The Course is Set for the Microchips of the ...today

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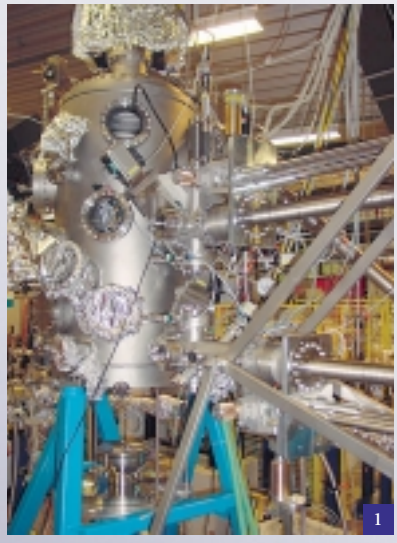
The prototype of high-performance optics for the fabrication of microchips of the next-but-one generation has now had its premiere. In the radiometry laboratory of the German Physical-Technical Institute (PTB) at the Berlin BESSY 2 electron synchrotron, chip features of as small as 50 nm were patterned for the very first time in Europe using the Micro Exposure Tool (MET) from Carl Zeiss SMT AG.

With more and more stationary and mobile intelligence, microchips are making our everyday lives easier. To achieve this, they must perform an increasing number of functions and process more and more data in ever shorter times, at any time and in any place, and with less electrical energy than in the past. Currently, the processing speed of the processors doubles every four years, and the capacity of memory chips increases by a factor of 10 every five years. The ITRS (International Technology Roadmap for Semiconductors) quantitatively plans the stages of this development in advance. Whereas the feature sizes of the current function elements are still around 130 nm, they will decrease to about 50 nm or even 30 nm toward the end of this decade.

The principle used to fabricate these components is similar to that used in slide projection: Light beams image the microstructures on masks on the silicon surface of a wafer. Each exposure is followed by subsequent chemical treatment (microlithography). The demands made on the precision of the projection optics in this process are enormous. In addition, with increasingly smaller features, light with increasingly smaller wavelengths must be used for projection.



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The market focuses on extreme UV lithography

Research laboratories, manufacturers and suppliers are currently working at full stretch on solutions for the production of semiconductors of the generation after next. "Most of the market participants are focusing on extreme UV lithography (EUVL)," said *Dr. Herrmann Gerlinger*, CEO of Carl Zeiss SMT AG. Only with UV light of an extremely short wavelength (13.5 nm) will it be possible to project the microstructures of the future semiconductor generation from the mask on to the wafer with the resolution required and to achieve high productivity at the same time. The MET successfully tested in Berlin uses this technology as a basis. The development was funded by the International SEMATECH (ISMT, an international association of chip manufacturers) and by the German Federal Ministry of Education and Research.

Mirrors instead of lens elements

The materials usable for optical systems do not transmit extreme UV light. For this reason, the imaging beams can no longer be directed by refraction through the lens elements, but only by reflection from mirrors. The aspheric mirrors made for these high-performance optical systems are aligned to a precision of a few millionths of a millimeter. Their surface figure (admissible deviation from the mathematically required surface) and the surface roughness are approximately three times the diameter of a hydrogen atom. This ensures the correct transfer of the structures on the mask to the chips, enables high contrast for edge-to-edge imaging and high reflectivity of the mirror surface. In addition, the demands for short exposure times and high throughput, i. e. high productivity, in chip fabrication are met. A comparison: in lens elements used in reflex cameras, the admissible deviation from the surface accuracy required is 50 to 100 times greater.

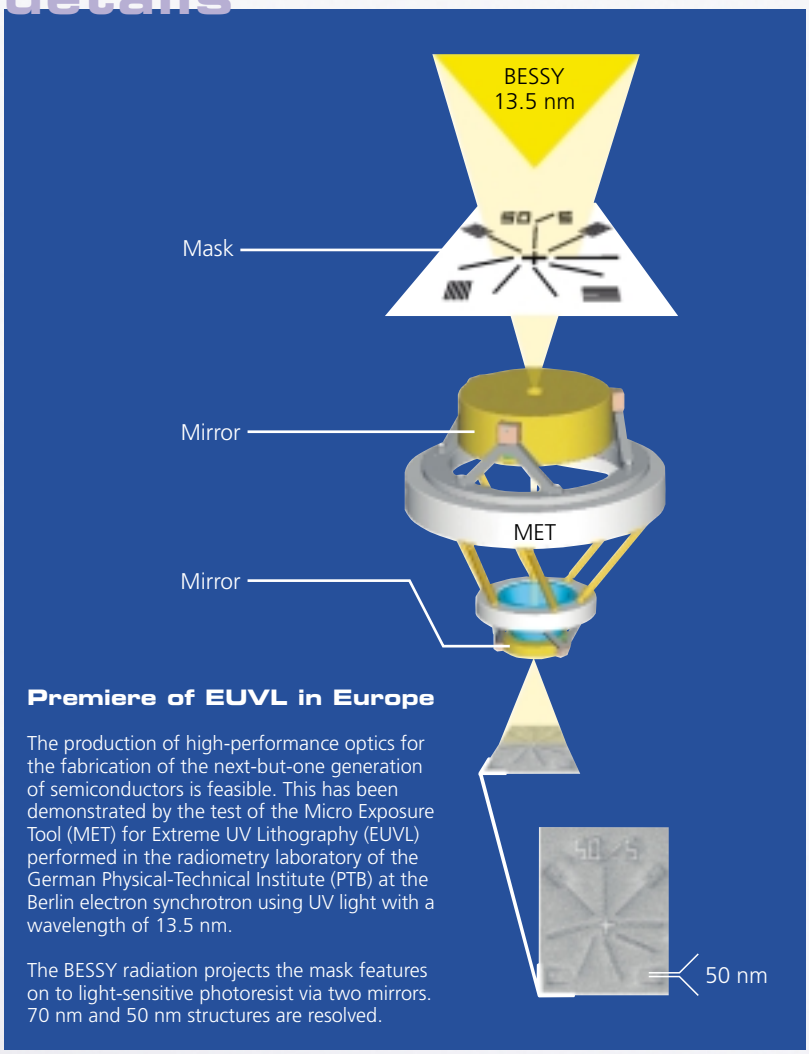
Fig. 1:
Experimental setup for testing the Micro Exposure Tool (MET) for Extreme UV Lithography (EUVL). The MET is located in a large metal vessel; the trans-radiated volume is a vacuum.

Future details

The next step

Together with its Dutch partner ASML, Carl Zeiss is developing the successor to MET within the framework of the Extreme UV Alpha Tool Integration Consortium (Extatic). *Noreen Harned*, VP of ASML and Extatic Program Manager, explains the goals of the European MEDEA+Consortium: "ASML is the only company in Europe developing a full-field exposure tool. We are well within our time schedule for starting volume production in the year 2007. The status of development is largely the same in Europe as in the USA, but ahead of Japan. The focus is on three critical areas – tool development, lens manufacture and development of radiation sources. The European activities are concentrated on the research and developments necessary to make EUV lithography a marketable technology. ASML will then provide the members of EUV LLC (an American R&D consortium launched by ISMT and Intel in 1996) with beta tools. We are the only manufacturer who has announced plans for the delivery of the first beta EUV tools."

The new optics used in the beta EUV tool will work with a considerably larger image field than MET and have six instead of two mirrors, which will also be markedly larger. Carl Zeiss SMT AG will again improve the surface accuracy and surface quality of the mirrors and the accuracy of the overall alignment over MET to be able to achieve the targeted resolution of 30 nm. MET will be used in a lab production system with an optimized set of mirrors by the International SEMATECH to develop photoresists which can be used with EUV in the fabrication of semiconductors.



Premiere of EUVL in Europe

The production of high-performance optics for the fabrication of the next-but-one generation of semiconductors is feasible. This has been demonstrated by the test of the Micro Exposure Tool (MET) for Extreme UV Lithography (EUVL) performed in the radiometry laboratory of the German Physical-Technical Institute (PTB) at the Berlin electron synchrotron using UV light with a wavelength of 13.5 nm.

The BESSY radiation projects the mask features on to light-sensitive photoresist via two mirrors. 70 nm and 50 nm structures are resolved.

Illustrations on the left and bottom right: Lithography optics for today and the years ahead. **Left:** Present-day **Starlith®** lens. **Bottom right:** The prototype for EUVL tested in Berlin – for the years ahead. The Micro Exposure Tool (MET) with high-precision mirrors has been developed by Carl Zeiss SMT AG in cooperation with the Lawrence Livermore National Laboratories, USA

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the years ahead...