WaveFront The Quarterly Newsletter of ASML Optics

April 2005

ASML Optics Supports ASML/Zeiss EUV Program

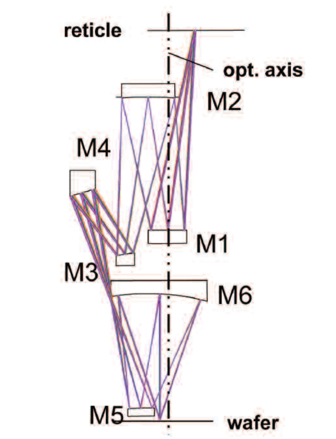

Figure 1: Optical schematic design example for an EUVL projection optic

Teams from ASML Optics and Carl Zeiss have worked closely together to solve what was once considered to be a potential showstopper for Extreme Ultra-Violet Lithography (EUVL), achieving an "extreme" optical quality level needed on the imaging optics.

EUV lithography operates using a 13.4 nm wavelength light source. The quality of optics required for the lithography system roughly scales with the light source wavelength so an EUV optical system must be ~18.5X and ~14.5X better than the current generation of tools that operate with a 248 nm source and 193 nm source. In addition to the surface figure error challenges presented by the shorter wavelength, the optical prescription and the spatial period bandwidth for the surface errors significantly increases the fabrication and test difficulty level of EUV optics.

Typical EUV optical elements are off-axis aspheres, which are generally considered the most difficult type of optic to manufacture. Until the recent introduction of the very high numerical aperture systems, virtually all lithography optical systems used spherical surfaces, which are inherently much easier to manufacture than off-axis aspheres. Even the very high numerical aperture systems have consisted of approximately 80 percent spherical and 20 percent on-axis aspheres.

The heart of the lithography optical train is the projection optic designed by Carl Zeiss. For EUVL, this is a 6-mirror optical system with a numerical aperture of 0.25. All materials absorb EUV photons at a wavelength of 13.4 nm, so unlike today's advanced 193 nm systems that use transmissive optics, EUV optical systems must be all reflective. To achieve the necessary imaging to support the 32 nm node and below, the 6-mirror system may use off-axis aspheres, and each mirror may have a surface error corrected to better than $\lambda/3000$ where λ equals 633nm; i.e. 0.2nm rms.

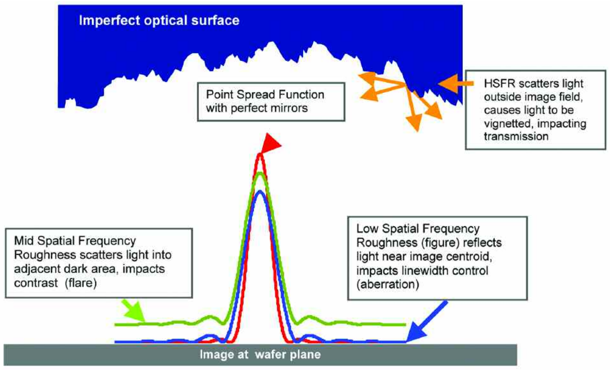

Figure 2: Impact on lithography for different spatial frequency imperfections in the optical surface

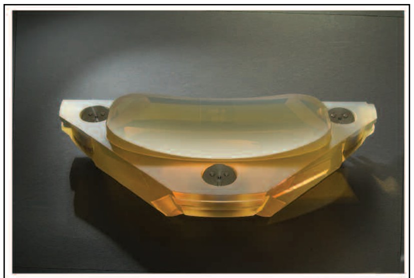

Figure 3: Extreme Precision Off-axis Asphere for EUV

Errors on an optical surface consist of "low" order errors, which are usually associated with the aberrations (up to 7th order) that impact an image's shape, mid-frequency errors that reduce image contrast and high-frequency errors that cause light to be lost because it is scattered outside the focal plane. Figure 2 illustrates these different types of surface errors. The range of spatial period errors on the optical surfaces that impact an EUV system is greater than the range for the 193 nm and 248 nm systems. For a 193 nm system only spatial period errors larger then 0.2 μm have an effect on system performance, while errors with periods as low as 0.01 μm contribute to an EUV system's performance. The need to correct all these spatial frequencies for EUV mirrors has meant that not only is the polishing of these surfaces a tremendous challenge, but the design and build of metrology to prove the sub-nm mirror performance has also been complex.

By combining expertise in optics polishing and in the development of unique metrology equipment, both ASML Optics and Carl Zeiss have polished mirrors for EUV lithography that are state of the art. The mirror in Figure 3 illustrates this. These mirrors are likely the most critical off-axis aspheres that have ever been made, and it is these extraordinary mirrors that may enable sub-45 nm imaging on ASML's EUV Alpha Demo lithography system later in 2005.

Extreme Precision Optics

ASML Optics, a supplier of extreme-precision optics, provides complete Design-to-Image™ solutions and distinct customer benefits with Asphere Advantage™ technology and PerfectWave™ metrology.

Upcoming Events

Optifab 2005
May 3-5, 2005
Rochester, New York
Booth #1403

CLEO/QELS 2005
May 24-26, 2005
Baltimore Convention Center
Baltimore, Maryland
Booth #1258

Optics and Photonics 2005
August 2-4, 2005
San Diego Convention Center
San Diego, CA

www.asml.com/optics

Unique Calcium Fluoride Process Rolls Out Cylindrical Lens for Deep UV

Over the past year ASML Optics has found a new niche in cylindrical processing of Calcium Fluoride optics. Drawing on more than a decade of Calcium Fluoride expertise and a series of highly specialized fabrication techniques, we have designed and ramped up production on Calcium Fluoride cylindrical lenses for advanced lithography Illumination systems.

As a synthetically grown, single-crystal substance, Calcium Fluoride is very soft and difficult to work with. Yet where fused silica and other traditional lens materials block or absorb shortwave light, Calcium Fluoride reliably transmits this illumination for deep UV applications, offering a much longer lifetime while reducing system-level wavelength compaction.

This challenging material requires a number of custom manufacturing processes in cylindrical optics. Processes offered by ASML Optics include technologically advanced diamond point turning (DPT) to minimize sub-surface damage and reduce cycle time, and a magnetorhealogic finishing (MRF) polishing technique to obtain figure specifications below 0.4 fringe at 633 nm wavelength. MRF polishing used in concert with our proprietary metrology enables ASML Optics to push optical correction to extreme-precision limits, improving polish predictability and reducing cycle time.

We use additional customized procedures for the final intricate shaping and precision beveling of the Calcium Fluoride optic, and a high energy compatible Anti-Reflective coating completes the process.

This unique combination of extreme-precision techniques developed by ASML Optics optimizes Calcium Fluoride cylindrical fabrication for some of the industry's most demanding optical applications.

Positions Open in Optical Design

ASML Optics is interested in recruiting optical designers. The successful candidates will interact with Systems Engineering, Opto-Mechanical Engineering, and the Manufacturing organization within ASML Optics to translate overall system requirements into optical system requirements. Responsibilities will also include sensitivity analysis and tolerancing for manufacturability, as well as patent research. These challenging positions require a minimum of a bachelor's degree or equivalent experience in Optical Engineering, Physics or Mathematics. Experience with both geometrical and physical optic design is required, as is experience using Code V and/or Zemax. Optical systems engineering, scatter analysis and the communication skills necessary to interact successfully with customers are also needed.

For more information regarding this position, contact Carolyn Mueller at 203-761-6458 or carolyn.mueller@asml.com.

Design-to-Image™ Solutions Offered by ASML Optics

ASML Optics is proud to announce its unique Design-to-Image services for your most demanding optical applications. Our capabilities include all forms of optical design from large diameter refractive and reflective aspheric optics to flats, windows and more conventional spherical lenses and mirrors. From design to component fabrication to system integration, ASML Optics can take your vision from concept to reality.

Watch for our new Design-to-Image advertisement featured in the May and June issues of *Laser Focus World*, *Photonics Spectra*, and *OE Magazine*. To learn more about how our Design-to-Image solutions can work for you, contact your local representative.

ASML

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