

Investigation of high-resolution contact printing

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Introduction/Motivation

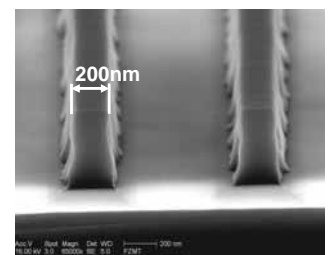
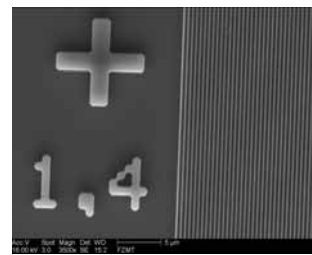
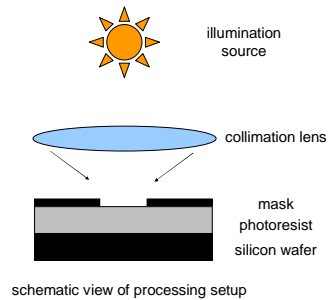
- mask aligners offer a cost-efficient alternative to expensive projection optics
- proximity and contact printing is frequently utilized at universities, research centers, and also small and medium enterprises (SMEs).
- resolutions down to 200 nm are possible using conventional mask, resist and illumination
- some combinations of line/space widths lead to specific light interference resulting in deteriorated resist profiles (M-shaped cross-sections, V-shaped line ends)
- simulation helps to understand processes and to eliminate unwanted artifacts
- the application domain of contact/proximity printing can be expanded in this way

Experiments

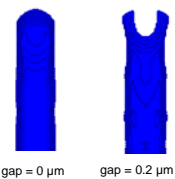
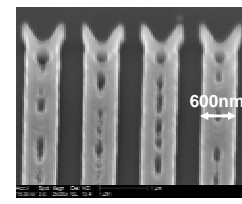
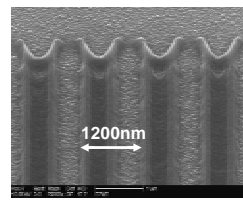
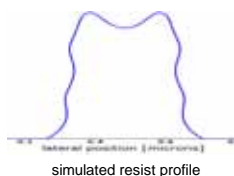
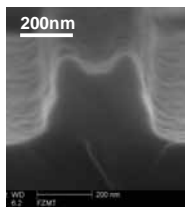
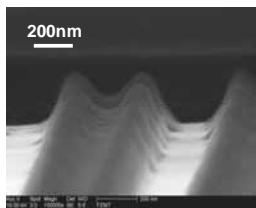
High-resolution results

Lithography Process conditions

- conventional (binary) masks
- broadband illumination
- exposure dose: 6 - 9 mJ/cm²
- commercial photoresist (AZ 6612)³, diluted, deposited on silicon wafer
- resist thickness: 360 nm



Artifacts: M-shaped cross-sections, V-shaped line ends



- effects due to specific light intensity distribution below the mask
- sensitive to pitch and proximity gap
- very deep M-shapes in some cases: critical as thin resist can not withstand dry etching

Possible causes of nonzero proximity gap:

- imperfect flatness of mask/wafer
- resist outgassing
- contamination particles

Simulation

Methods

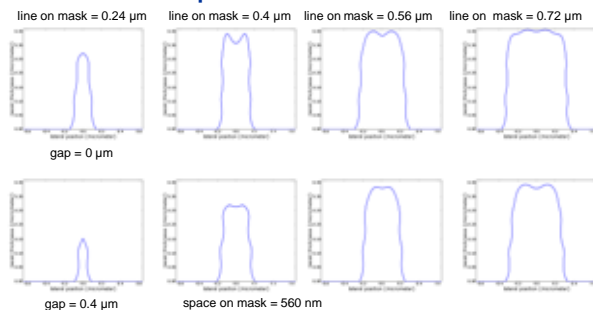
exposure modeling:

- method based on diffraction theory, for fast predictive simulations
- rigorous electromagnetic modeling (FDTD), for accurate simulations

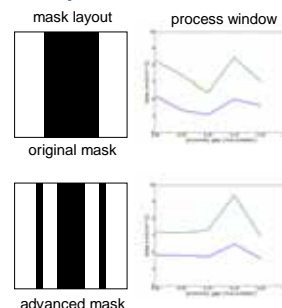
resist modeling:

- simple model based on development threshold (accurate resist parameters are not available)

Simulated resist profiles



Mask optimization



Parameters:
800 nm full pitch
target CD: 400 nm +/- 10%
broadband illumination

improved process window due to optimization

Summary

- contact printing processes using conventional techniques were investigated
- resolution down to 200 nm is possible
- special effects due to light interference below the mask arise in dense structures
- effects are sensitive with respect to pitch and proximity gap

References

- B. Meliorisz, A. Erdmann: Simulation of mask proximity printing, *Journal of Micro/Nanolithography, MEMS and MOEMS*, Apr-Jun 2007, Volume 6, Issue 2, 023006
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