Scalable Fizeau Interferometer

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We describe the design idea, optimization and construction of an interferometer for different apertures. Starting from a scalable plano convex collimation lens, diameters from 250 mm to 600 mm can be obtained without changing the design of the interferometer head. Only distances have to be adjusted. The critical parameters MTF, field curvature and distortion do not exceed their given limits.

1 Introduction

For the production of ASML lithography systems, optically high performance plan surfaces of various sizes must be measured interferometrically. In addition, depending on the product type, harsh requirements are placed on imaging quality, e.g. distortion, field curvature, lateral resolution. Since the commercially available (non-customized) interferometers do not fulfil the requirements entirely and do not allow the flexible adaption of selected parameters, an in-house development is needed.

2 Optical design

The optical design is based on a fixed interferometer head and a scalable collimation lens (Fig. 1).

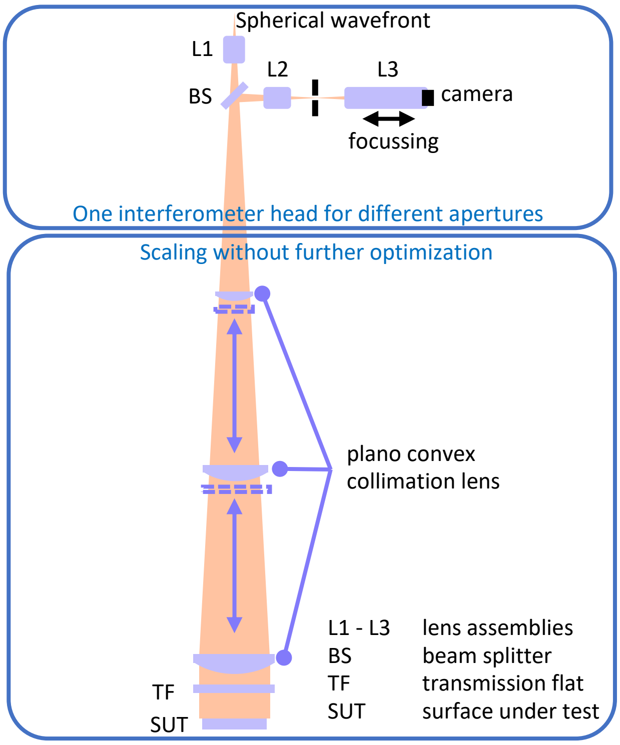

Fig. 1 *Draft of the optical design.*

The spherical wavefront passes L1 and BS and is collimated after each of a selected plano convex lens. The SUT is imaged on a camera passing L2 and L3 and the interferometer aperture in between. L3 can be moved to focus on the SUT.

3 Optimization approach

The optimization was done in Zemax for apertures between 250 mm and 600 mm. In addition, the wavelengths 779 nm, 780 nm and 781 nm were tested in order to ensure that the replacement of the laser do not downgrade the optical performance of the system, if the new laser provide not exactly the same wavelength.

The illumination beam path was optimized with the parameters L1 and BS to a sufficiently collimated wavefront for all apertures. After that for the imaging path, the parameters L2 and L3 were optimized, so that MTF, image field curvature and distortion were within a specified range.

Here, L1 - L3 are assemblies with several lenses of different curvature, radii and materials. When selecting the lenses, catalog parts or at least easily available materials were used whenever possible. Only lenses with spherical and plan surfaces are used.

4 Optimization results

First, the result of the optimization for the illumination beam path is shown. Here, the collimated wavefront-error is about 0.5 λ (see exemplary Fig. 2).

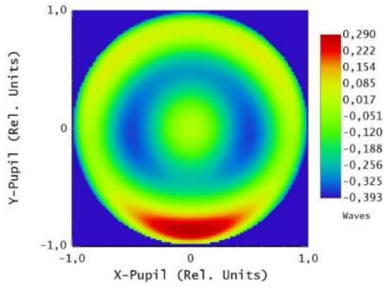

Fig. 2 *Wavefront of illumination for a diameter of 350 mm.*

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For a comparison of the MTFs, they are calculated at different field positions and wavelengths. The design goal was to achieve a MTF-value above 0.5 for at least 50 cycles per mm at the camera over the full field. It can be seen that the MTF remains nearly constant even when the plano-convex lens is replaced by other apertures within the optimized range and does not change significantly across the field (Fig. 3).

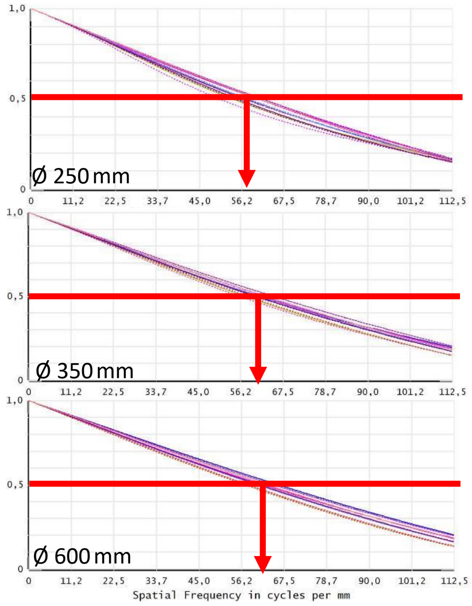

Fig. 3 *MTF of imaging path for different apertures. Each at different areas in field and wavelengths.*

Since the image field curvature is directly linked to the MTF at different field positions, its analysis shows a corresponding behavior for different apertures. It is always within ±0.1 mm and thus within the given specifications (Fig. 4).

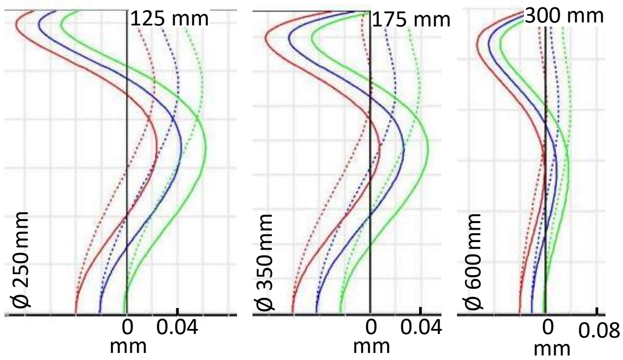

Fig. 4 *Field curvature for apertures. Each at wavelength of 779 nm (green), 780 nm (blue) and 781 nm (red) and tangential (solid) or sagittal (dashed).*

Finally, the distortion is verified. It has a maximum displacement in the object field of 0.1 mm. In relation to the camera used, these are ±1 pixels and therefore do not interfere with the requirements of the interferometrically measurements (Fig. 5).

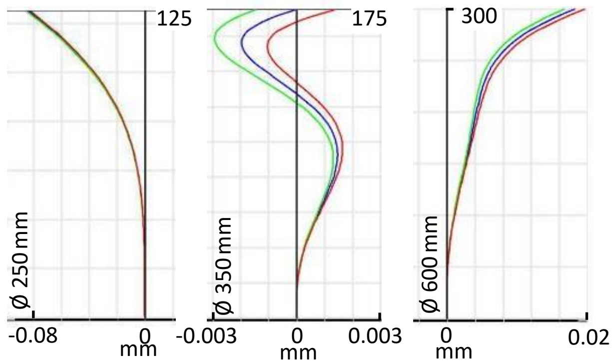

Fig. 5 *Distortion for different apertures. Each at wavelength of 279 nm (green), 280 nm (blue) and 281 nm (red).*

5 Mechanical setup

A design with an aperture of 350 mm was chosen for the setup and folded with two folding mirrors. All components of the interferometer head were compactly built on a breadboard and placed vertically.

Fig. 6 *Mechanical setup.*

6 First results

After adjustment, the first light shows that the main objectives have been achieved and the interferometer is ready for measurement. Note the large field of view, the good contrast and the insensitivity to vibration without vibration isolation. However, there is still room for improvement in the adjustment.

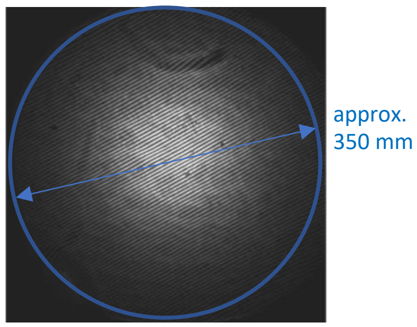

Fig. 7 *Live view after adjustment.*

7 Conclusion

The paper presented the concept and implementation for a Fizeau interferometer with a scalable aperture within 250 mm to 600 mm. The laboratory setup for 350 mm delivers first promising results. The next step is the qualification of the system.

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