PROJECT PROFILE

T409: Development and proof of concept for projection mask-less lithography (Projection-ML2)

HIGH-SPEED COMMUNICATIONS SYSTEMS

Partners:

CEA-LETI
EQUIcon Software
Fraunhofer Institute (ISiT, IOF, HHI)
Infineon Technologies
Institute for Microelectronics Stuttgart
Ionen Mikrofabrikations Systeme
Leica Microsystems
Philips
STMicroelectronics

Project leader:

Hans-Joachim Doering,
Leica Microsystems

Key project dates:

Start: January 2004
End: December 2006

Countries involved:

Austria
France
Germany
The Netherlands

As device features become ever smaller – now below 50nm, novel lithographic techniques are essential for fast chip development and prototyping, as well as for low and medium volume chip production – a key European asset. The MEDEA+ T409 Projection-ML2 project involves the development of novel technology in the domain of mask-less lithography (ML2). This is based on proven projection electron optics and targets the 45nm technology node, which can be extended below this level. The project is intended to ensure that Europe becomes the leader in a novel technology with substantial industrial potential, having a direct impact on employment and the creation of an outstanding skill base.

Major innovations in electronic device manufacturing are vital to maintain historical trends in performance improvement. Optical lithography and next generation lithography technologies – such as extreme ultraviolet lithography (EUVL) and electron projection lithography (EPL) – are mask-based solutions designed for high volume chip production. Other techniques, such as single electron-beam direct write (EBDW), concentrate on laboratory work with high resolution.

Therefore, for fast chip development and prototyping and for the fabrication of low and medium volume devices, new technologies are required providing solutions at reasonable cost and time-to-market. As an example, an International SEMATECH study in March 2002 of the cost-of-ownership for the first year of production at the 50nm node, showed that a mask-less lithography system with a throughput of five 300mm wafers per hour (WPH) and a tool price of €16 million, would be cost effective for the production of devices with up to 1000 wafers per design.

Fast growing market

As indicated in the MEDEA+ electronic design roadmap, the global demand for ASICs and SoCs is expected to grow to 50% of the total market in 2005. As a consequence, the worldwide interest in fast prototyping, as well as cost-effective low and medium volume production, will increase still further. The challenge for the chipmakers is to have the required technology available in time.

Within the MEDEA+ T409 Projection-ML2 project, a vertical consortium consisting of tool vendors – including two SMEs – and research institutes, in collaboration with their three major European chipmaker customers (Infineon, Philips and ST Microelectronics), is specifically addressing this challenge by jointly developing a mask-less lithography (ML2) technology. This will increase the strength of European tool suppliers in the direct-write electron-beam-based tool market, and enable European chipmakers to have the right technology available at the right time.

The aim of the project is the development of a novel electron-beam based projection technology for mask-less lithography – Projection-ML2 (PML2) – that targets the fast development and fabrication of devices, such as application-specific integrated circuits (ASICs), complete system-on-chip

(SoC) devices and micro-electromechanical systems (MEMs), with production levels of less than 1000 wafers per design, including fast prototyping of high volume designs.

Key objectives – sub-50nm resolution and sufficient wafer throughput

The fundamental technical performance challenge for electron-beam direct-write (EBDW) lithography – eliminating the need for expensive masks – is throughput. Whereas mask-based optical lithography at 248nm and 193nm, and its EUV successor at 13.5nm, are expected to achieve 60 WPH and more, EBDW lithography is currently two to four orders of magnitude slower. The limited throughput of EBDW lithography is caused by the serial nature of the exposure process and the limited, useable writing current.

Increasing throughput using new ideas in electron-beam (e-beam) lithography is the focus of active research in industrial and academic laboratories around the world. In 2002, Leica and STIFT/Thuringia sponsored an international workshop for mask-less lithography. This provided an opportunity for interaction between more than 50 experts from Europe and the USA. A direct follow-up action after the workshop was to start a European initiative and create a network of chipmakers, tool suppliers, advanced research institutes and universities in Europe with the aim of focusing on mask-less lithography.

During that workshop, IMS Nanofabrication Vienna presented its Projection-ML2 concept, which was subsequently discussed in detail with Leica. After thorough evaluation, Leica – which is now co-ordinating the MEDEA+ T409 project – decided to focus its ML2 efforts on the IMS Projection-ML2 concept proposal.

A primary innovation is the development of a 200x reduction electron optical system with a dynamic beam-structuring device, the so-called programmable Aperture Plate System (APS). Key microsystems technologies for the realisation of APS were developed by the Fraunhofer Institute for Silicon Technology (ISIT), Itzehoe, Germany. An ultra-fast optical data path to the APS is provided by the Fraunhofer Heinrich Hertz Institute (HHI), Berlin. The APS with 200x reduction e-beam optics is equipped with a high-precision scanning wafer stage to create a massively parallel writing strategy with several hundred thousand electron beams with 25nm diameter.

The project is split into two parts:

1. The development and realisation of a proof-of-concept tool for 45nm node CMOS manufacturability on 300mm wafers. During the last phase of the project, intensive performance tests will be carried out to show the feasibility and suitability of this technology for the semiconductor industry; and
2. A feasibility study on the extendibility of the concept towards advanced beta tool specifications. Key subsystems are being investigated with respect to 45nm node lithography requirements at 2 WPH throughputs. The final goal is to provide practical engineering solutions to enable the possible delivery of the first PML2 beta tools in 2007/2008 (outside the scope of the MEDEA+ project).

Project success will enable European IC-partners to be among the first companies to offer fast development and prototyping with leading edge cycle times for most advanced CMOS designs.

An opportunity to secure the market

The involvement of the main European chipmakers in the project is of great benefit for the tool development efforts and will accelerate the introduction of this new technology. Therefore this MEDEA+ project strengthens the competitive power of the European semiconductor industry as a whole. Manufacturers of low and medium volume devices such as ASICs, SoCs or MEMs in particular will greatly benefit from this emerging form of lithography.

In 2003, the market for optical lithography tools was about €3.2 billion. The expected ML2 share potential is currently estimated to be up to a quarter of that market. This amounts to a potential future PML2 market of €800 million. The challenge for European manufacturers is to introduce a competitive ML2 technology at the right time, thereby increasing their lithography equipment market share and establishing an alternative to challenging developments, in particular Japanese-driven electron-beam-based lithography techniques.

Establishing leadership in this market will keep Europe among the world leaders in the development and further exploitation of microelectronic technologies, thus creating jobs and employment.

MEDEA+ Office
33, Avenue du Maine
Tour Maine-Montparnasse
PO Box 22
F-75755 Paris Cedex 15, France
Tel.: +33 1 40 64 45 60
Fax: +33 1 40 64 45 89
Email: medeaplus@medeaplus.org
http://www.medeaplus.org