Contamination Control for EUV lithography

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ICCC INTERNATIONAL CENTRE FOR CONTAMINATION CONTROL

Introduction

This poster presents the contamination control activities and parts of the infra structure at TNO International Centre for Contamination control (ICCC). The laboratory is located in Delft at the Van Leeuwenhoek Laboratory in the Netherlands. At TNO we have over 15 years experience in contamination control for EUV and DUV lithography. With a focus on molecular contamination on optics and masks and particle cleanliness. Our latest addition is EUV Beam Line 2 (EBL2) an exposure facility for EUV irradiation experiments for EUV optics and masks lifetime research.

Rapid Nano

The Rapid Nano is our particle counting platform. This system is used to detect particles on non patterned surfaces to analyze particle fall out of tools and processes. The present generation of the tool is capable of detecting particles down to 43 nm (PSL equivalent) using multi azimuth illumination. Sample are mounted in a scan box with pellicle to prevent particle fall out during measurements. The box can handle mask blanks and 150 mm wafers.
The next generation Rapid Nano 4 is under construction and with this system we expect to be able to detect particles down to 20 nm using 193 nm wavelength illumination. This system will be hooked up to our reticle handler to do fully automated and clean sample transfer.

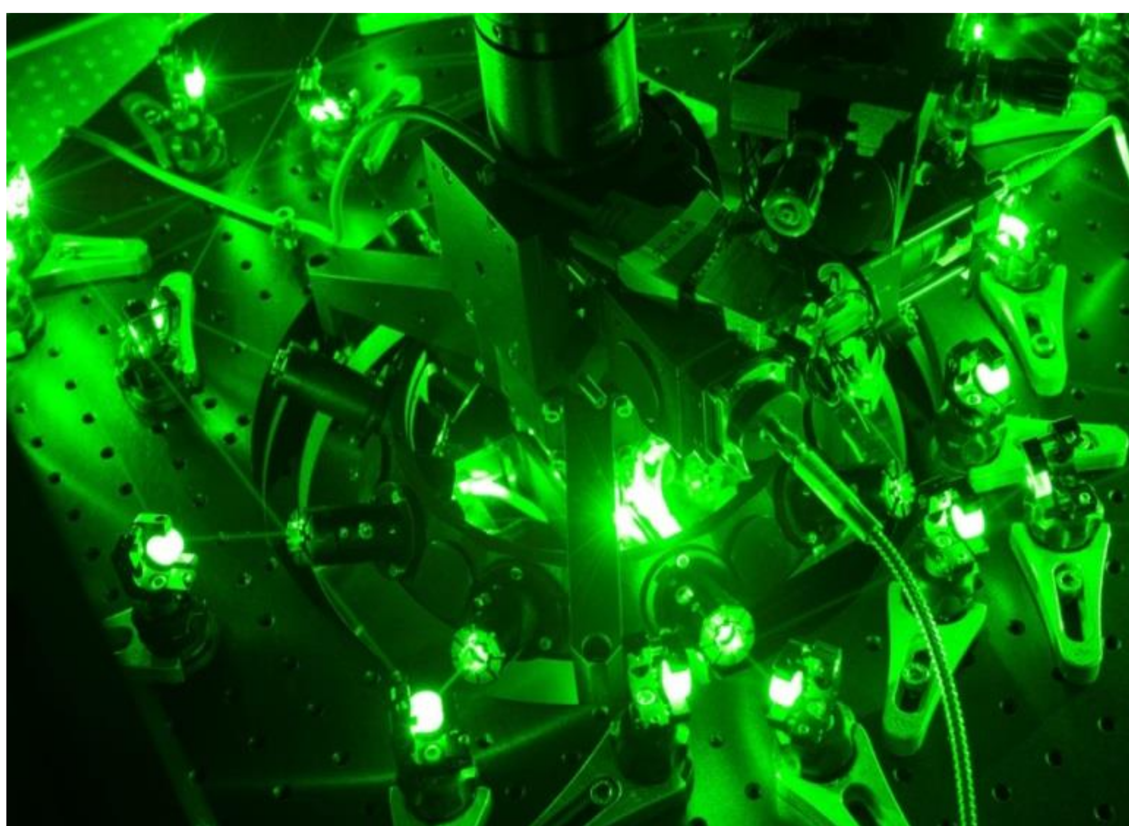

Figure 1: Multi azimuth illumination in our particle scanner Rapid Nano 3

Reticle handler

Our reticle handler is a study platform to improve to a cleanliness of 0.0001 PRP (@ 40 nm) and is a.o. meant for transferring samples to the Rapid Nano 4. It is also possible to hook up other tools to this system to do qualification of robots and general cleanliness of the tools. We are aiming to help equipment manufacturers in designing the tools needed for the next generation litho. Our expertise on clean robot design and manufacturing dates back to the EUV AD tools were we developed and qualified the reticle handlers.

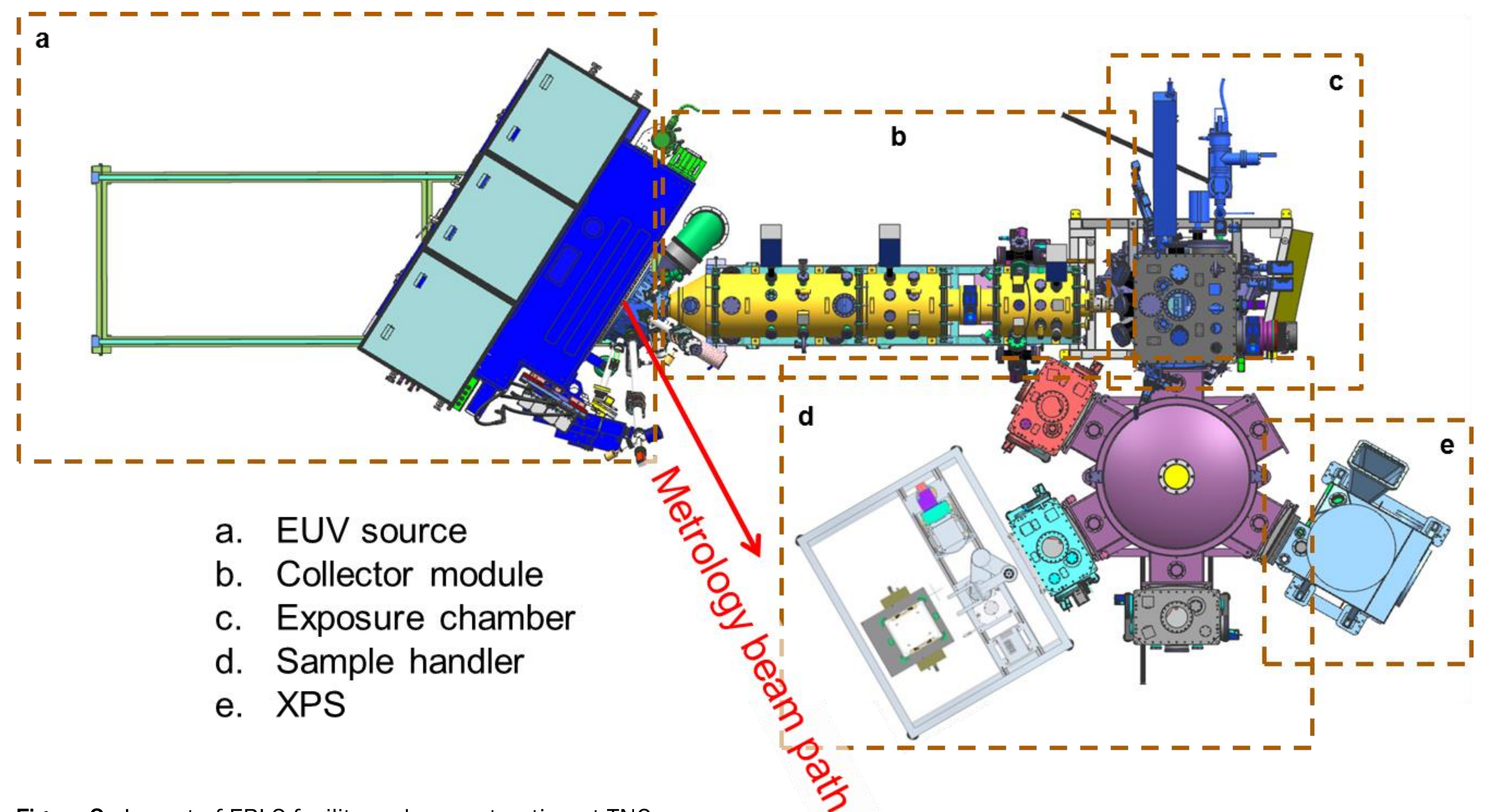

Figure 2: Layout of EBL2 facility under construction at TNO

Figure 3: Reticle handler in ICCC cleanroom

EUV optics contamination

For EUV optics contamination we have build an extensive infra structure together with our R&D partners Carl Zeiss and ASML. Here we can test and analyse contamination mechanisms with EUV, DUV and electrons and investigate cleaning and mitigation methods. For this we have dedicated plasma, radical and ion exposure facilities, where we can mimic for instance EUV scanner conditions. Analysis is performed using multiple instruments:

- XPS up to reticle size
- SEM-EDX
- Ellipsometry
- HIM
- XRD and XRF
- Optical Coherence Tomography (OCT)
- Retarding Field Analyzer and langmuir probes for plasma analysis
- Airborne and Surface Particle counters
- Plasma cleaners
- Wet cleaning facilities

EBL2

Presently we are integrating EBL2, an open access facility to investigate the effects of EUV radiation on surfaces to enable future EUV HVM production. Figure 2 shows the layout of EBL2. EBL2 contains a 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. The facility will be open to customers from early 2017.

EBL2 will be accessible to third parties, delivering:

- **EUV power and intensity:** EBL2 will meet the intensity roadmap for EUV litho tools up to 2024.
- **Flexible sample size:** EBL2 will accept small test samples as well as EUV masks
- **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:** dose control, gas control, temperature control, and spectral purity
- **Surface analysis:** Real-time *in-situ* imaging ellipsometry to monitor sample status, and the XPS is capable of analyzing exposed samples without breaking vacuum

Conclusion

TNO has unique expertise and facilities to assist you with resolving contamination issues in litho, whether it is DUV or EUV and we can help with implementing the solution in the tools.

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.