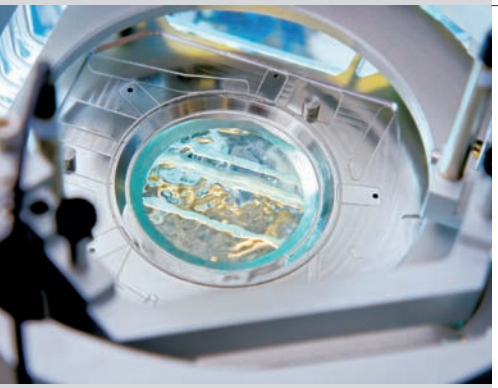
PROJECT RESULT

Lithography

MEDEA+

2T304: Lithography based on quite extreme ultra high NA 193 nm optical immersion development (LIQUID)



Horizontal co-operation extends reach of immersion lithography

Optical lithography plays a key role both in the manufacture and the cost of microelectronics devices. The MEDEA+ LIQUID project has extended the 193 nm optical lithography platform to support half-pitch resolutions between 60 and 38 nm, using immersion lithography. The consortium focused on developing the processes, test methods and infrastructure to support chip manufacturers in volume production. This close co-operation between the major chipmakers and their equipment and materials suppliers has ensured that Europe will be able to retain its domination of the global photolithography market.

Lithography costs are now the most important element of semiconductor fabrication, accounting for 35% of the cost of a chip. The price of the equipment required to project circuit images onto a wafer will continue to rise with future generations of ever smaller devices. European equipment and materials suppliers are now the world leaders in this strategic market thanks to continuous investment in research in successive MEDEA and MEDEA+ projects.

A primary limiting factor to the further reduction of node spacing has been the wavelength of the light used in the optical lithography required to produce the photomasks or 'reticles'. Until recently, the greatest node resolution has been limited to 50 nm. Consequently, a comprehensive solution had to be developed within a very short time frame to resolve details down to 38 nm in line with the international technology roadmap for semiconductors (ITRS).

The MEDEA+ 2T304 LIQUID project set out to develop the processes, materials and equipment required to extend use of immersion lithography to achieve this. The project was led by ASML, the global leader in photolithography equipment, in partnership with optical component and materials suppliers together with the major European chipmakers.

Increasing numerical aperture

One of the main advances in the field of semiconductor processing has been the use of immersion lithography to extend use of existing equipment. It involves replacing the air between the projection lens of the imaging system and the silicon wafer with a layer of liquid. This fluid refracts or bends the light, resulting in a greater resolution because the lens can be designed with a numerical aperture greater than one. This makes possible smaller features as the larger the aperture, the better the resolution.

LIQUID has now extended the use of water-based immersion lithography in both single and double exposure applications. The project has led to improvement in lithography exposure tools as well as critical materials such as fused silica, calcium fluoride (CaF_2) and immersion liquids.

A particular technical challenge was the reduction in water evaporation, which has a negative effect on overlays and the performance of sensors. The number of defects has also been decreased by several redesigns of the immersion hood.

In commercial terms, the market for water-based 193 nm immersion lithography comprises all of the high-end critical layers employed in semiconductor manufacturing. The performance of memory chips and

logic devices will be greatly enhanced through the use of immersion lithography in production. Applications for the latest semiconductor devices will be found in many industrial and consumer electronics domains as well as in health sector equipment.

High standard of collaboration

Within the four-year timeframe of this MEDEA+ project, the research phase progressed through development of the first prototype exposure devices to production-capable systems and infrastructure. By the end of the project, immersion lithography had become the technology of choice for critical layers in semiconductor manufacturing. This short time-scale was unprecedented and was only possible through co-ordinated, highly innovative efforts between European material suppliers, application developers and tool-integration teams.

The initiative for this project came from ASML which perceived immersion lithography as a possible candidate for extending the optical lithography process while continuing the use of the current 193 nm laser wavelength. The other project partners joined as they all had a common interest in developing this new technology, which could only be successful if the entire lithography chain was involved.

While four of the equipment development partners worked together on the immersion exposure systems, the application developers also provided input and specified requirements for the design of the exposure systems. The co-operation between these partners resulted in delivery of the processes for the different nodes. During the course of the LIQUID project, conference papers were presented at meetings of SPIE – the international professional society that deals with photo-optical lithography.

Co-operation between the material suppliers, application developers and tool integration teams was also very successful and resulted in a great progress for immersion lithography.

Chipmaker and supplier benefit

Lithography is the heart of the chip-manufacturing process. The world's leading lithography equipment suppliers are European companies, obtaining 90% of their business from outside of Europe. Despite the high level of outsourcing in semiconductor manufacture, it is European expertise, know-how and advanced lithographic equipment that proves its superiority day by day in all regions of the world.

The success of the studies and subsequent developments in this MEDEA+ project has resulted in considerable progress in chip performance, enabling European chipmakers to provide new devices for applications ranging from consumer to automotive electronics. The main impact of LIQUID on the European semiconductor lithography-related industry is that it enables all companies involved to maintain a leading position on the world stage. Moreover, extending use of 193 nm processes over at least two more nodes will dramatically reduce the cost of introducing new generations of ever smaller devices in wafer-fabrication plants.

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ASML
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JenOptik
LTM/CNRS
NXP
Photronics
Qimonda
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STMicroelectronics

PROJECT LEADER:

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KEY PROJECT DATES:

Start: January 2005
End: December 2008

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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.