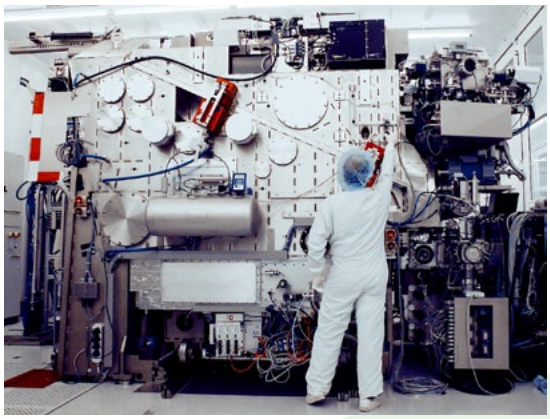
Project result

Cluster for Application and Technology Research in Europe on NanoElectronics

CT301 | Extreme UV lithography entry point technology development [EXEPT]

EXEPT

The extreme ultra-violet (EUV) lithography process is rapidly progressing as a viable production technique for less than 32nm semiconductor wafer technology. The CATRENE EXEPT project was set up to explore the possibilities for extending the lithography process to the 22, 16 and even 11nm nodes. The successful completion of the project now puts the European semiconductor lithography industry at the forefront of chip production expertise worldwide. During the course of the project, technology was developed to enable 22nm imaging at an acceptable cost-of-ownership in high-volume industrial-scale production.



Extreme ultra-violet lithography comes of age

Over recent years, EUV lithography has gradually become the standard process used for volume semiconductor manufacturing. Through the use of double patterning technologies, it has been possible to extend the application of immersion lithography to the 32nm node. However, EUV is capable of far higher feature density and therefore allows for a greater level of functionality in a standard chip package. Consequently, the primary aim of the CATRENE EXEPT project was to develop the necessary technologies, tools and infrastructure components as required for high-volume EUV lithography for the 22 nm node while laying the groundwork for extension to 16nm and 11nm nodes.

The CATRENE EXEPT project brought together a consortium of fifteen of the leading players in the European semiconductor equipment manufacturing industry and institutes with the aim of comprehensively extending the lithography tool technology to enable imaging at the 22 nm node at an acceptable cost of ownership level for industrial chip production as well as to develop EUVL infrastructure components for which competence and an industrial base exist in Europe. With the introduction of EUV lithography for high volume semiconductor production lines, the project aims at opening new business opportunities for the participating companies, at positioning the institutes at prominent international levels in their fields of activities and overall at safeguarding the international semiconductor industry in enabling the realization of the technology roadmap in lithography as given in the ITRS. Significant progress was already achieved on the 32nm platform in 2011 and this progress continued in 2012. Several 32nm pre-production tools are now operational at customer sites running wafers for process development. Tools were shipped employing both the laser-produced plasma (LPP) source and the discharge-produced plasma (DPP) source. Work on source debris mitigation and a collector prototype, ready for source collector module (SoCoMo) integration, has continued further outside the scope of EXEPT. This required an extension to the project in order to balance the various contributions.

Lithography at 22nm a reality

Development of the EUV lithographic platform for high-volume manufacture (HVM) at 22nm was progressively pursued throughout the course of the 3-year project. The system performance qualification of the 22nm lithographic tool started in the 2nd half of 2011 and continued in 2012. The final

Partners:

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AMTC
ASML Netherlands B.V.
Bruker Advanced Supercon GmbH
Carl Zeiss SMT GmbH
Dynamic Micro Systems Semiconductor Equipment GmbH
FOM institute DIFFER
Fraunhofer Institute for Integrated Systems and Device Technology (IISB)
IMEC - Interuniversitair Micro-Electronica Centrum vzw
IMS Chips
Media Lario Technologies
SAGEM Défense Sécurité
SUSS MicroTec Photomask Equipment GmbH & Co.KG
Xenocs
XTREME technologies GmbH

Project leader:

Gerold Alberga
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Key project dates:

Start: March 2009
End: June 2012

Countries involved:

Belgium
France
Germany
Italy
The Netherlands

PROJECT CONTRIBUTES TO

Communication	
Automotive and transport	
Health and aging society	
Safety and security	
Energy efficiency	
Digital lifestyle	
Design technology	✔
Sensors and actuators	
Process development	✔
Manufacturing science	✔
More than Moore	✔
More Moore	✔
Technology node	22nm

milestone was achieved in August 2012. The optics for the 22nm tool are based on the development of a high numerical aperture EUV lens and the irradiation lossless illumination system, with a high degree of illumination setting flexibility. This sets new standards of excellence in the field of semiconductor lithography.

Good progress was also achieved on the development of the source collector module. Due to the huge challenges involved in developing a production-ready system of this kind, the partners also collaborated in key technology areas outside of EXEPT to ensure that the relevant enabling technologies would be available when they are needed. One example is the EUV source technology, which has to be capable of more than 100 wafers-per-hour throughput.

The highly modular EUV lithographic system will allow for future upgrades and facilitates the distribution of the development work along the supply chain. Further EUV lithographic infrastructure components are developed. Those services include mask (repair and cleaning) technology and critical dimension (CD) metrology and should be seen as part of the whole EUV infrastructure.

The EXEPT project is a direct follow up to the EAGLE project (completed mid-2009), in which technologies for the EUV lithographic pre-production tool platform were developed. The EXEPT project enhances the prospect that Europe will further secure its world-wide leadership in the EUV lithography market. The project consortium members are companies from the European semiconductor equipment industry, several research institutes and a mask shop.

Most consortium members received funding from their respective national governments.

Ahead of Asian competitors

Over the last few years, there has been a growing interest in EUV lithography from the integrated circuit (IC) industry. This has been demonstrated during several conferences and in scientific publications at such events as the SPIE conferences, the EUV symposia and in several leading technical periodicals.

ASML, one of the consortium members, has already shipped six pre-production tool systems, (partly based on the technology developed in the earlier EAGLE project, with imaging capability close to 20nm) and has received 10 orders for the next generation, (the technology for which was partly developed in the EXEPT project). The shipment of the first of these new tools was made before the end of 2012. At that moment, the far-eastern competitors had not yet announced the shipment of any EUV tools.

With the completion of the project, the 22nm system is forecasted to become the first choice high-volume EUV manufacturing tool.

Potential for further development

The work performed in the EXEPT project, as a continuation of the activities of the earlier EAGLE project, has further matured both the EUV lithography technology and the EUV infrastructure. The results of the EXEPT project have contributed to an increase of employment opportunities in the EUV ecosystem and have provided the European semiconductor manufacturing industry with a leading position in the field of EUV lithography.

The successful development of EUV technology for high volume semiconductor manufacturing has exhibited the potential to provide new fields of European expertise for application areas that will emerge in the near future. These include lithography at wavelengths well beyond those covered in this project, biomedical microscopy, metrology, the development of elemental analysis equipment and advanced research on solar energy.

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CATRENE (Σ! 4140), the EUREKA **C**luster for **A**pplication and **T**echnology **R**esearch in **E**urope on **N**ano**E**lectronics, will bring about technological leadership for a competitive European information and communications technology industry.

CATRENE focuses on delivering nano-/microelectronic solutions that respond to the needs of society at large, improving the economic prosperity of Europe and reinforcing the ability of its industry to be at the forefront of the global competition.