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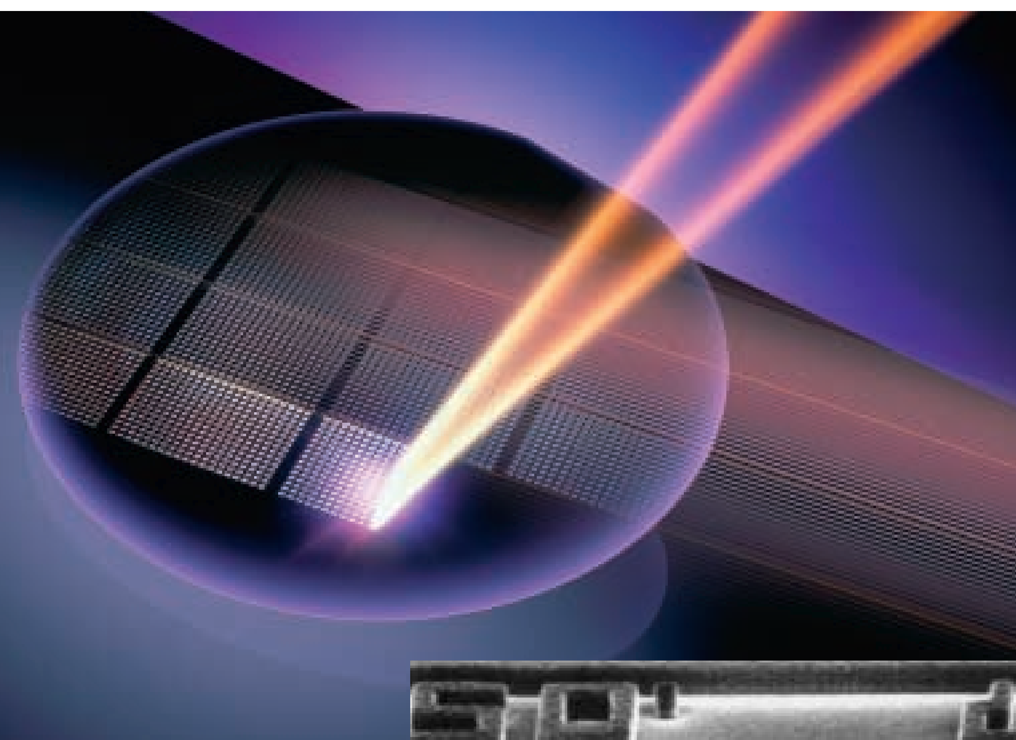
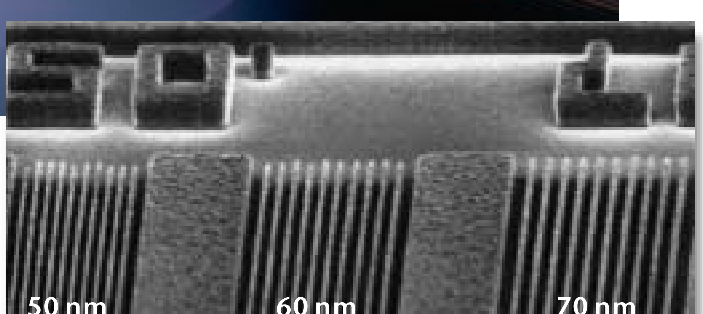
# Fit for Future Chip Technology

**Schott Lithotec is a world leader in high-tech optical materials for micro-lithography. In a new project the company is now also developing key materials and components for Extreme Ultraviolet Technology (EUVL).**

According to Moore's Law the power of computer chips doubles approximately every 18 months by continually miniaturizing their structure. This is only possible if appropriate microlithography processes are available to treat the silicon wafers. Inevitably continuously smaller light wavelengths are used in the exposure machines (wafer steppers) which transfer the complicated design of the electronic components and circuits. Nowadays mass production is handled by eximer lasers which work with wavelengths of 248 and 193 nanometers (nm = one-billionth of a meter) and thus belong in the invisible, short-wave UV range. For the next generation of chips, which will be going into production beginning in 2005, wavelengths of 157 nm are foreseen, which can be produced using fluorine lasers. Back in 1999, a German consortium started work on 157 nm lithography. As the world's leading manufacturer of calcium fluoride crystals, Schott Lithotec is playing an important role in the consortium.






*The use of ever smaller light wavelengths reduces the structure gaps on computer chips and thus increases their performance. Right: First 50 nm structures produced with EUVL.*

## Innovation Tempo High

To maintain the tempo of the International Technology Roadmap for Semiconductors, i.e. the planning agreed between the chip manufacturers, the foundations must be laid down now for "Extreme Ultra Violet Lithography" (EUVL). EUVL is operated with an extremely short-wave UV radiation of only 13 nm and is set to lead to structure spacings of 50 nm to start with, reducing to spacings of less than 35 nm in due course. This is the most likely variant of lithography after the introduction of the 157 nm version. The changeover to EUVL technology means a shift from the transfer of images from masks to the wafer by using lenses. The use of EUV light requires the exclusive use of reflecting optical elements instead of transmission optics, in essence mirrors. These consist of a substrate with very special properties, to which the reflective layers are applied.

## Masks, Lenses, Mirrors

Microlithography is not just a question of the radiation sources, but above all the suitable materials for components and systems. Schott Lithotec AG of Jena is the only manufacturer at the present time supplying all the technologies currently in use. These materials include high homogeneity optical glasses, fused silica and calcium fluoride. The substrate requirements for 13 nm lithography represent a further challenge. For example the material must have an extremely low thermal expansion so that it does not distort when warmed up. Based on optical simulations, the expansion would have to remain below just a few ppb (parts per billion) per Kelvin range. One ppb per Kelvin means that a body 100 millimeters long may not expand more than 0.1 nanometers when heated up by one degree – this greatly surpasses

*EUV lithography marks a change in technology in which lenses are completely replaced with mirrors.*

*Prototype of an EUVL wafer stepper by the Lawrence Livermore National Laboratory, California, USA.*

*The fused silica substrates are lapped, then polished and then under clean room conditions finally coated with more than 100 layers, each only a few atoms thick.*

all previous demands on so-called zero expansion materials. It calls for the development of a new material and enhanced measurement techniques if the required material properties, with regard to expansion behavior, flatness, surface finish and freedom from imperfections, are to be verified with absolute certainty.

## Extremely Clean Rooms

Yet virtually undetectable thermal expansion is only one of several requirements that the substrate material for the so-called mask blanks has to meet. Another indispensable aspect is that it must be capable of being polished to an exceptionally high degree to give a final surface roughness of only a few tenths of a nanometer, which is in the range of a few atoms.

To avoid even the slightest imperfections, the preparation, polishing and coating stages are carried out in extremely clean rooms. Every minute imperfection on the mask is reproduced on the chip, just like every speck of dust on a slide stands out when it is projected onto a wall. On a square mask blank with a 15 cm edge, not a single imperfection is permitted that is larger than 50 nm. Even verifying this by measurement is an enormous challenge.

*Test structure with "Zerodur" glass-ceramic for mechanical EUVL components.*

Schott Lithotec, in cooperation with appliance manufacturers and institutes such as the IOM (Institut für Oberflächenmodifikation = Institute for Surface Modification of Leipzig), is investigating various correction processes to further improve the overall surface of the masks by carefully removing the minutest amounts of material from it.

A further prerequisite is a degree of material homogeneity which can only be achieved with the special processes used for the manufacture of optical glasses. With its "Zerodur" glass ceramic and its proven performance in scientific and industrial applications, Schott is in an excellent starting position, since this material already comes very near to meeting these requirements. Nevertheless some fundamental work still needs to be done.

## Sights on Higher Market Shares in Microlithography

The goal of Schott Lithotec and Schott Glas is clear. If the broad industrial introduction of the EUV technology is imminent from 2006 onwards, key materials and components should come from Schott. These include the substrate material for masks and optical elements plus the complete mask blanks. The share of the microlithography market is set to be expanded continuously. Schott Lithotec plans to transfer its current world leadership in the manufacture of calcium fluoride to the technologies of future lithography generations too ■

## More than 100 Layers to make a Mirror

To coat the substrates Schott Lithotec has set up an "Advanced Quality Production Line" using modern sputtering technology under clean room conditions. From its very conception, emphasis was placed on achieving low reject rates. On the journey from the substrate to the mask blank more than 100 layers are applied – each only a few atoms thick. As no material reflects EUV radiation naturally, artificial crystal grids have to be generated which produce the necessary mirror effect by means of interference. This also explains the high number of layers required. Schott Lithotec is also cooperating with external partners in this area. These include the Fraunhofer Institute for Applied Optics and Precision Mechanics (IOF, Jena) and the PTB (Federal Physical and Technical Office) in Berlin. The metrology required to test the reflection behavior of the mask blanks while they are still in the production stage is being developed especially for Schott Lithotec by Jenoptik Mikrotechnik and AIXUV GmbH of Aachen, the first supplier of commercially available EUV radiation sources for laboratory use.

Schott Lithotec and Schott Glas EUVL programs have been running since May 2001 with financial support from the Federal Ministry for Research and Education (BMBF). These activities are also part of both a total German concept for EUVL and in the European MEDEA+ research initiative. MEDEA is the successor program to JESSI ■

## Together to the Target

Those involved in the EUVL consortium are:

- Schott Lithotec
- Schott Glas
- Carl Zeiss
- XTREME Technologies (a merger of Lambda Physik and Jenoptik for the development of EUV sources)
- Infineon
- Philips
- Leica
- Jenoptik
- ASML (as stepper manufacturer)