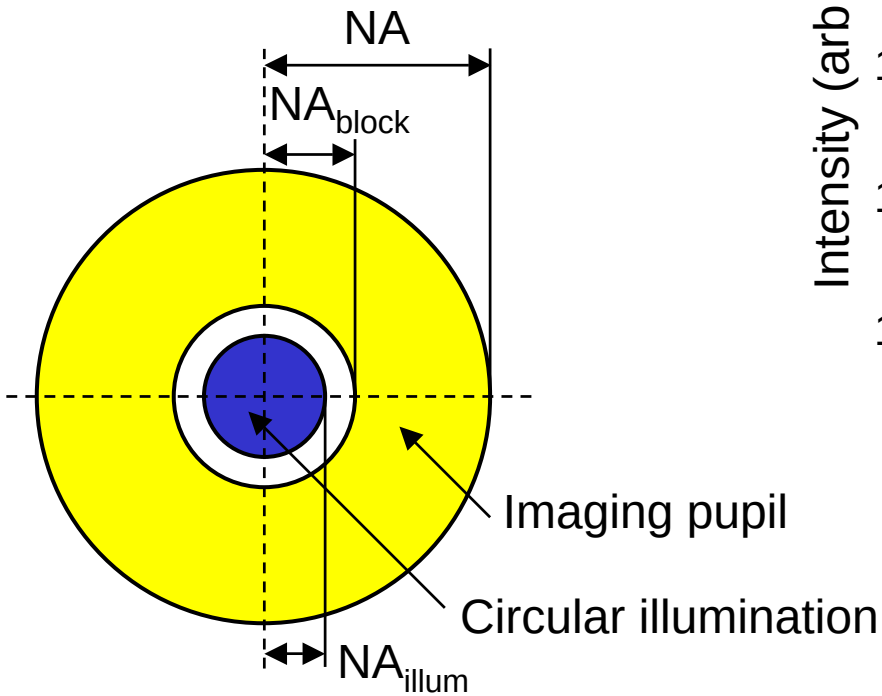
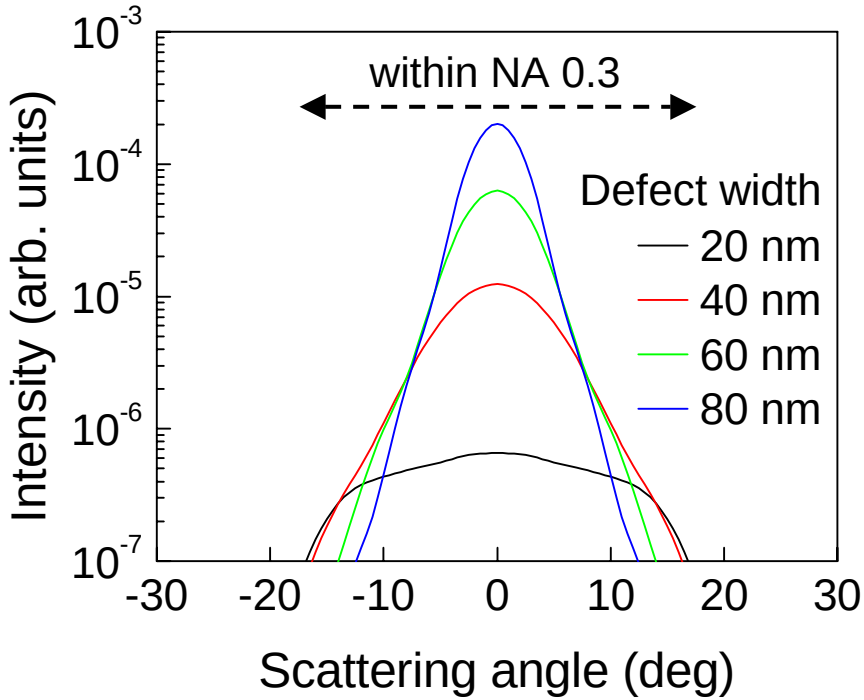
Dark-field imaging system model

NA = 0.3

NA_{block} = 0.1

NA_{illum} = 0.08





Scattering at normal incidence

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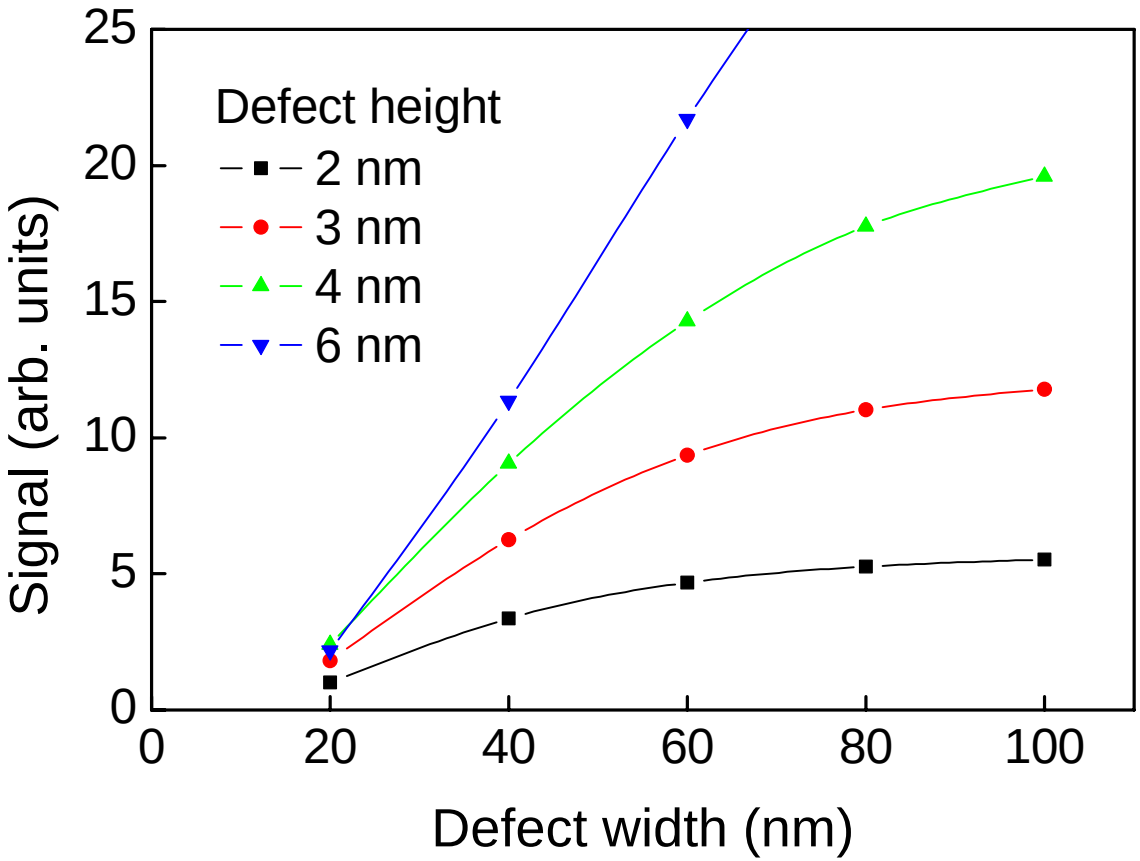
Visibility vs defect size



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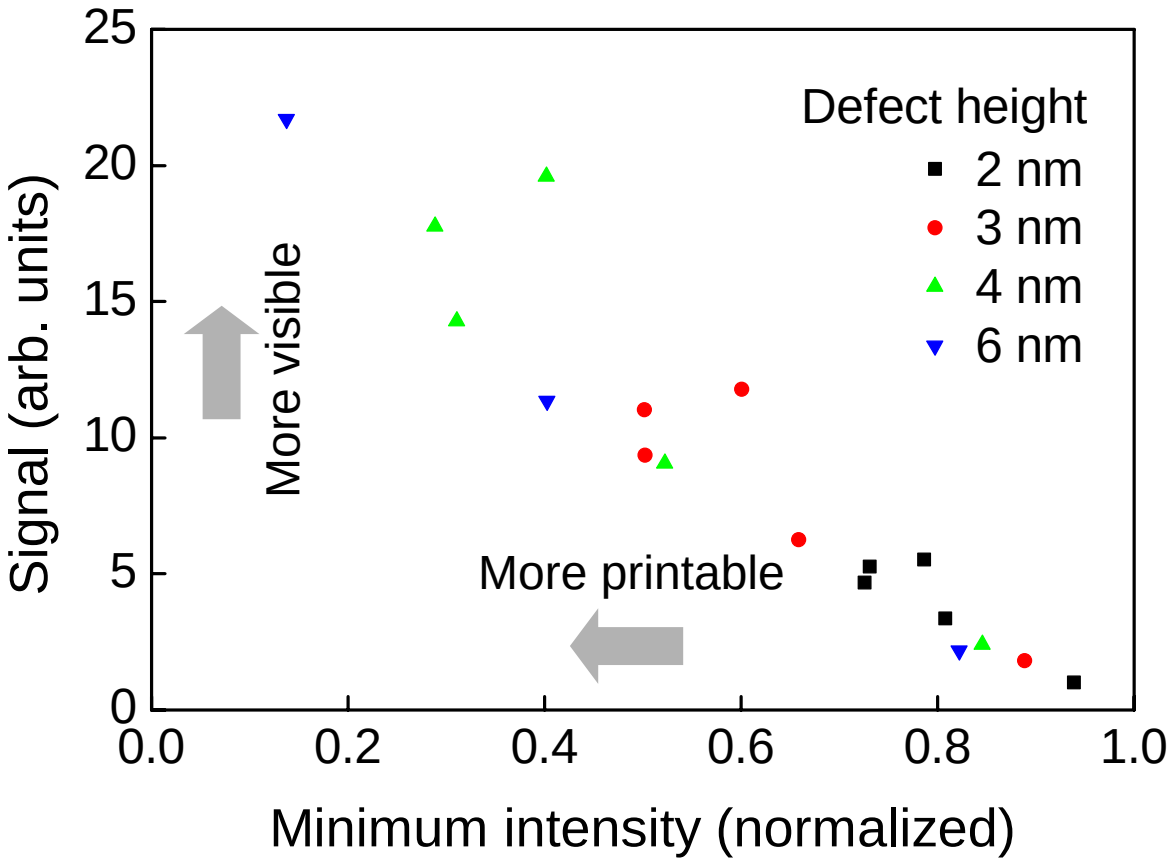
Visibility vs printability



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Conclusion

- Electromagnetic simulations and image simulations were performed for Gaussian-shaped defects with width 20-100 nm and height 2-6 nm.
- When an isolated defect is printed, the largest drop in the image intensity occurs at width of 60-80 nm; and a higher defect is more printable.
- For defects with width up to 80 nm, the inspection tool's signal obtained by dark field imaging is in inverse proportion to the minimum intensity of the printed image.