Future Lithography Techniques – Special Reference to Intel's EUVL

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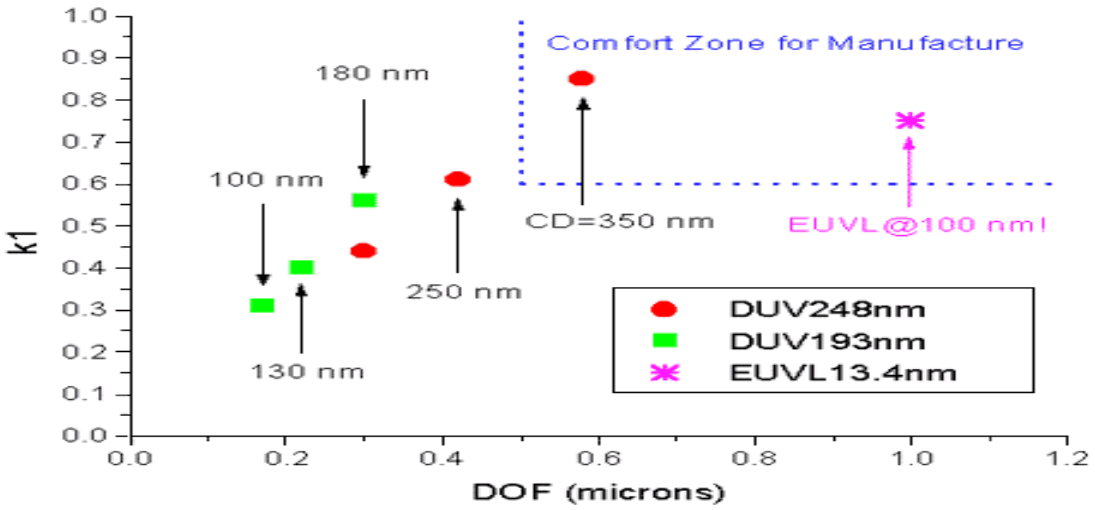
Organization

- Introduction and present status
- Motivation- Need for future lithography techniques
- EUV Lithography
  - Required components
  - Experimental results
- Conclusion

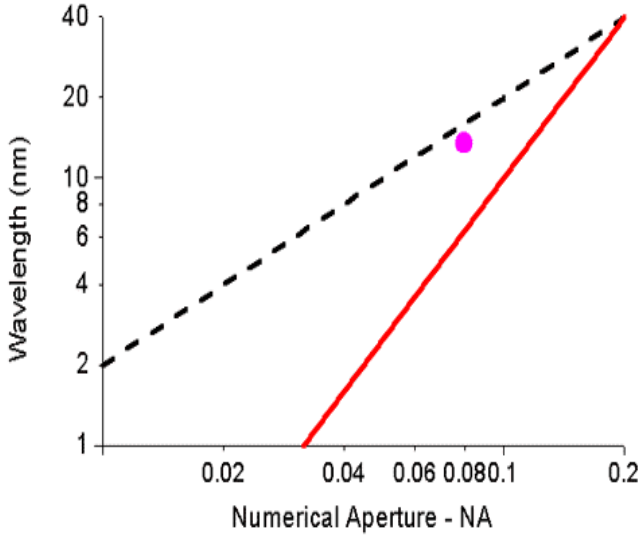
Introduction and Present status of Lithography

- **Lithography**
  - **Resolution:** $R = \frac{k_1 \lambda}{NA}$
  - **Depth of focus:** $\sigma = \frac{k_2 \lambda}{(NA)^2}$



Motivation

- For R=100nm : $\lambda = 200\ nm\ *\ NA$
- For DOF=0.5um: $\sigma = (NA)^2 \times 10^{-6}$
- Proposed NG Lithography
  - Extreme Ultraviolet Lithography (EUVL)
  - X-ray Lithography
  - Electron-beam Lithography
  - Ion-beam Lithography

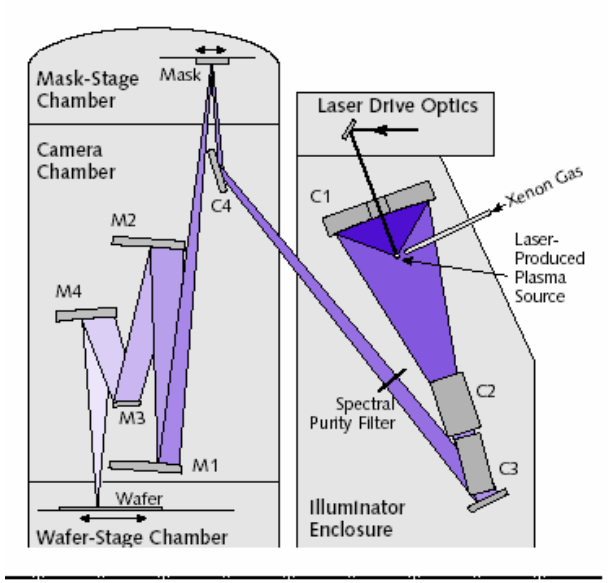


EUV Lithography

- Similarity with optical lithography: natural extension of optical lithography at short wavelength radiation.
- Difference: material property at EUV
  - Vacuum Environment
  - Reflective optics
  - Reflective masks

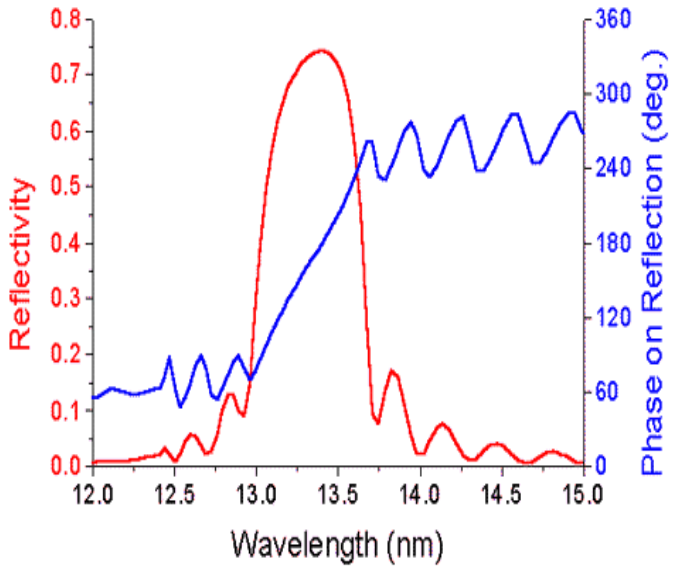
EUV Lithography (cont.)

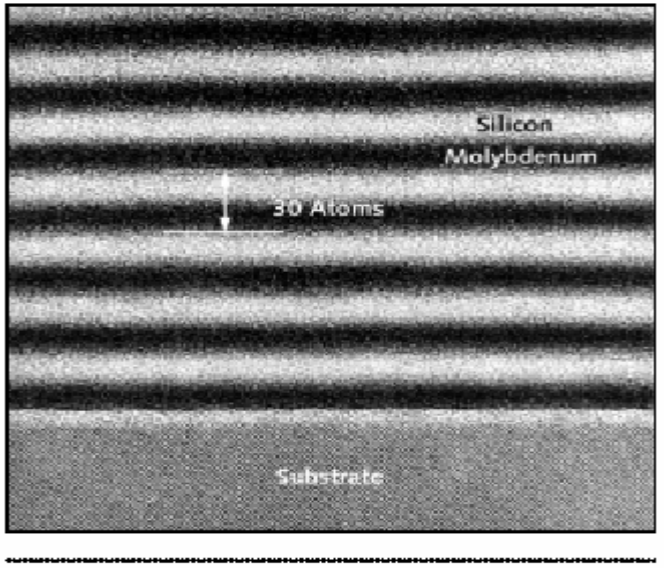
- Major subsystems of EUV
  - Multi-layer Reflectors
  - EUV Cameras
  - Masks
  - EUV Radiation Source
  - Resists



Multi-layer Reflectors

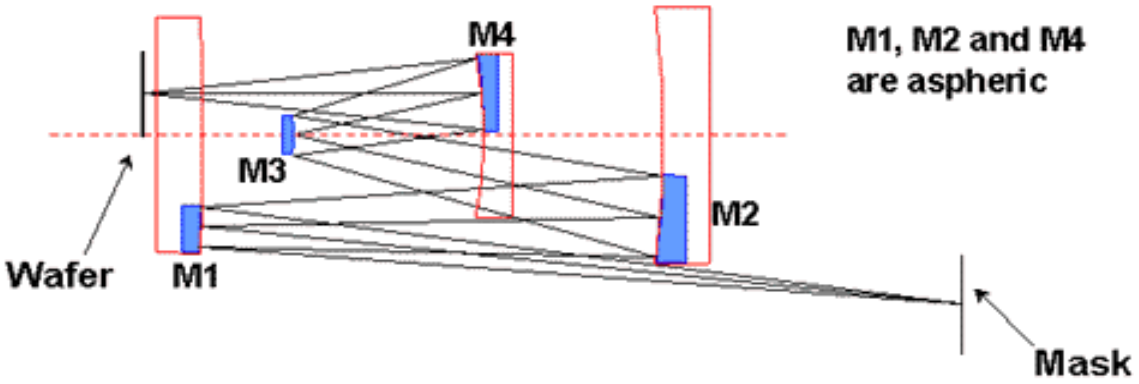
- Coating of multi-layer thin films (ML's) consisting of large number of alternating layers of materials having dissimilar EUV optical constants
- Alternating layers of Mo and Si : 13 nm





EUV Cameras

- Reflective optics design more difficult – fewer degree of freedom for mirrors, hence aspheric surfaces
- Four mirror reflective optics



- Important features of camera: better resolution, image with reduction factor of 4, close aspheric structure

Masks

- EUVL masks are reflective
- Patterned absorber of EUV radiation on top of an ML reflector deposited on a robust and solid substrate (e.g. silicon wafer)
- Reflectance spectrum of the mask must match to that of the ML-coated mirrors of camera
- Anticipated to be fabricated using standard production techniques
- Concerns: ML coating defect repair, pellicles can not be used, hence other methods for protecting EUV masks

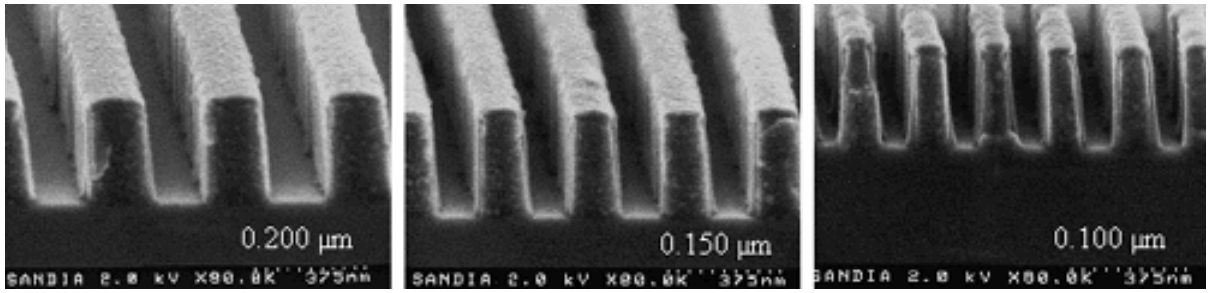
EUV Radiation Source

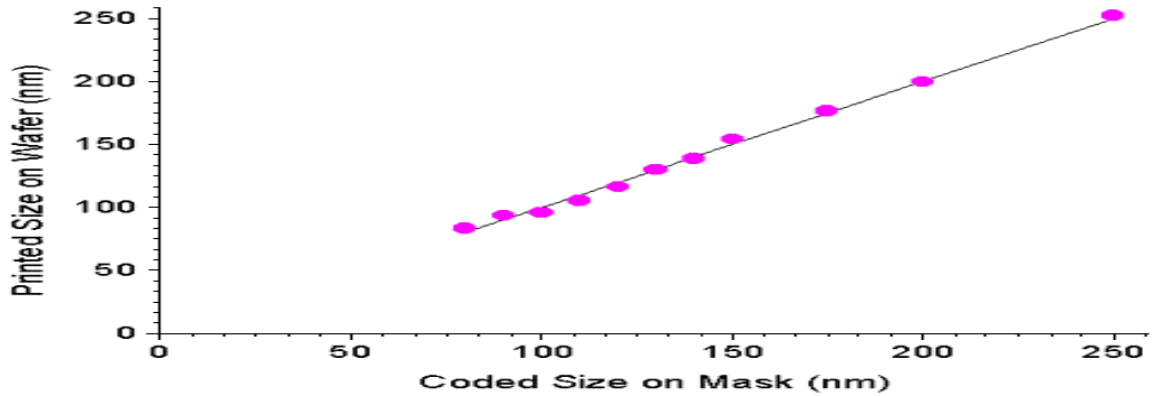
- Must be of sufficient intensity
- Must start out extremely small
- A Laser-Produced Plasma (LPP) source
- A powerful 1.06um laser excite a continuous jet of xenon gas
- Challenges of building the light source
- Main condenser mirror subject to distortion, deterioration of C1's surface, mechanical instability

Resists

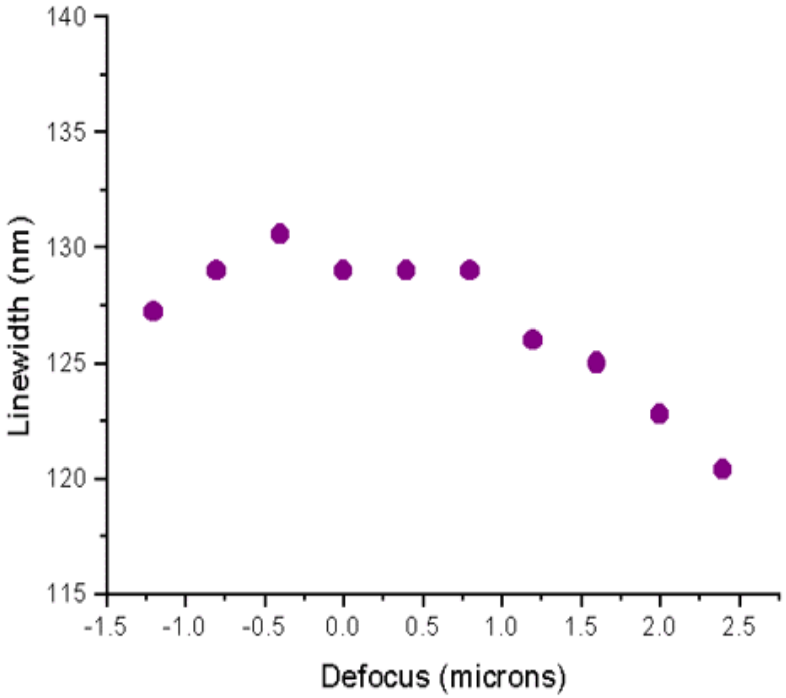
- Problem in developing a satisfactory photo resist because of absorption of EUV by all materials
- Printing should occur in a very thin imaging layer at the surface of the resist
- Must have excellent etch resistance
- Resist types worked on
  - Silylated single-layer
  - Refractory bi-layer
  - Refractory tri-layer

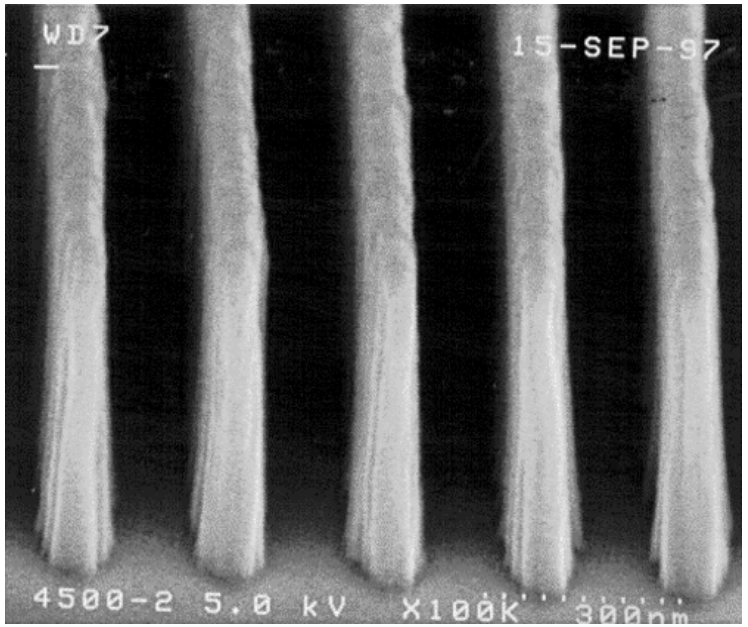
Experimental results





Experimental results (cont.)





Conclusion

- Open Research Issues
  - Methods for protecting EUV masks
  - Mask distortion due to EUV heating
  - Condenser (C1) lifetime
  - New tool for measurement of optical devices
  - Laser source
  - Defect free mirror and mask production

In spite of al these issues there has been significant advancement in EUVL, hence looks promising for Future

Thanks