

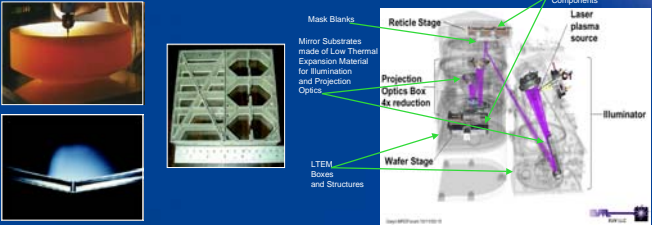
# Challenges to EUV mask blanks volume production

Holger Seitz <sup>a</sup>, Frank Sobel <sup>a</sup>, Markus Renno <sup>a</sup>, Thomas Leutbecher <sup>a</sup>, Nathalie Olschewski <sup>a</sup>, Thorsten Reichardt <sup>a</sup>, Ronny Walter <sup>a</sup>, Hans Becker <sup>a</sup>, Ute Buttgerit <sup>a</sup>, Günter Heß <sup>a</sup>, Konrad Knapp <sup>b</sup>, Taku Morisawa <sup>c</sup>, Yoshio Okano <sup>c</sup>, Rainer Lebert <sup>d</sup>, Christian Wies <sup>d</sup>, Bernhard Jäggle <sup>d</sup>

<sup>a</sup> Schott Lithotec AG, Jerusalem Str. 13, D-98617 Meiningen, Germany <sup>b</sup> Schott Lithotec AG, Otto-Schott Str. 13, D-07745 Jena, Germany  
<sup>c</sup> Schott Nippon K.K., 7, Honshio-cho, Shinjuku-ku, Tokyo 160-0003, Japan <sup>d</sup> AIXUV, Steinbachstr. 15, D – 52074 Aachen, Germany

## Extreme Ultraviolet Lithography benefits from specific technology background of SCHOTT

- 35+ years of manufacturing expertise with LTEMs
- 5+ years as optical materials supplier for IC equipment industry
- 5+ years of mask blank production experience
- 3+ years partnering in EUVL programs



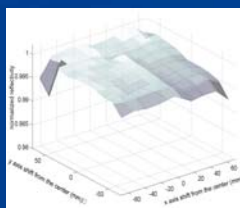
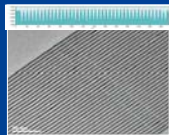
## SCHOTT Lithotec produces EUVL mask blanks with advanced features in a full-scale manufacturing environment

- Low defect LTEM 6025 substrates with improved flatness
- Highly reflective uniform low stress EUV multilayer stacks
- Dry etch optimized Alternative Absorber Material System
- Complete Low defect backside coated EUV Mask blanks

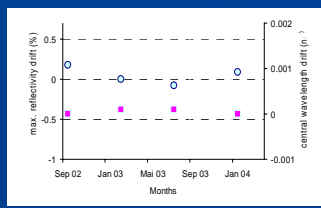


## Continued focus on advanced sputtering technology now results in excellent optical properties of multilayer stacks

- High accuracy of the central wavelength
- High-end periodicity of the deposition process
- Best optical uniformity of the EUV response
- Long time scale stability: no degradation
- Multilayer cleaning meet durability requirements



Normalized EUV-uniformity of the maximum EUV-reflectivity



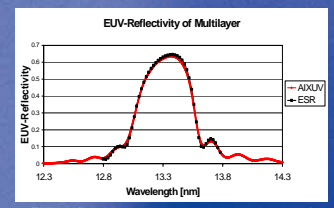
Reproducibility of maximum EUV-reflectivity and central wavelength

## New EUV-Reflectometer from AIXUV GmbH supports both improvement of optical properties and process stabilization

- Calibration by measurements at Electron Storage Ring
- Absolute accuracy of EUV-reflectivity < 1%
- Reproducibility of EUV-reflectivity < 0.2%
- Absolute accuracy of central wavelength < 0.002 nm
- Reproducibility of central wavelength < 0.002 nm



High-Throughput EUV-Reflectometer from AIXUV (20 - 40 s per 0.1x1 mm spot)

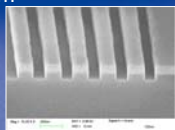


EUV-reflectivity measurements on one sample using the EUV-Reflectometer and the Electron Storage Ring (ESR)

## Latest achievements in developing TaN Absorber and SiO<sub>2</sub> Buffer Layers

### TaN based absorber

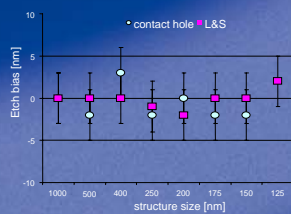
- High etch selectivity
- Sub – 100 nm feature size achievable
- Etch bias nearly 0 with 100% over etch
- Pattern size uniformity < 10 nm



Lines and spaces with 125nm feature size after TaN absorber and SiO<sub>2</sub> buffer coating dry etching processes

### SiO<sub>2</sub> based buffer

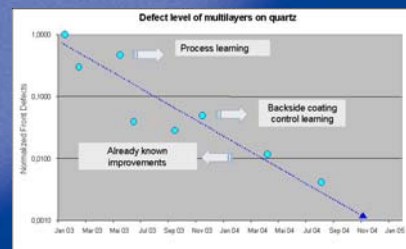
- Sidewall angles close to 90°
- No under etch of buffer layer
- High etch selectivity with lower and upper layers



Etch bias experimented on 70nm TaN based absorber for dense lines and contact holes with different structure size

## Extensive defect reduction program including all manufacturing steps

- Each point corresponds to a mean value of total defects over dozens of samples
- Defect inspection capability are on the way to be improved with calibration samples



Defect reduction of multilayers on quartz

### Acknowledgement

This work has been supported by the German Ministry of Education and Research under contract number 13N8089. The program is part of the Medeat program EXTUMASK. Calibration of reflectivity measurements in the EUV spectral region was done at the Physikalisch-Technische Bundesanstalt (PTB) using the Electron Storage Ring at BESSY II in Berlin, Germany. We like to thank Frank Scholze and his team for their excellent cooperation.