TNO TPD

Battle for the square nanometer

Next Generation Lithography

The chip industry is moving rapidly towards the limit of current chip machine technology, the so-called wafersteppers. The upcoming generation of machines that work with light wavelengths of 157 nanometres will be followed by a vacuum. Literally. Researchers at TNO are working with ASML, Philips and Zeiss on technology in a vacuum that will enable the enormous step towards extreme ultraviolet light with a wavelength of 13.5 nanometres. The aim is to create a working prototype by the end of 2003.

TNO TPD delivers innovative and complete solutions for large companies, SMEs and the government. Our fields of knowledge are: acoustics and vibrations, models and processes, and imaging and instrumentation. Projects, both national and international, vary from system development to consultancy.

Moore's Law from the 1960s states that the performance of computer chips doubles every 18 months. Until recently that law was correct but now it only takes a year. This gives an indication of the pace of change in the miniaturisation of the electronic structures that are etched onto silicon chips. The technology involved in this is comparable to photography. A light source in the waferstepper illuminates a 'mask'. That is a quartz plate with a pattern layer, whose imprint is depicted in miniature on a silicon wafer. The imprint forms the basis for a chip.

Price of miniaturisation

State-of-the-art machines are currently achieving this with light wavelengths of 193 nanometres, thereby creating the capacity at high production speeds to write electronic lines 100 nanometres wide. The width is the 'performance driver': faster chips mean even less width. But etching ever narrower lines with the required definition has its price. Miniaturisation demands ever better and more expensive optical equipment and extremely accurate positioning of the silicon wafer. Another influential factor in

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miniaturisation is the need to work with incrementally shorter wavelengths.
They shifted from 365 to 248 to 193 and will soon go to 157 nanometres. Extreme ultraviolet (EUV) requires an even shorter wavelength: 13.5 nanometres.

Diameter: one atom

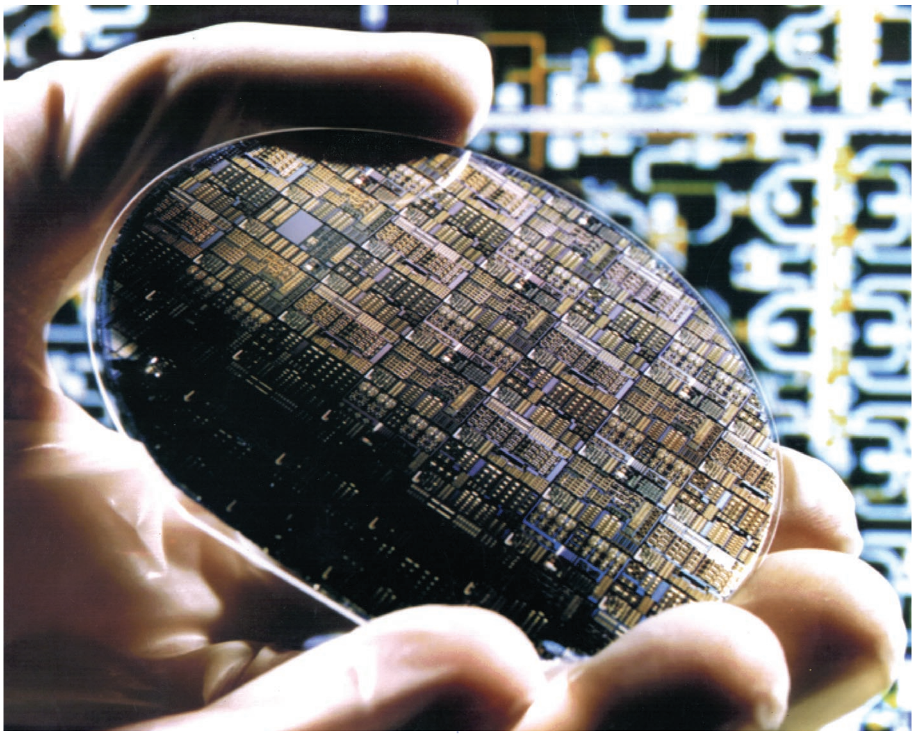
The leap to the extreme ultraviolet range comes under the banner of 'Next Generation Lithography'. And it is not alone. Many more options are being explored, like working with ions and electrons. For every option, however, there are significant technological hurdles. For example, achieving a production volume of 50 of more wafers an hour is a big challenge for many of the options using charged particles.
EUV Lithography (EUVL) is equally difficult to achieve. In the 13.5 nanometre range there is no transparent material, not even gas. Therefore, the whole process has to be conducted in a vacuum, which has an enormous impact on the machine's design.

Extremely clean

One of the fields in which TNO is active for EUVL is contamination control, both at particle and molecular levels. The machines must remain extremely clean during production. Every vacuum system has a background pressure of water and a small amount of contamination by hydrocarbons. This can lead to the oxidation or contamination of the reflective coating. That is why the mirrors get a protective layer a few nanometres thick and the vacuum system has to be extremely clean to keep contamination to a minimum.
A related problem is that every mechanical contact leads to the release of particles and thus contamination.

Answer

A second TNO project within the scope of the EUVL work concerns the development of a vacuum-compatible 'level sensor'. Accurate positioning and measurement of the position of the wafer is essential for the photographic factor depth of field. TNO is also designing and building the mask handling system for the EUVL prototype. The mask must be placed in the machine via an airlock using a robot - and then remain on exactly the right spot.
It is currently held in position by vacuum suction, but that mechanism will of course be impossible once the whole machine is operating in a vacuum. Electrostatic clamps or 'chucks' will take on the task and TNO is developing them.



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