MEDEA+

PROJECT PROFILE

T403: Extreme ultraviolet alpha tool integration consortium (EXTATIC)

LITHOGRAPHY

Partners:

ASML
Carl Zeiss
SAGEM
Xenocs

Project leader:

Hans Meiling,
ASML

Key project dates:

Start: June 2001
End: December 2004

Countries involved:

France
Germany
The Netherlands

Integrated circuit feature sizes are forecast to shrink to 45 nm and below before the end of the decade. Optical lithography, long a mainstay process of the semiconductor industry, cannot continue to this point, as fundamental physical limits of refractive optics will have been reached. Of the several replacement technologies currently under consideration, extreme ultraviolet (EUV) lithography is strongly backed by many key players as the most likely successor for volume production. EXTATIC, one of a cluster of EUV-related MEDEA+ projects, aims to develop a new reflective optical system operating at a wavelength of 13 nm, and to provide the first EUV-exposed 300 mm wafers for evaluation.

Developments in photolithography have been central to the success of the semiconductor industry in continuously reducing the cost of integrated circuits (ICs) by around 25 to 30% a year per function. This has been brought about largely through progressive reductions in the critical dimensions.

Since the 1970s, linear feature sizes have typically decreased by a scaling ratio of 0.7 every three years – and latterly every two years. This has been achieved by measures such as shortening of the wavelength of light sources, increasing numerical apertures for optical systems, use of half-tone phase-shift masks and other resolution-enhancement technologies, for example annular illumination, and the development of high-performance resists.

New technology needed

By making use of tools operating respectively at wavelengths of 193 nm and 157 nm, optical lithography is predicted to remain applicable up to the forthcoming 100 nm and possibly 70 nm nodes. But, as features shrink to 50 nm and below, so-called ‘next generation lithography’ (NGL) tools will be required.

The cost of developing a single total system through to a commercially available solution is expected to approach € 1 billion. Hence, the achievement of a global consensus on an affordable post-optical technology is crucial.

Approaches using electron projection lithography (EPL), electron-beam direct-write (EBDW) and other NGL technologies are all currently under investigation. It appears, however, that EUV will be the preferred choice of major equipment makers and semiconductor companies around the world. Significant global EUV activities targeting 70 nm chips exist, driven by the USA, by Japan and also by Europe. EUV lithography is the main candidate technology being pursued under the MEDEA+ programme.

Developing basic system

In the three-and-a-half-year MEDEA+ T403 EXTATIC project, a consortium co-ordinated by leading lithography equipment supplier ASML is determining the essential requirements and developing a basic optical system to use EUV light at a wavelength of 13 nm. Partners are optics specialist Carl Zeiss and high technology electronics

manufacturer SAGEM, together with Xenocs, an SME specialised in the sputtering of multilayer coatings.

The study will lead to the construction of a full-field EUV research tool – the EUV alpha tool – that will be used to expose 300 mm wafers. The goal is to demonstrate that EUV is indeed the lithography technology of choice for the 50 nm node and beyond.

Associated initiatives are addressing other key elements of the lithography infrastructure, including:

- Illumination sources;
- Resist materials and processing equipment;
- Mask making, mask equipment and materials in the MEDEA+ T404 EXTUMASK project; and
- Metrology equipment for critical dimension and overlay control.

The overall activity is co-ordinated by the MEDEA+ EUV Cluster Steering Council (CSC), a task force consisting of members of the MEDEA+ Technologies Steering Group, extended by the three EUV project leaders and the leader of PREUVE, the French national research programme in this area.

Building on solid foundation

EXTATIC uses the results of work that began in 1999. Prior to the commencement of the alpha tool project, core competence was built up in the former European Commission Esprit project EUCLIDES. Further results and knowledge were available from PREUVE.

The MEDEA+ EXTATIC project is divided into three work packages, the first of which focuses on system architecture, system engineering, and programme management. It also includes the design, assembly and test of sub-units – including wafer and reticle stages, various sensor modules, wafer- and reticle-handling modules, system electronics and software. The aim is to have first exposures in the alpha tool by the end of 2003.

In the second work package, Carl Zeiss is undertaking the optical and mechanical design of the optical column, as well as the development of mirror fabrication, multilayer coating technology, and optical system integration. In parallel, SAGEM will produce active optics and evolve new mirror polishing and mounting technology, while Xenocs will pursue an alternative coating technology.

Shipment of the illuminator and the projection optics box of the alpha tool from Zeiss to ASML is scheduled for 2003, after which the main focus will be on further development of key optical technologies to reach the specifications for future EUV lithography tools.

Integration of a metrology framework and several sensors is due to be completed by mid-2002, as the initial phase of the third work package. This will be followed by the integration of the whole system, permitting a year of wafer exposures for testing and improving the whole system.

After delivery of the optical train to the integration team, additional in situ metrology will continue as part of the process of setting up the optics in the exposure tool. In the final year, a masks and resist process, which could be developed in two other projects of the MEDEA+ EUV cluster, must be used.

Great potential for Europe

The position of the three major semiconductor manufacturers in Europe is dependent on access to the latest technology. This is particularly true for the DRAM memory production at semiconductor manufacturer Infineon, where operational costs must be reduced to a minimum, partly by shrinking the die size. Lithography, which represents around 35% of total chip manufacturing costs, is one of the main factors involved in meeting this goal.

Europe is well positioned to fulfil the demand for NGL systems.

Sales of lithographic equipment are expected to grow significantly in the next few years, and expectations are high that EUV lithography will hold the key to the future. By the end of the decade, hundreds of machines should be shipped, each with a significantly higher value than that of today's systems. A substantial share of this business, worth a projected € 10 to 20 billion, would make a significant impact on Europe's high-technology trade balance and employment prospects.

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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 for the e-economy.