PROJECT PROFILE

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

LITHOGRAPHY

Partners:

Alcatel Vacuum Technology
ASML
Carl Zeiss SMT
FOM
Media Lario Technologies
Philips Extreme UV
Sagem Défense Sécurité
XTREME technologies

Project leader:

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Key project dates:

Start: February 2006
End: December 2008

Countries involved:

France
Germany
Italy
The Netherlands

Extreme ultra violet (EUV) lithography is the new technology of choice to push the limits of optical lithography for fabrication of integrated circuits at the 32 nm node and below. The EAGLE project is developing a high volume EUV lithographic platform to ensure Europe's continuing dominance in the global lithographic production field, ahead of Japanese competitors. The project builds on the results of earlier MEDEA+ and EU projects that have involved leading European companies, research institutes and universities. Success will have a major impact on the European equipment industry and ensure European semiconductor manufacturers remain able to produce competitive products at the right time.

Photolithography is an essential element in fabricating semiconductor chips and remains the key enabling technology in reducing feature size in microelectronics in line with 'Moore's law' on the doubling of circuit density every two years. It involves projecting light via a photomask or reticle to form an image of the circuit on the silicon wafer, which is coated with a light-sensitive photoresist. After the development process, exposed areas are washed away, making it possible to etch circuit details on the wafer surface. A typical semiconductor device undergoes 30 or more such steps in the chip-fabrication process.

Lithography is the most important cost factor in the semiconductor fabrication plant, accounting to over a third of the processing costs for silicon chips. A typical wafer stepper used to project circuit images costs more than € 10 million, while the price of a mask set for current processes is € 500,000. And these costs will continue to grow for future generations of devices.

Optical lithography using deep ultraviolet light with a wavelength of 193 nm together with immersion technology appears to be extendable down to the 45 nm node. However, half-pitch resolutions of 32 nm and below for future generations of even denser devices would require double exposure or double imaging techniques that would halve wafer production throughput while markedly increasing mask-set prices. Extreme ultraviolet (EUV) lithography with a wavelength of 13.5 nm is therefore now considered as the only viable cost effective solution for high volume chip manufacture at the 32 nm node and beyond.

Helping win global race

Extensive work in major EUREKA and EU projects involving chipmakers, wafer stepper, light source, imaging system and mask equipment manufacturers, materials suppliers and research organisations has ensured that Europe is in the global vanguard of lithographic development. The MEDEA+ 2T301 EAGLE project is now building on the results of these projects – in particular on the outcomes of the MEDEA+ T403 EXTATIC EUV and T405 EUV sources projects, and the EU Framework Programme IST More Moore project – to help win the global race for next generation lithography solutions.

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The main goal of EAGLE is the development of a complete lithographic platform for the volume manufacture of 32 nm node electronic devices by 2009 in line with the International Technology Roadmap for Semiconductors (ITRS). Results of this project will be extendable to even smaller resolutions – at least as far as the 16 nm node – and so help Europe secure global leadership in the EUVL market to serve the microelectronics industry for the next decade.

While the MEDEA+ EXTATIC project led to the construction of an alpha demonstration tool for further research, new technological developments are required in critical subsystems such as handling and sensor systems, optics, collectors and sources to build a system qualified for use in a high volume semiconductor fab. EAGLE is therefore bringing together optical system producers, reflective coatings specialists, gas/vacuum systems experts and EUV source and collector manufacturers under the leadership of ASML, the dominant semiconductor lithographic tool manufacturer worldwide.

An EUV lithography tool consists of an EUV light source that includes a collector and debris-mitigation system – essential to ensure long life of the collector optics. The EUV light is shaped by the illumination system and a mask handled by a reticle stage for projection on to the wafer.

EAGLE itself will concentrate on the most critical areas of the technology for an EUV lithographic platform for volume manufacturing with special emphasis on cost of ownership as a result of wafer throughput and component lifetime requirements. The activities are distributed over three work packages:

1. EUV lithographic tool system architecture design and integration, and handling and sensor systems development;
2. Design and development of the illumination system and improvement of the projection optics, development of at-wavelength metrology and new multilayer coatings for the EUV optics; and
3. Source collector module specification, qualification and integration, collector and coating design optimisation, collector material and multilayer coating development, collector cleaning, debris reduction and optics lifetime improvement.

Volume production use

Targets for system design and prototyping are focused on the requirements for 32 nm node high volume production with an initial system throughput of at least 40 wafers per hour, upgradeable to over 100 wafers per hour – requiring adequate illumination power at the wafer and a wafer-handling system able to run at this level. The platform should also be extendable to at least 22 nm node requirements in terms of alignment, focus and both image and wavefront sensors.

Other targets include an increase of collector efficiency in terms of transmitted power from source to intermediate focus (IF), including the debris-mitigation system. Debris-mitigation should enable a sufficient collector life time. This results in a suppression of the debris of the source by several orders of magnitude. The debris-mitigation system should have an optical transmission of the highest possible level. This will also require improvements to the collector coating to ensure such a collector lifetime after debris-mitigation and collector-cleaning cycles.

Outside EAGLE, other essential components of the system will be improved where necessary in parallel with the MEDEA+ project and will also be manufactured for incorporation in the EAGLE tool. These include:

- Base frame with vacuum and air mount systems;
- Wafer and reticle stages offering a more than 100 wafer per hour throughput and with accuracy, overlay and focus requirements in line with 32 nm imaging, extendable to at least 22 nm;
- A six-mirror projection-optics system suitable for 32 nm high volume manufacturing with a lifetime according to industry standards; and
- An EUV source enabling exposure of over 40 wafers per hour, requiring an EUV power of around 1 kW in 2π.

All components will be assembled in a fully integrated system that will be used to demonstrate the achievements of the EAGLE project.

Major impact forecast

EAGLE is intended to solve a range of key technology issues involved in use of EUV lithography in high volume production. Success in this MEDEA+ project will have a major impact on the European equipment industry and boost skilled employment possibilities. It will ensure that Europe will be able to supply an EUV lithography tool to meet the ITRS for the production of 32 nm node devices at an acceptable cost of ownership. Moreover, it will enable major European chipmakers to supply competitive products in line with global market needs.

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