EUV Mask Development:
Mask Pilot Line at Infineon

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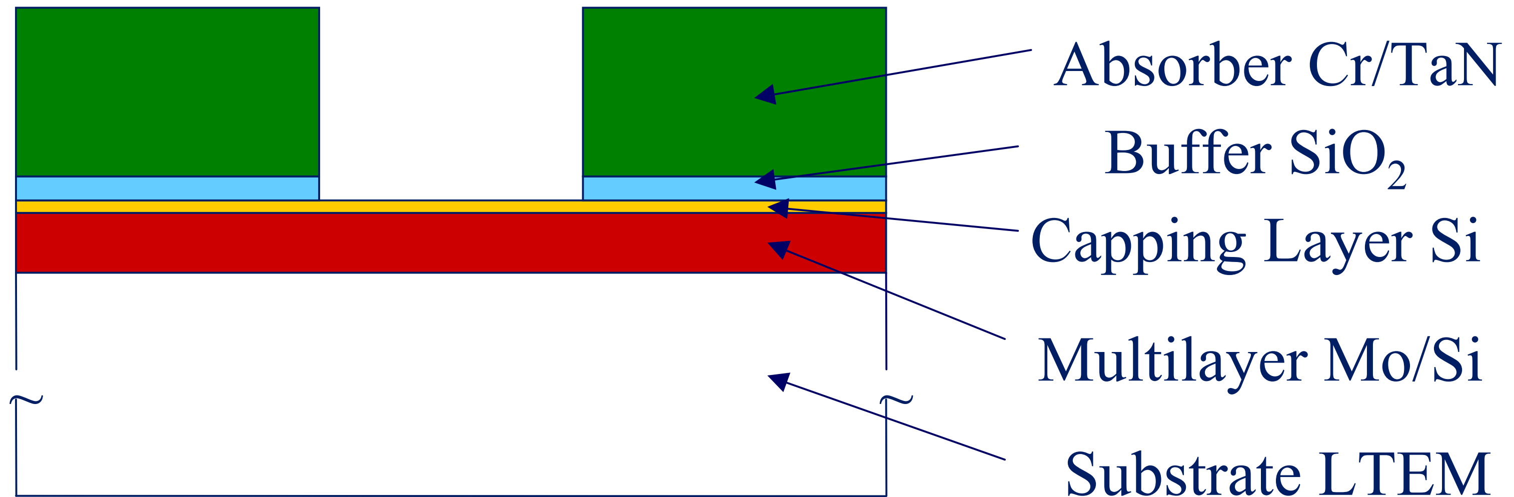
Outline

- EUV Mask Concept
- Mask Processing Flow
- Mask Pilot Line
- Results of Processing
- Conclusions

EUV Mask Concept



- Open issues :
  - Removable pellicle
  - Additional layers (etch stop, conductive, backside, smoothing)
  - Handling structures/ mounts
  - Capping layer material

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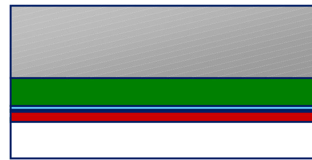
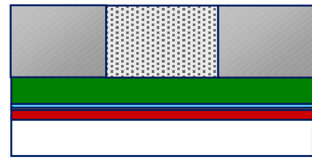
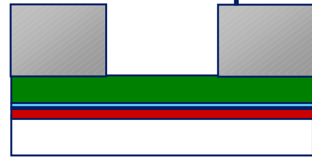
EUV Mask Process Flow



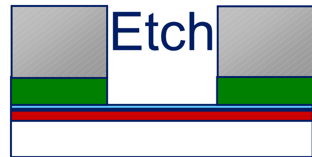
Write



Develop

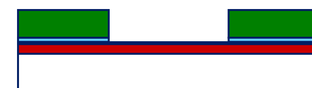


Absorber Etch

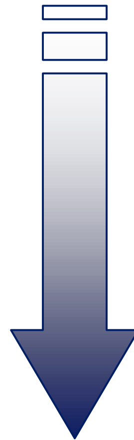


Strip

Buffer Etch



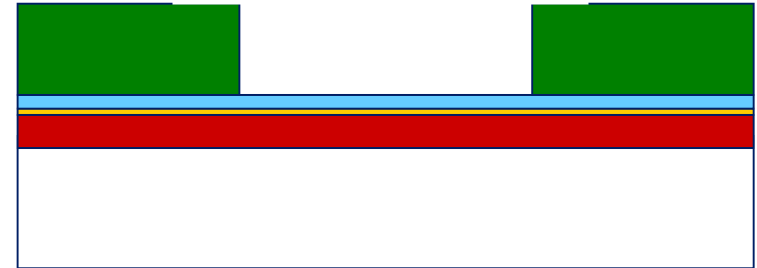
Front End Process (Overview)



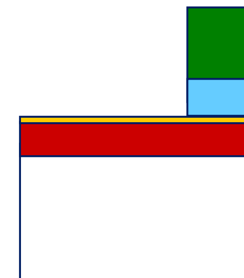
Back End Processes

- Clean
- Metrology
- Inspection
- Repair

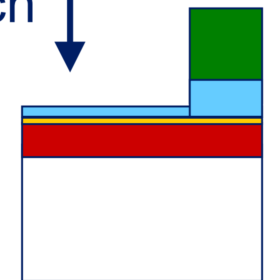
Etch Process



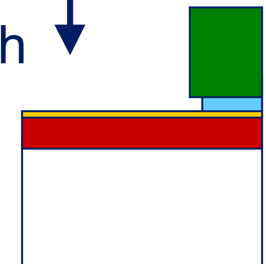
Dry Etch



Dry Etch



Wet Etch



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Infineon/IMS EUV Mask Pilot Line

Steag ASR 5000 or Steag ASP 5000

Data Prep.

Supplier Blanks

DFX Blank Inspection

Leica SB350

ETEC Alta

Toshiba EBM

PEB

LEO 1560 CD-SEM

STEAG ASP5000 Developer

Developer

Lasertec 2000 Inspection

Plasmatherm SLR 770

Leica LMS IPRO 2 Placement

Quantronix Laserrepair

STEAG ASC 500 Strip/Cleaning

KLA CD-SEM

Amat Centura 5200

SNP 9000 Nano Profiler

Micrion FIB Repair

STEAG ASC 500 Cleaning

KLA SLF 77 Inspection

RAVE

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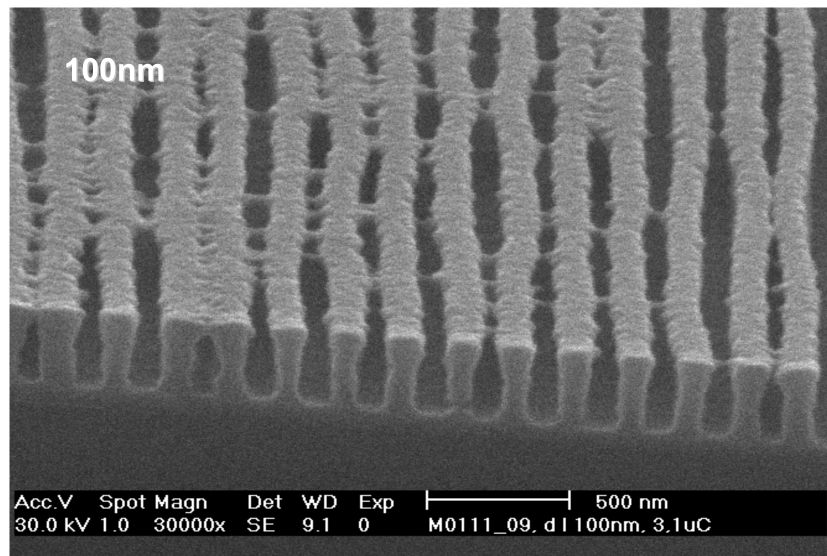
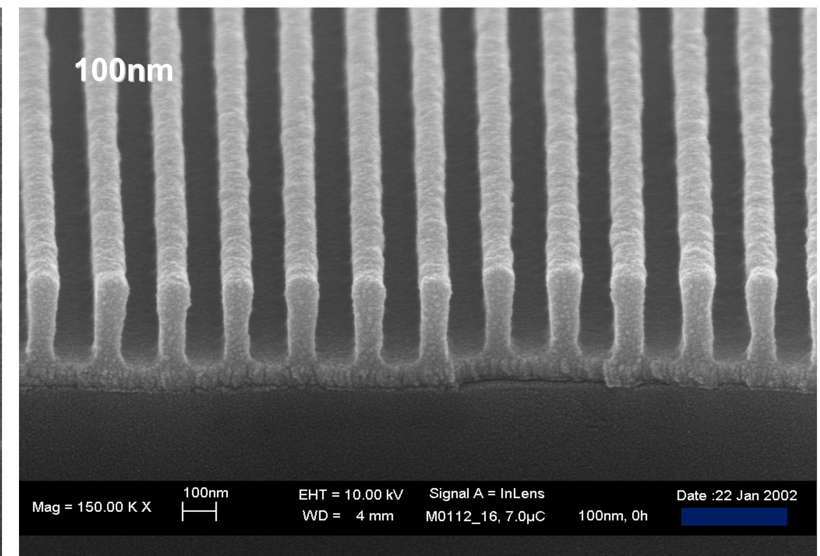
Resist Evaluation for EUV Mask Patterning

Resist A, 350nm



Resist B, 350nm



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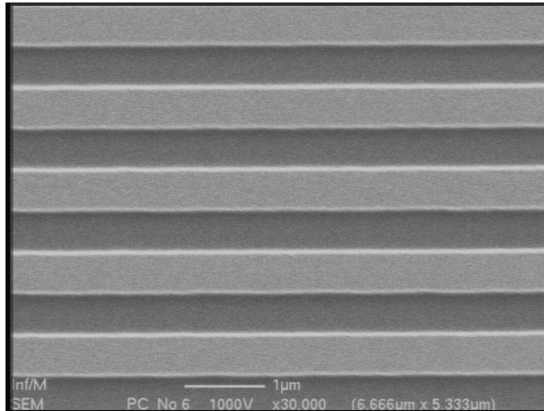
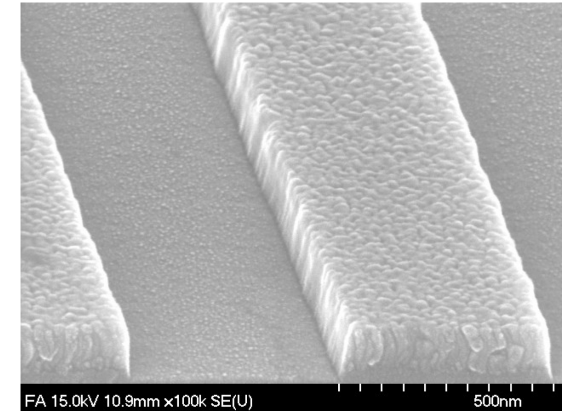
26.02.2002

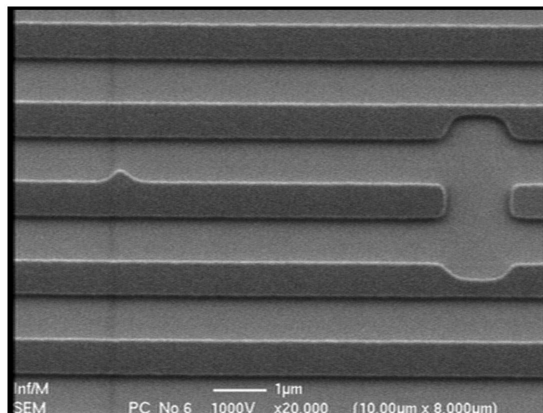
Process Evaluation - Alta Line



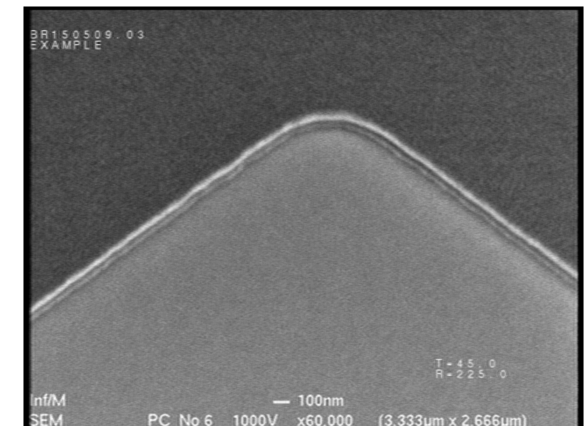
CoG Mask
(only Cr-Etch)



Dummy Mask
(after Cr and
Quartz-Etch)



Multilayer Mask
(after Cr- and
Quartz-Etch)



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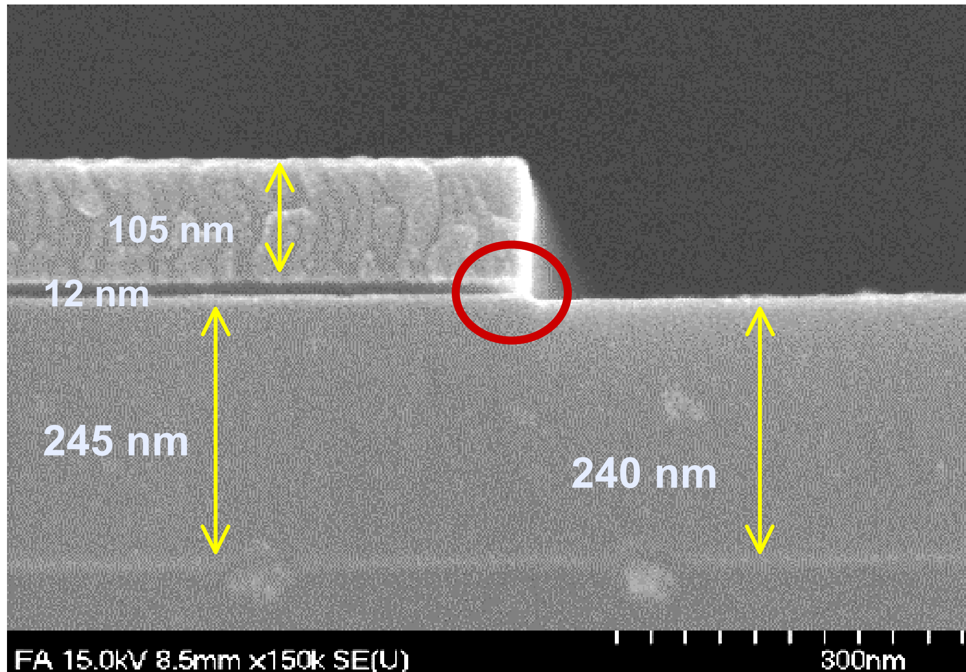
Etch Development - Dry Etch Process



- Cr: Cl/O Chemistry
- SiO_2: Cl/F Chemistry

- Absorber angle >85°
- 3-5nm overetch into Si
- Etch rate of SiO_2: 1.28nm/s
- Etch selectivity SiO_2:Si = 1.4:1

To avoid Si-cap overetch while accepting small lateral underetch:

9 nm Plasma C/F etch + 11 nm HF Etch

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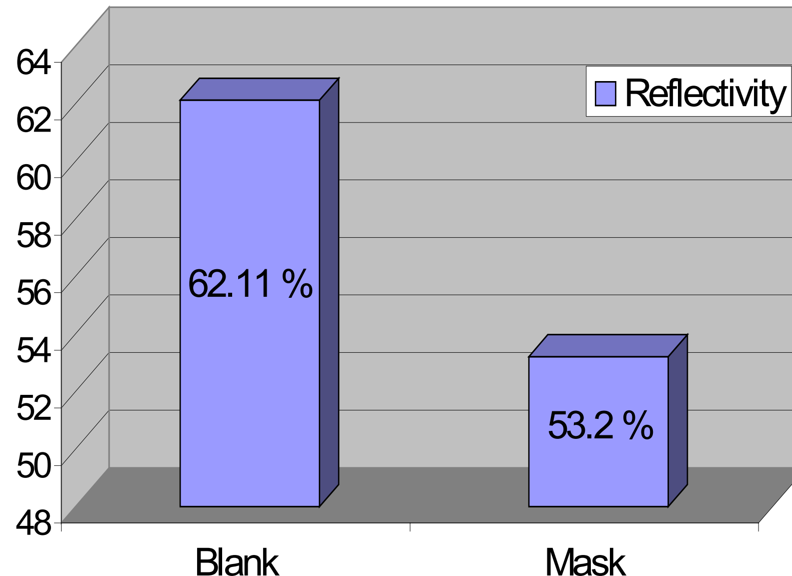
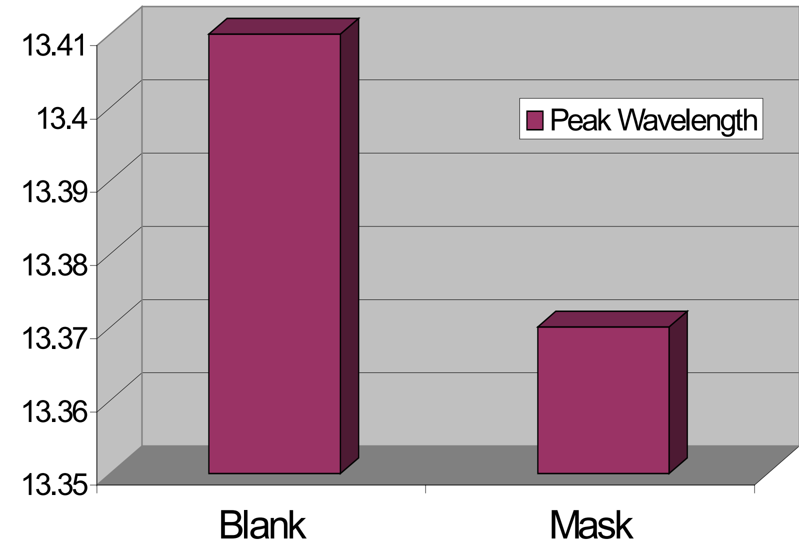
Influence of Processing on EUV Reflectivity





Measurements by E. Gullicson (ALS) and B. Meyer (PTB/BESSY-II)

- Approx. 9 % reflectivity loss (absolute) after processing
- Small wavelength shift → smaller d-spacing
- Origin currently under investigation :
  - etch depth, uniformity, contamination layers ?
  - thermal load ?

EUV Multilayer Mask Inspection

- KLA-Tencor SLF27
  - Wavelength 365 nm
  - Inspection with highest sensitivity setting
  - Inspection contrast smaller compared to phase-shift or Cr-masks
- Lasertec MD 2000
  - Wavelength 633nm (reflected light)
  - Inspection with standard settings
- Common parameters
  - Only reflected light inspection
  - Die-to-die inspection
  - Inspected area 550mm²

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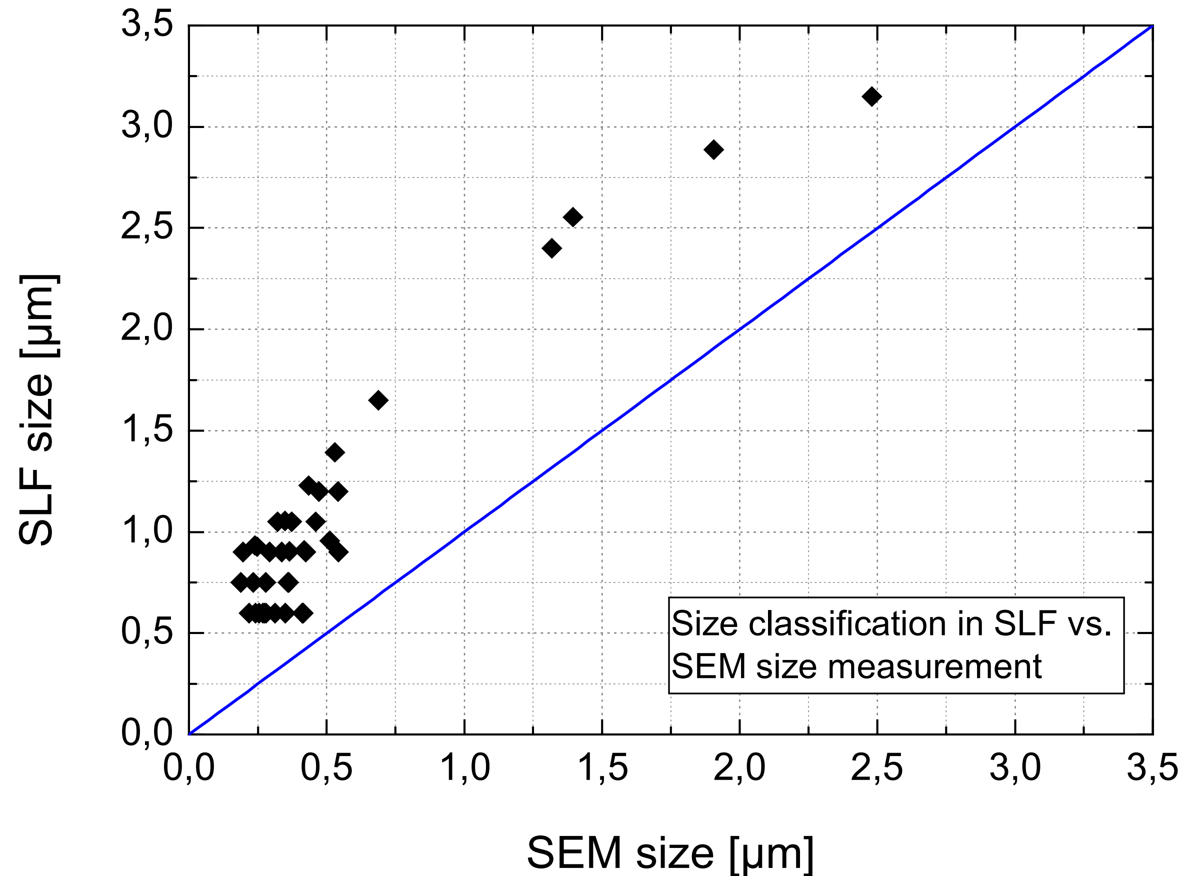
EUV Mask Inspection Results



- Insufficient defect size classification
- Still high defect levels (out-of-cleanroom processing)
- Most defects < 1 µm
- 90 % of same defect type

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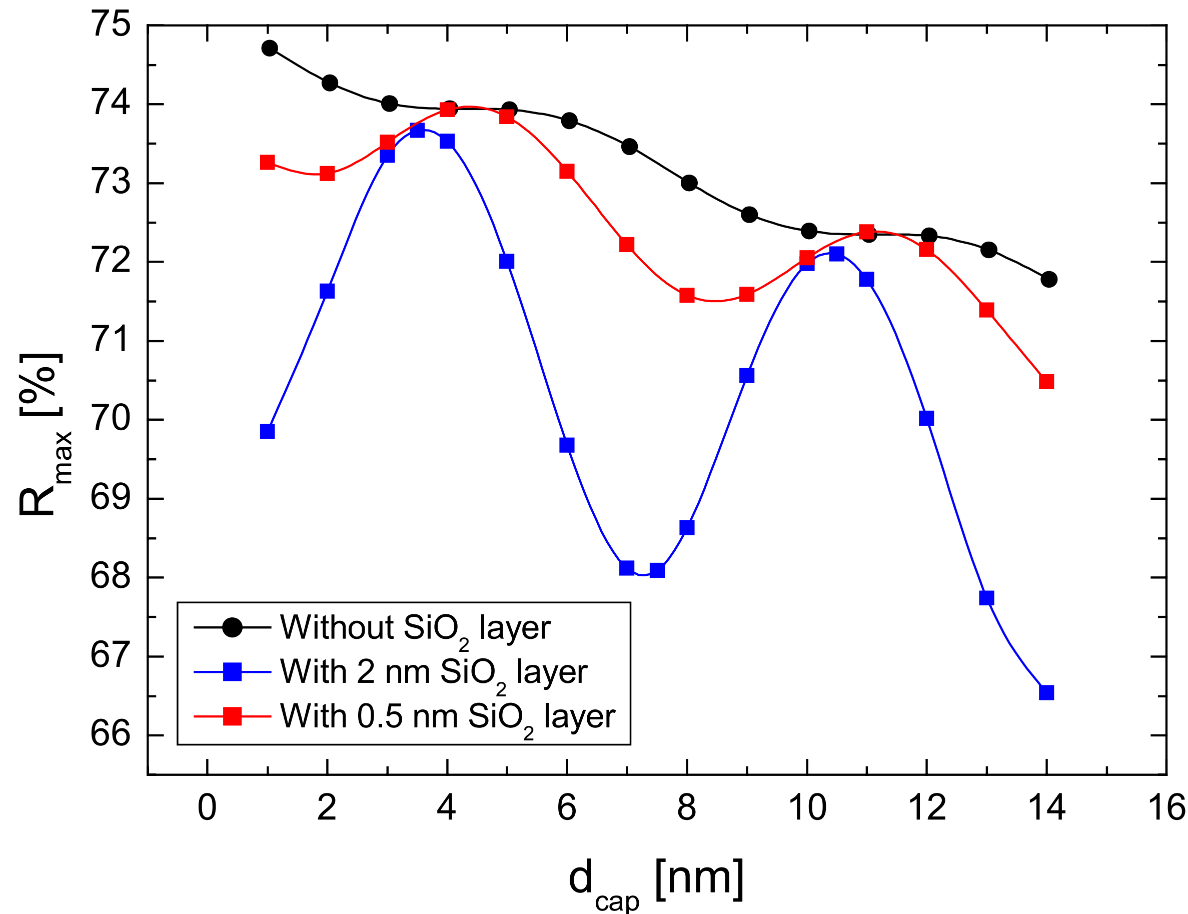
Calculations on Capping Layer Sensitivity



- Without additional SiO_2 layer : step-curve for peak reflectivity
- Residual SiO_2 causes oscillations due to interference
- Optimized layer thickness reduces effect

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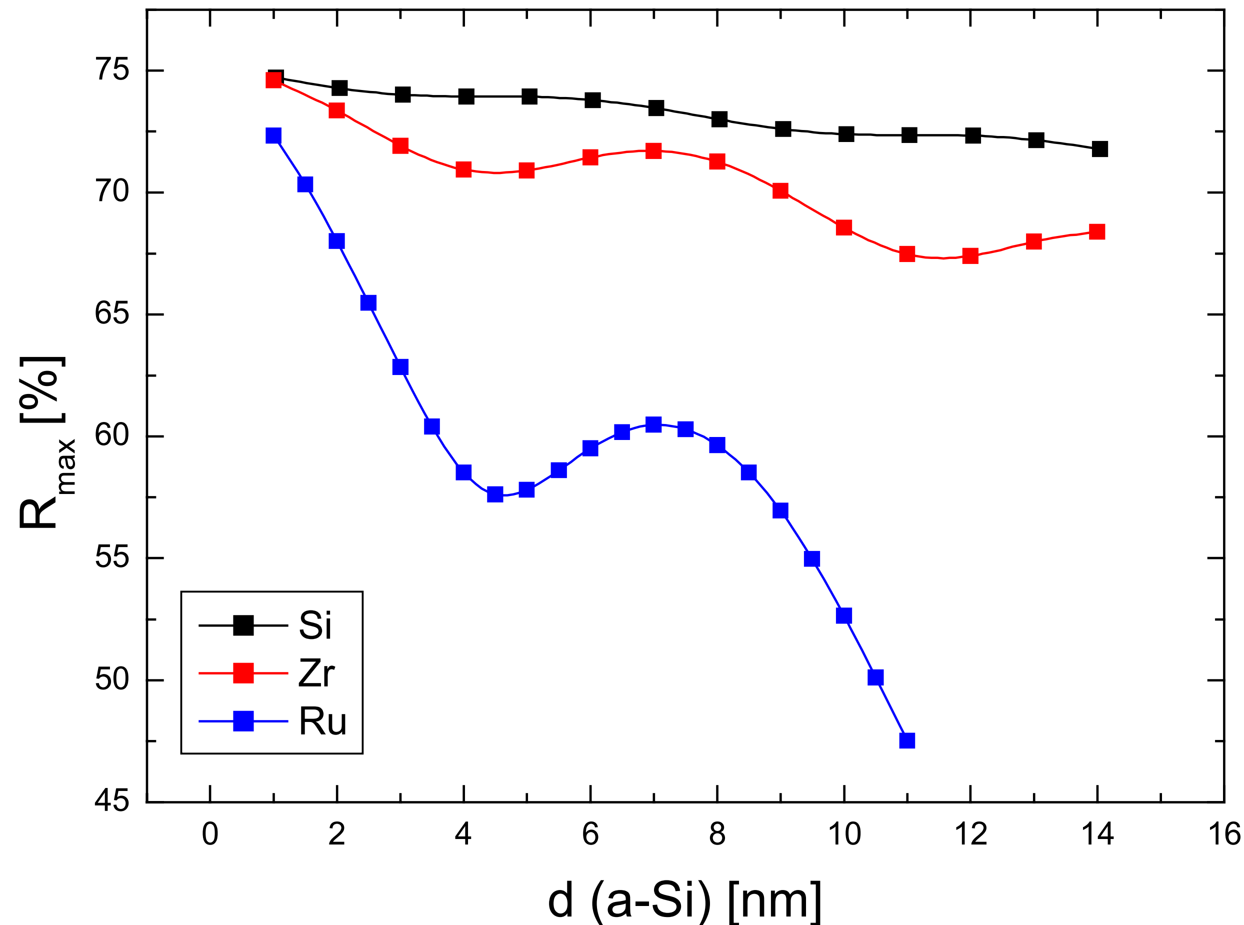
Comparison of Capping Layer Materials



- Si better than Zr or Ru due to smaller absorption and smaller oscillations
- Stability of Si-surface has to be considered

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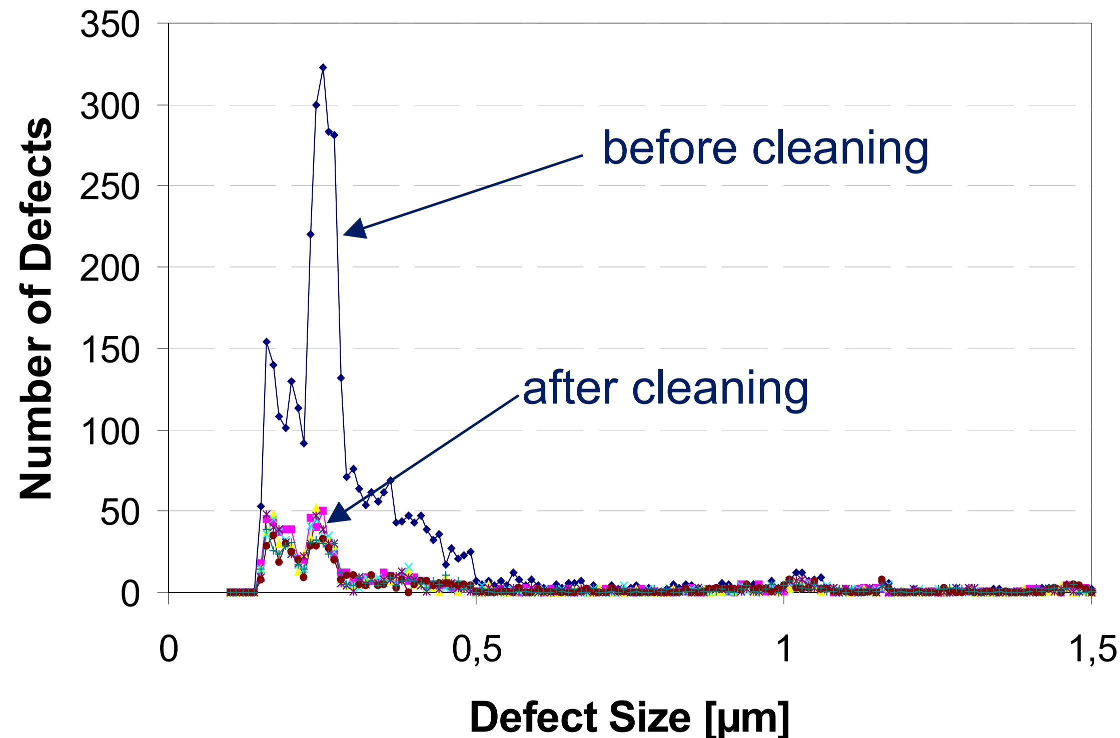
Evaluation of Cleaning Efficiency



- Measurements with DFX tool show high repeatability
- Cut-off below 150 nm due to resolution limit
- Highest cleaning efficiency for particles with 200-500 nm size

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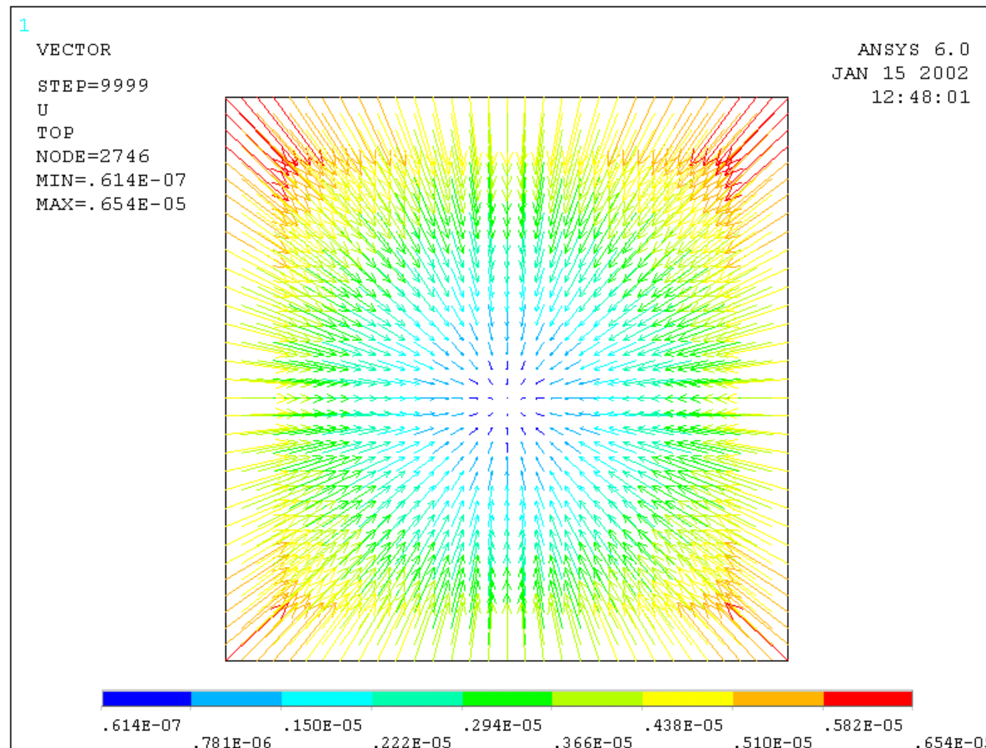
Determination of Layer Specifications



40 MPa ML stress change on full area : 4.8 nm max IPD on 3-point chuck.

- Absolute ML stress value needs to be specified with ≈ 8 MPa precision for 1 nm IPD control (worst case result) on 3-pt. chuck
- Local variation of 40 MPa on 40x40 mm^2 area causes 0.8 nm IPD

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Conclusions

- Practical process development as well as specification work started successfully.
- EUV mask process line at Infineon and IMS allows flexible processing with various materials.
- Promising results of resist evaluation.
- Successfull processing of dummy and multilayer masks on Alta and 50 kV line.
- Calculations on layer specifications show sensitivity of capping layer.
- Chucking concept under discussion.
- Layer stress specifications determined.

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Acknowledgements

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