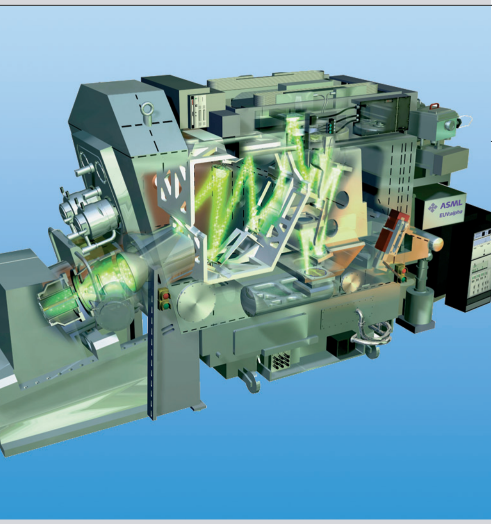
PROJECT RESULT

Lithography



T403: Extreme UV alpha tools integration consortium (EXTATIC)

EUV lithography tool developments ensure European lead in key processing technology

Photolithography using extreme ultraviolet (EUV) light is a key enabling technology for the production of 32 nm half pitch and below semiconductor devices. Extensive work on optics and coating technologies in the MEDEA+ EXTATIC project has led to the development of a full field EUV lithographic tool essential for future process research in this area. Two such 'alpha' tools are being delivered to research centres in 2006 to continue these efforts. This is an important factor in enabling Europe to maintain its global lead in sophisticated semiconductor chip processing equipment.

As chip feature size decreases, more functionality and memory can be integrated on the same area. Reducing half pitch from the 65 nm now possible to 32 nm and below by the end of the decade would typically mean four times more memory could be provided for a digital camera, processors could halve in size while doubling speed, or devices made smaller to reduce power dissipation.

Photolithography is a critical element in the production of microelectronic devices and accounts for over a third of manufacturing costs in a typical wafer fabrication facility. The process involves projecting light through a photomask – or reticle – to form an image on the silicon wafer, coated with a light-sensitive photoresist, making it possible to etch circuit details on the wafer surface. A typical semiconductor chip undergoes 30 or more such steps during manufacture.

As circuit details become ever smaller, it is essential to ensure that new technologies are available for these wafer fabrication processes. Current photolithography methods rely on 193 nm wavelength deep ultraviolet light but this is coming to a practical and theoretical limit.

While originally thought suitable for circuit details down to the 65 nm node, development of immersion processes has extended use of 193 nm technologies down to the 45 nm node – but at a high cost in terms of equipment and productivity. To achieve details of this size either requires double 'patterning' – double exposure – that needs twice as many masks and cuts manufacturing throughput by half or wet lithography with complex optical proximity correction (OPC).

New approach required

So, despite continuous improvements in optical technologies, a new approach was required. Global industry consensus was that this can best be provided by use of extreme ultraviolet (EUV) light with a wavelength of 13.5 nm – actually soft X-rays.

Delivery of the first commercial systems intended for high volume manufacturing with EUV will be required by 2009, enabling industry leaders to be able to start full scale production in 2010 or 2011. Current optical technology will continue to be used of course, but for less critical layers.

MEDEA+ therefore encouraged Europe's leading companies and research centres in wafer steppers, light sources, imaging systems and mask manufacturing to work together in a group of projects to create innovative solutions to winning the global race for next generation lithography (NGL) solutions. The EUV cluster covered four main elements of the lithography process: tools, masks, illumination sources and processing.

The MEDEA+ T403 EXTATIC project acted as the focus of the EUV cluster, integrating the various elements being developed into a suitable exposure tool with relevant optics to enable full scale research to be continued on EUV processing.
Main members of the EXTATIC consortium were leading global process equipment manufacturer ASML and its optics partner Carl Zeiss. Two French companies – SAGEM and Xenocs – offered complementary expertise in 'active' optics and alternative coating processes.

Ultra-high vacuum

Many changes were required for the EUV production equipment. Unlike existing machines that run at atmospheric pressures, EUV tools must function in ultra high vacuum as soft X-rays are absorbed by all materials. Sensors, optics and handling equipment had to be adapted accordingly – something that had not been done before. Wafer stages and the photomask itself had also to be made vacuum compliant.
As no material is transparent to EUV, demagnifying optics have to be reflective and so are made up of a series of mirrors. Equally, it is not possible to protect the reticle against particles as all materials absorb EUV radiation strongly. This also leads to a bigger problem of how to keep the mask clean during transport, use and storage, as even one particle on the reticle could lead to device failure.
Near normal incidence reflection of EUV radiation with high peak intensity can only be achieved by molybdenium/silicium multilayer stacks. Suitable reflective optics surfaces require extremely high precision polishing and coating techniques. While the technologies involved were not new, results had only been achieved before under laboratory condition. For EXTATIC, an ion-beam assisted electron beam evaporation technology has been developed for optimised mirror coatings.

Two alpha tools

As a result of EXTATIC, ASML has been able to develop a full-field EUV lithographic research tool bringing together the elements developed in the EUV cluster. This machine can expose wafers at much smaller dimensions than previously possible. Two of these 'alpha' tools were delivered in 2006 – much earlier than all competitors – to enable research to continue in this critical area. One of the tools will be installed at the IMEC research centre in Leuven, Belgium, while the other will go to the College for Nanoscale Science and Engineering at the University of Albany in New York State.
Co-operation within the MEDEA+ programme has ensured the European microelectronics industry and its equipment and materials suppliers were working to the same schedule for the timely development of EUV technology.
Success in the various MEDEA+ EUV cluster projects means Europe is now ahead of the world in this key enabling technology, with a six to 12 month lead over competitors from Japan. Work is continuing in the parallel EU IST MORE MOORE project. And the second phase MEDEA+ T403 EAGLE project should ensure Europe will be able to supply a greater share of the equipment market for EUV processes and bolster employment security in Europe.

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PARTNERS:

ASML
Carl Zeiss
SAGEM
Xenocs

PROJECT LEADER:

Anton van Dijsseldonk
ASML

KEY PROJECT DATES:

Start: June 2001
End: December 2005

COUNTRIES INVOLVED:

Germany
France
The Netherlands

MEDEA+ Office
140bis, Rue de Rennes
F-75006 Paris
France
Tel.: +33 1 40 64 45 60
Fax: +33 1 40 64 45 89
Email: medeaplus@medeaplus.org
http://www.medeaplus.org

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MEDEA+ focuses on enabling technologies for the Information Society and aims to make Europe a leader in system innovation on silicon.