Qualifying the ASML Job Scriptor for CNF Use

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Primary CNF Tools Used: ASML PAS 5500 Stepper, Heidelberg DWL2000 Mask Writer, Optical Microscope

Abstract:

The ASML deep ultraviolet (DUV) Stepper, while precise and controlled for semiconductor manufacturing, is susceptible to human error in Micro-Electro-Mechanical Systems and optical device fabrication, which require complex exposure patterns and specialized alignment. For this reason, the goal was to qualify a new tool update: the Job Scriptor. This process began by testing and validating multiple computer-aided design (CAD) layouts. The project simulated a job with the ASML Stepper and fabricated a photomask for experimental comparison. The resulting software simplifies the generation of complex job files for the ASML lithography stepper by enabling off-site job creation, allowing users to prepare their work before entering the cleanroom. In conclusion, this update will let users perform more complex photolithography processes, paving the way for advanced automation in optical-device fabrication.

Summary of Research:

The goal of this project was to qualify the ASML Stepper's new feature update, the Job Scriptor, for CNF use. This Job Scriptor simplifies photolithography processes in the cleanroom, unlike the conventional workflow where users must manually input parameters into the tool. It allows users to visualize the complete exposure plan beforehand with specific parameters like reticle positioning and exposure fields. As a result, users can ensure correct placement of every pattern before the job is executed, reducing the risk of costly fabrication errors.

The qualification process started with creating a CAD layout of a wafer-scale exposure pattern to compare with its experimental and computational simulations. The CAD layout represented a wafer-scale pattern containing an array of repeated test structures with pattern leads that electrically connect to contact pads for potential transport measurements. Creating this layout required using the GDSTK library in Python to generate 1,000,000 squares, each 1 micron in length, along with a set of leads in the center of the design. This layout was meant to test the Job Scriptor's ability to produce repeated test structures while retaining the design's central geometry. After creating the CAD layout, the project moved to photomask fabrication in the cleanroom. This involved using the DWL2000 Heidelberg Mask Writer, which used a high-resolution, high-speed laser to pattern a photosensitive chromium-coated mask plate. The fabricated photomask would be used as an experimental comparison with our CAD layout.

After fabrication, the ASML Stepper's Job Scriptor used the CAD file to verify its functionality. This helped simulate the intended exposure layout to examine the Job Scriptor's performance. The Stepper accurately reproduced the CAD layout into an exposure job, producing a large 1,000 x 1,000 array inside a circle, filled with 1,000,000 repeated 1 µm structure squares. Validating this software involved four main criteria: central exposure region present, exposure region centered, wafer orientation preserved, and no unintended features. Each qualification criterion was met, demonstrating that the Job Scriptor successfully translated a CAD layout into a simulated exposure image.

Before fully qualifying the ASML Stepper Job Scriptor, optical microscopy examined the quality of leads on the fabricated mask. Experimental comparison included three main features: a central exposure region present, an exposure region centered, and wafer orientation preserved with the CAD layout. These leads were placed on the photomask to fabricate contact pads for potential material characterization. They were then examined under an optical microscope and used to qualify the ASML Stepper Job Scriptor. Because the microscopy showed that the fabricated structures matched the intended CAD geometry based on these three features, the Job Scriptor was successfully qualified for CNF use.

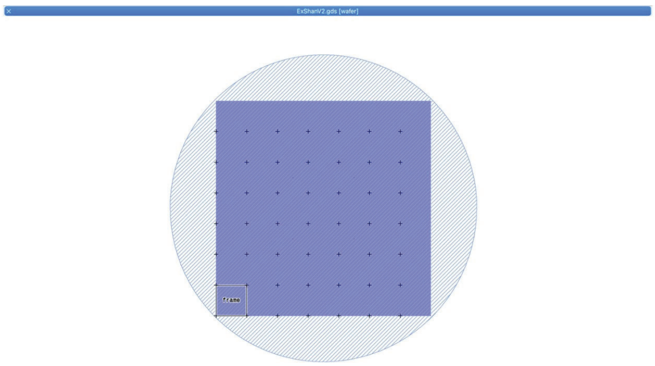

Figure 1: CAD layout showing a wafer with repeated structures and leads inside.cleaned with IPA.

Conclusions and Future Steps:

This project qualified the ASML Stepper's new Job Scriptor update for future CNF use, both using experimental and software-based validation. This will greatly simplify job generation for CNF users by enabling offsite job creation and future capabilities in lithography workflows, such as multi-image stepping distances. It will allow users to visualize the complete wafer patterning before exposure, as well as specific parameters like die placement and reticle positioning. Overall, this update will not only reduce fabrication errors but also significantly lower the costs associated with them. This will increase throughput and improve user experience with photolithography.

Qualifying the ASML Stepper's Job Scriptor for CNF use will also enable a wide range of future lithography applications. For example, it will enable users to prepare jobs containing multiple device designs/exposure fields, potentially paving the way for devices like Micro-Electro-Mechanical Systems that require unusual geometry, driving advances in the field of electronics. This new software can also be integrated into the CNF design workflow by enabling new capabilities such as graphical user interface (GUI)-based interactive wafer visualization and focus/exposure matrices.

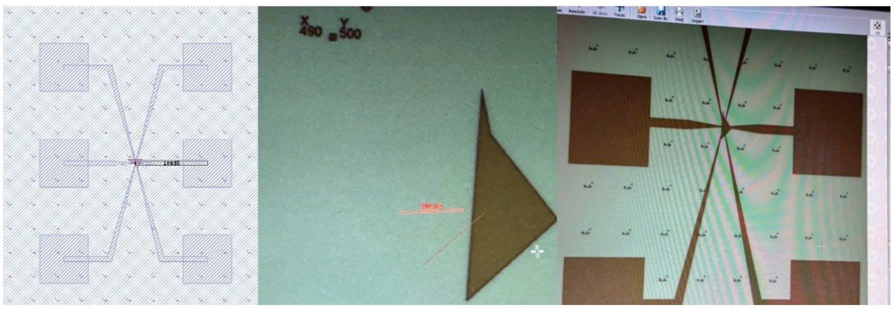

Figure 2: Comparison of CAD layout with experimental results under an optical microscope.

Validation criterion	CAD Design	Generated Result	Outcome
Central exposure region present	Yes	Yes	Pass
Exposure region centered	Yes	Yes	Pass
Wafer orientation preserved	Yes	Yes	Pass
No unintended features	None	None	Pass

Figure 3: Qualification criteria comparing the CAD layout with the generated ASML job.

Figure 4:Workflow used to qualify the ASML Stepper Job Scriptor for CNF use.

References:

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[2]. Cornell Nanoscale Science and Technology Facility. (2020). ASML job cheat sheet. https://www.cnfusers.cornell.edu/sites/default/files/Equipment-Resources/ASML%20Job%20Cheat%20Sheet2020.pdf.