# EBL2: An EUV tool for testing components, photomasks, and pellicles

**Edwin te Sligte, Norbert Koster, Freek Molkenboer, Peter van der Walle, Pim Muilwijk, Wouter Mulckhuyse, Bastiaan Oostdijck, Christiaan Hollemans, Björn Nijland, Peter Kerkhof, Michel van Putten, André Hoogstrate, Alex Deutz**

TNO, P.O. Box 155, 2600 AD, Delft, The Netherlands
Edwin.teSligte@tno.nl

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ICCC INTERNATIONAL CENTRE FOR CONTAMINATION CONTROL

## EBL2

TNO is integrating EBL2, an open access facility to investigate the effects of EUV radiation on surfaces to enable future EUV HVM production. Figure 1 shows the layout of EBL2. EBL2 contains an EUV Beam Line, which consists of an EUV source (a), a Collector Module (b), and an Exposure Chamber (c). Samples are loaded using a Sample Handler (d), which also provides access to an XPS system (e). The EUV source provides an additional metrology output port for low-power applications.

EBL2 will be accessible to third parties, delivering:

- **EUV power and intensity:** EBL2 will meet the intensity roadmap for all foreseen EUV litho tools and EUV sources, exposing at ~10 W total power.
- **Flexible sample size:** EBL2 will accept small test samples as well as EUV masks for both EUV exposure and XPS analysis. Masks with pellicles are also accepted.
- **NXE compatibility:** Reticles received in NXE compatible state will be returned in NXE compatible state.
- **Flexibility:** Tunable EUV spot size & profile, with spectral and spatial filtering options; gas environments from high vacuum up to 4 mbar, including controlled addition of contaminants.
- **Parameter control:** EUV sensors that detect every pulse, real time RGA to monitor the gas environment. Sample backside temperature can be controlled over a range from -20°C to 150°C.
- **Surface analysis:** Real-time *in-situ* imaging ellipsometry to monitor sample status, and the XPS is capable of analyzing exposed samples without breaking vacuum.

## EUV irradiation

A Sn-fueled Ushio LDP source is used to generate EUV. A two-stage grazing incidence collector system projects the EUV onto the mask location, as shown in Figure 2. The intermediate focus ensures separation of the source and sample gas environments.

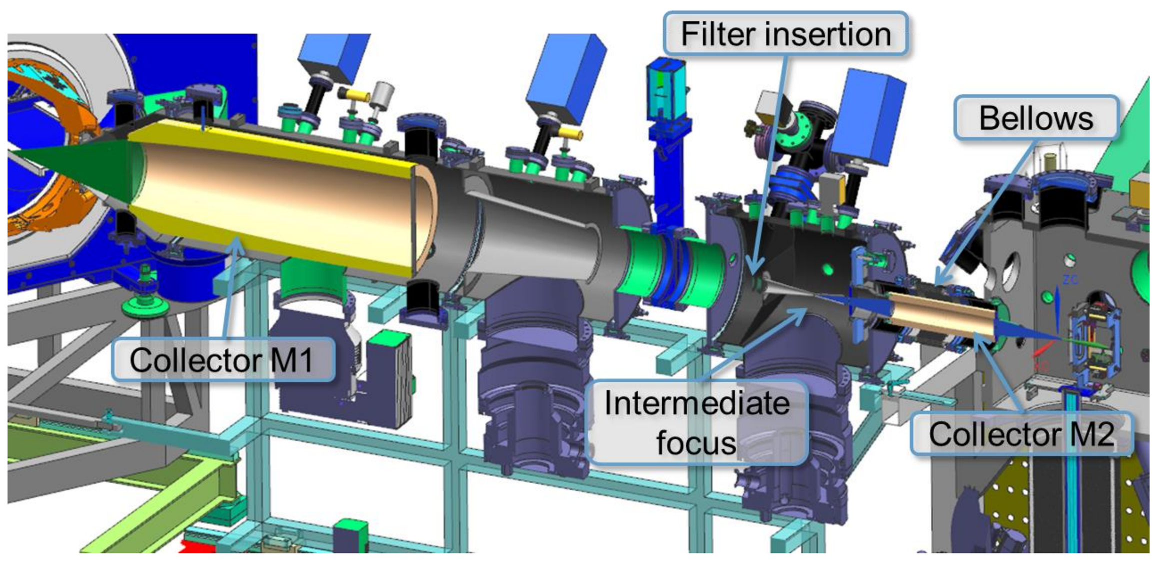


**Figure 2:** Collector module design overview

The spot size in focus is 0.8*1.2 mm, with peak intensity 1.3 W/mm$^2$ *in band*. Total EUV power is is around 10 W, while operating at 3 kHz. The EUV beam can be defocused by moving the Source and Collector Module away from the reticle. This changes the spot profile as shown in Figure 3. The maximum spot size attainable is over 30 mm, at which point the spot assumes a donut shape.

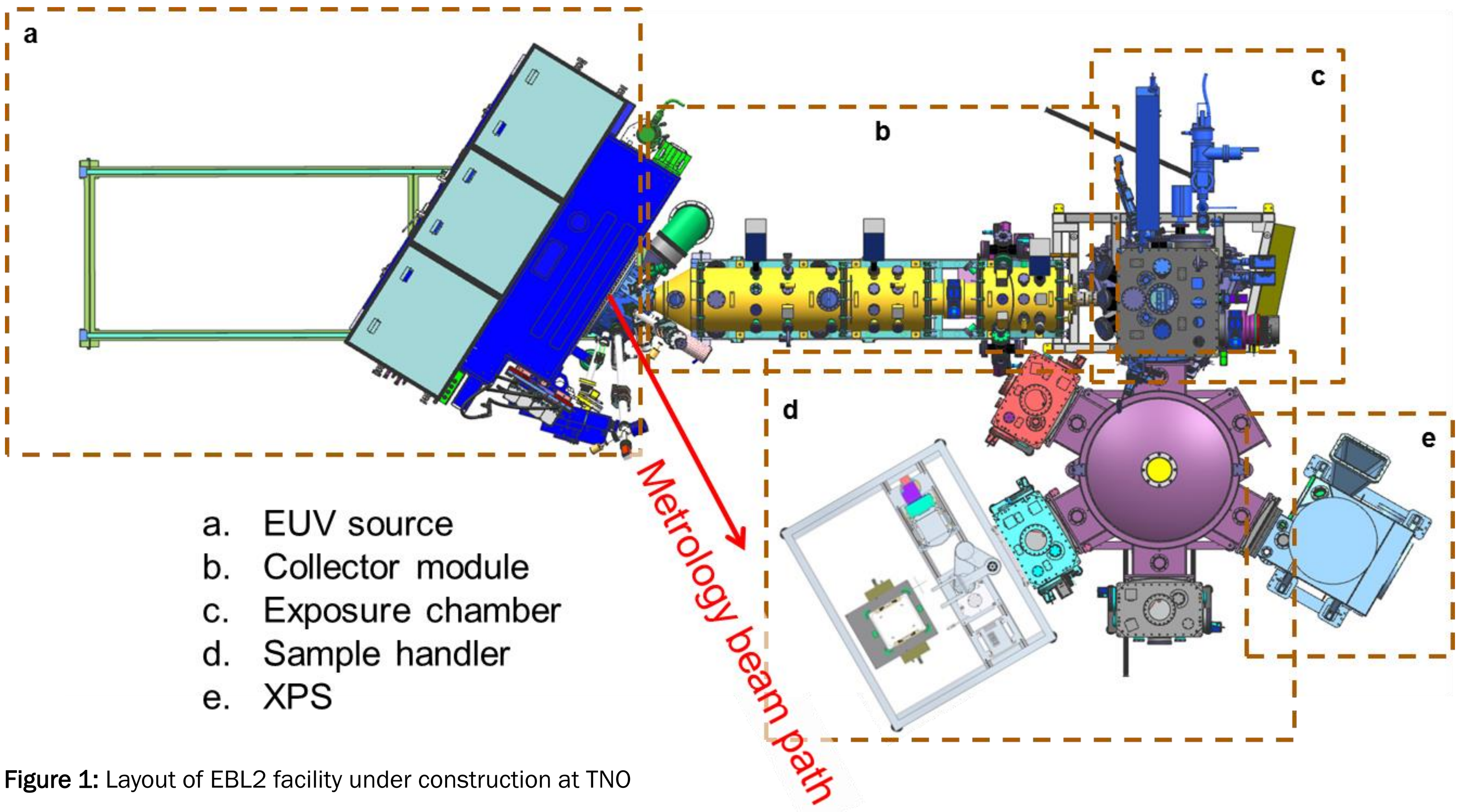


**Figure 1:** Layout of EBL2 facility under construction at TNO

Light at unwanted wavelengths can be filtered using spectral purity filters (SPFs), which can be mounted between the collectors. The performance of one possible SPF design (50 nm Zr, 200 nm Si, 30 nm Mo) is shown in Figure 3. Light outside the 12.5-18.5 nm window is suppressed from 10% of total power to 1% of total power.

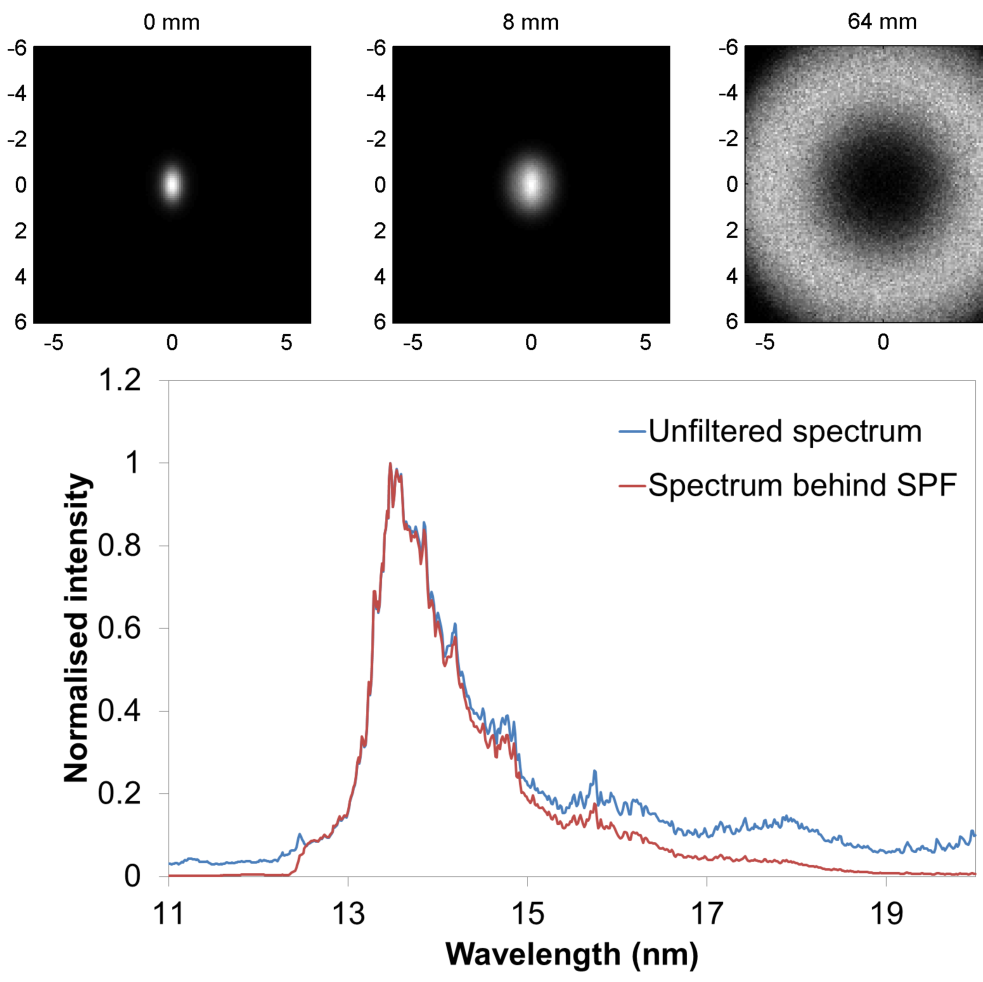


**Figure 3:** Top: Effect of defocusing on spot profile (scales in mm). Bottom: effect of an SPF.

## Sample environment

The gas environment will be controlled by adding gases to the clean high vacuum environment; pressure during source operation will be below 1E-6 mbar. Gas composition can be set independently of total pressure, and will be controlled by an RGA system.

Reticle back side temperature will be controlled over a range from -20°C to 150°C using a cooler and backfill gas. The imaging ellipsometer monitors the sample with 0.1 mm imaging resolution and 15 mm field of view. Reticles are loaded automatically from standard dual pods by the handling system provided by ASYS.

The handler handles masks on inner pod base plates. A transfer robot transfers the sample or reticle from an outer pod to the load lock, which is evacuated. A vacuum robot then transfers the sample to any of the other modules. These include cleaning with hydrogen radicals, short term parking and long term vacuum storage, as well as the beam line and the customized Kratos XPS. The XPS will be able to address 100% of the reticle surface.

## Status and Outlook

The beam line is under construction, and the vacuum handling hardware and XPS have been installed. The EUV source has passed acceptance testing and is in shipment. Figure 4 shows the current integration status at TNO in Delft. First light is expected end of 2016.

**Figure 4:** Current integration status.

EBL2 will be a flexible and controlled EUV exposure and analysis facility, enabling experimentation, modelling and interpretation on many topics relevant to the EUV community. The facility will be open to users in early 2017.

**Acknowledgements**

TNO would like to thank technology partners Ushio (EUV source) and Asys (reticle handlers). Additional funding by EU programs SeNaTe and E450LMDAP, Dutch Ministry of Economic Affairs through NanoLabNL and Toekomstfonds.

EBL2

This work has been performed in the framework of the International Center for Contamination Control, established by TNO. Partners are welcome to join ICCC in the challenging development of dedicated contamination control solutions.