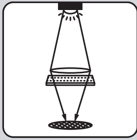
PROJECT RESULT



Lithography

2T301: EUV advanced generation lithography in Europe (EAGLE)

Introducing EUV photolithography to mass production

Extreme ultra-violet (EUV) photolithography has been considered the lithographic technology of choice for chipmakers, offering a clear path for development at the 32 nm node and potentially down to 16 nm in the future. However there were question marks over its suitability for volume production, due to a lack of suitable tools and equipment. The EAGLE project developed an EUV photolithographic platform that is robust and economic for volume production. The success of this MEDEA+ project paves the way to a dominant position for Europe in global equipment markets for the most advanced More Moore technologies.

The photolithography stage in manufacturing semiconductor chips is one of the most important phases in the production process. And when seeking to develop ever-smaller chip packages, it is also one of the most challenging to change. With then-current optical-lithography technologies approaching their limits, the MEDEA+ 2T301 EAGLE project sought to develop an alternative platform for volume semiconductor manufacturing, based on extreme ultra-violet (EUV) lithographic technology.

EAGLE targeted a European EUV photolithographic platform capable of operating at the 32 nm node level in pre-production with limited volume production runs. A successful completion would enable the semiconductor industry to begin producing semiconductors using EUV at the 32 nm level, in accordance with the International Technology Roadmap for Semiconductors (ITRS).

EUV photolithography is not the only lithographic method available. However the optical-lithography alternatives of double patterning – exposing the substrate to the light source twice – have the disadvantage of adding to the bottleneck potential of the lithographic stage, and so are less than ideal as candidates for development to full production capability.

The EAGLE consortium brought together key European equipment producers and their suppliers to attack the problem. Most of the partners have a long experience of working together in previous EUV projects. In particular, EAGLE built on the results of the MEDEA+ EXTATIC project to develop an EUV pre-production capability at 32 nm, bringing together critical subsystems such as handling and sensor systems, optics, collectors and sources to construct a production platform suitable for use in a semiconductor fabrication plant.

Better than expected progress

By the end of the project, EAGLE had exceeded its target, delivering a particularly advanced EUV photo-lithographic platform capable of pre-production throughputs at levels down to 27 nm.

The newly developed EUV lithography platform is known within project leader ASML as the NXE3100. While the original target capability for the platform was 32 nm, better than expected progress with the demonstration tools and the optical components has allowed ASML to offer it to customers as a 27 nm capable tool.

One key achievement was the development by Zeiss of a new high-performance projection-optics system for the platform. While based on the same design as the demonstration tool developed in the previous EXTATIC project using six mirrors and a numerical aperture (NA) of 0.25, significant performance improve-

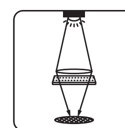
ments had to be realised to reach the 27 nm manufacturing capability. In particular, the performance of the optics has been improved significantly. Furthermore, the flare specification was halved from 16% in the EXTATIC demonstrator down to 8% for the NXE3100.
The projection-optics coatings were developed by FOM together with Zeiss. The two partners achieved a significant improvement in single mirror reflectivity by around 4%, delivering an overall 50% improvement in projection-optics transmission. The new coatings are also able to withstand the higher thermal loads that are a consequence of high-volume manufacturing conditions.

Orders from three continents

The final integrated NXE3100 EUV platform came into full operation at ASML during the third quarter of 2010 to meet demands from global actors at forefront of the More Moore roadmap. Very few international competitors are able to provide similar solutions to achieve resolution below 32 nm. ASML has been supplying EUV lithography pre-production tools, with the help of the other project partners, since the end of 2010. Already orders have been placed from five customers on three continents.
The NXE3100 remains a current platform for ASML and, as well as already enabling production of chips at the 27 nm node, it is being used as a basis for developing the next generation of EUV tools. The platform is the one chosen by ASML for its participation in a subsequent CATRENE project, EXEPT, which, commencing in 2009, aims to develop the technologies, tools and infrastructure components for high-volume EUV lithography at the 22 nm node by 2012.
EAGLE's successful conclusion ensured that the project partners and their European subcontractors and customers were able to commence chipmaking in 2010 at better than the 32 nm level, at a cost of ownership likely to be acceptable to a range of customers. The fact that the project also delivered on time according to the ITRS has helped European companies to retain their place in global semiconductor manufacturing markets.

Importance of collaboration

This MEDEA+ project owes a good part of its success to positive outcomes from earlier MEDEA+ projects that also involved leading European companies, research institutes and universities. The EXTATIC project was of special significance, as that particular effort led to the construction of an initial demonstration tool in EUV lithography.
EAGLE's successor, the CATRENE EXEPT project, is using the results to develop an even finer lithographic production capability, at the 22 nm level, by 2012. Its key challenges include developing a new projection lens, a new illumination system with additional features adapted to the projection lens, high-accuracy wafer and reticle-stage systems, and sensor systems with much greater precision.
The continuing success of this work demonstrates clearly the importance of these collaborative projects at European level.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Philips Extreme UV
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KEY PROJECT DATES:
Start: February 2006
End: June 2009

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