EUV contamination control at TNO

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Summary

Contamination control and component lifetime assurance are key enabling technologies for EUV lithography. TNO has an extensive track record on this topic, including source contamination and plasma-surface-materials interaction. The EUV contamination-control program for example has been running at TNO for over ten years. The overall program goal is to support the introduction and development of EUV lithography. We show here a few examples of our work applicable to EUV source development.

EUV exposure

The EUV Beam Line (EBL) facility has been operated jointly by TNO and Carl Zeiss SMT since 2005. The facility contains a beam line, in which samples can be exposed to EUV irradiation in a controlled environment. Attached to beam line is an XPS system, which can be reached via an in-vacuum sample transfer system. This enables surface analysis of exposed samples without breaking vacuum. The compound instrument is used to develop and validate optics lifetime strategies for ASML EUV scanners[1].

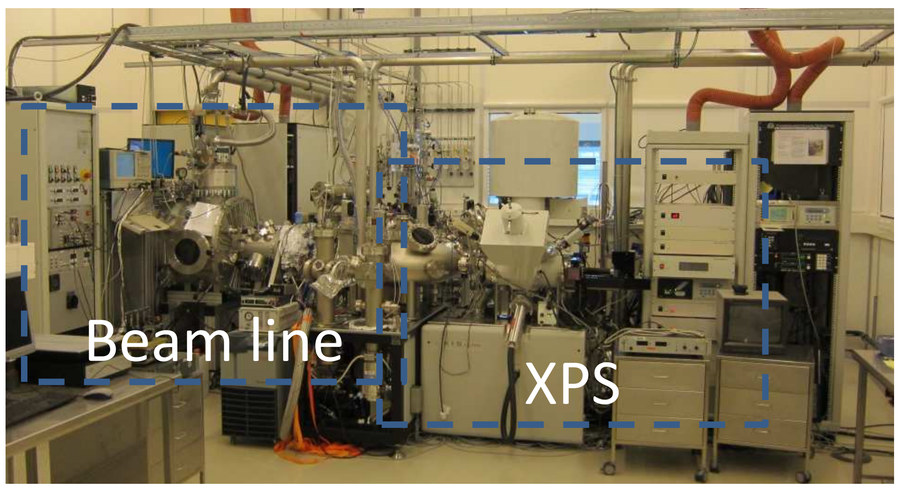

Figure 1: EUV Beam Line (EBL) at TNO

EBL2

An improved facility is needed to perform experiments at higher intensities and EUV loads. TNO is currently designing such a beam line with *in vacuo* XPS. Targeted improvements include:

- Increased EUV power and intensity
- Increased flexibility: Samples up to EUV mask size (152 mm square), tunable EUV spot size & profile, more spectral filtering options, operating pressure up to source-relevant regimes
- Increased reliability through automated sample handling, better source automation, and improved dose control
- Increased sample data:
    - In-situ ellipsometry during exposure
    - Additional ports for EUVR or other analysis tools

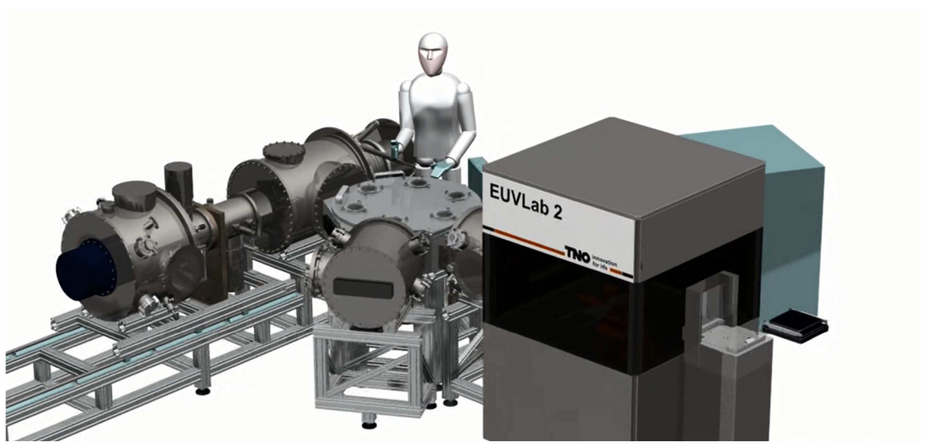

Figure 2: EBL2 CAD impression

Tin contamination and cleaning

We currently study the deposition and cleaning effects for tin contamination. This work is focused at tin-based EUV sources. We have built a dedicated setup that can study both tin deposition and cleaning effects. It was used for example to test potential protection layers for EUV optics w.r.t. tin cleanability.

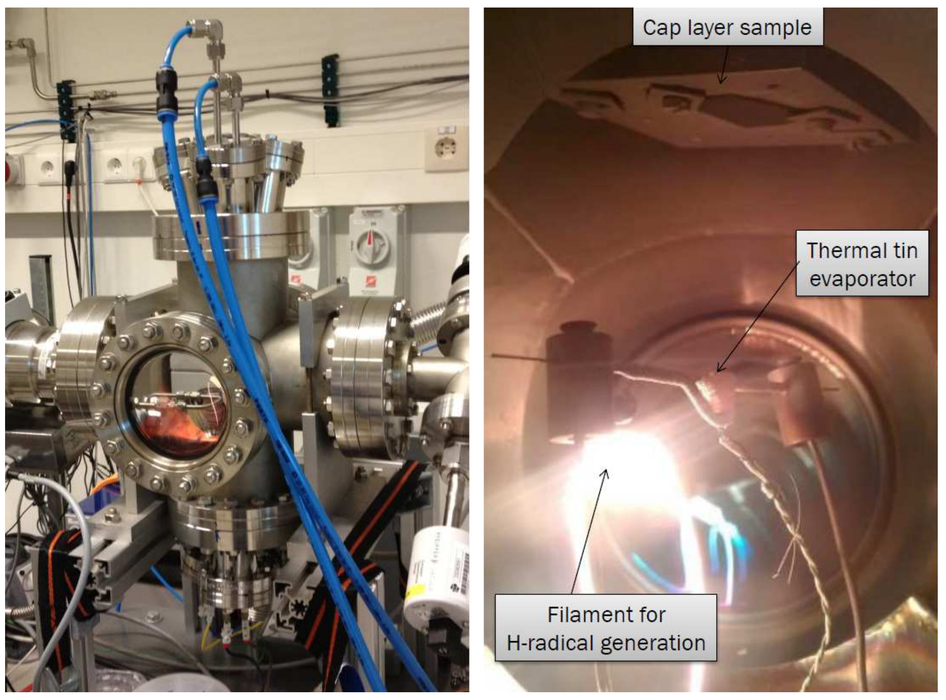

Figure 3: . Setup for Simultaneous Deposition and atomic hydrogen Removal of Tin (SDRT) at TNO

Hydrogen ion irradiation

The ions that are generated in EUV sources and photoionized plasmas can have various effects on materials and components. Offline investigation of these effects is possible at the TNO Ion Exposure Setup (TIES). Figure 3 shows the setup, and showcases some of the ion energy distributions it can generate. Ion current densities in excess of 4 A/m^2 can be generated for all ion energy settings.

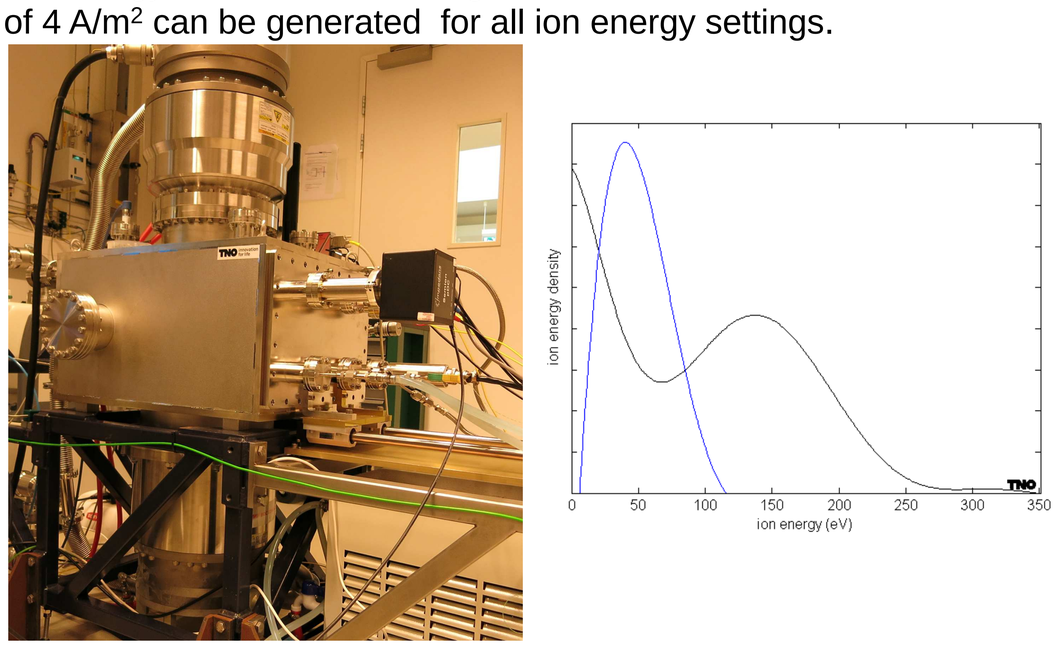

Figure 4: TNO Ion Exposure Setup (TIES), and sample ion energy distribution measurements

Acknowledgement

Part of this work has been performed in close collaboration with our customers ASML and Carl Zeiss SMT.

1. “Strategy for Minimizing EUV Optics Contamination During Exposure”, N. Harned et al., EUVL symposium 2008, Lake Tahoe