MEDEA+

T405: EUV source development (EUV Sources)

LITHOGRAPHY

Partners:

AIXUV
Alcatel
Carl Zeiss
CEA / DPC / SPAL
CEA / DRECAM / SPAM
FOM
University of Orleans – GREMI
Innolite
Institute of Optoelectronics (Warsaw)
JENOPTIK Mikrotechnik
Philips Extreme UV
THALES Laser
XTREME technologies

Project leader:

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Key project dates:

Start: June 2001
End: December 2004

Countries involved:

France
Germany
Netherlands
Poland
Sweden

Extreme ultraviolet (EUV) lithography is opening up a new chapter in semiconductor development. It is the leading contender to establish next-generation lithography technology that makes possible features as small as 50 nm. A critical issue is development of a source emitting radiation at the wavelength for the optical systems required. The MEDEA+ EUV Sources project brings together more than a dozen expert organisations to assess and select from two approaches – electric discharge or laser excited plasma. The project will allow the European microelectronics industry to stay ahead of strong US and Japanese competition in the way lithography technologies are developed well into the next decade.

Optical lithography is a key element in semiconductor production. It involves passing light through a mask of the chip design and projecting it on to the silicon wafer, where it exposes special photoresist chemicals used to protect unetched circuit details. Until now, visible light sources have sufficed, but new processing technology based on extreme ultraviolet light (EUV) lithography will be required for next generations chips that are expected to be much more complex and powerful than today's ones.

EUV has shorter wavelengths than visible and UV light and can therefore be used to define smaller and more numerous features. However, there are drawbacks to its use. For example, EUV can be absorbed by air and by the types of lenses that have been traditionally used in chip-making technologies. To get around those limitations, the process needs to take place in a vacuum, with highly sophisticated mirror systems to project chip patterns on to the silicon wafers.

A number of EUV research groups are carrying out developments in this technology to make sure European semiconductor industries remain competitive in the face of such an advance. The T405 EUV source development project, part of the MEDEA+ EUV cluster of projects investigating possible first generation solutions, brings together a consortium of 13 European organisations to determine what type of device will sit at the heart of later generations of EUV lithographic production tools, and to establish a development road map for the chosen source. Follow-on projects will focus on the production of devices using the technology.

Continuously shrinking details

In the past, lithography for high-end semiconductor devices used h- or i-line mercury lamps for respectively 436 and 365 nm wavelengths; but 0.25 micron dimensions needed pulsed gas discharge excimer lasers offering wavelengths of 248 nm. Stepping down to 100 and 70 nm details required argon fluoride (ArF) and molecular fluorine (F2) excimer lasers at 193 and 157 nm, respectively.

Next generation lithography (NGL) technology will be required to shrink the structures even further, to 50 nm and below. Industry consensus is that EUV at a wavelength of 13.5 nm will be necessary. But, while EUV appears to be the most promising

technology for NGL, none of the known laser and electrical discharge excited sources appears to be reliable or resilient enough to be produced industrially – although each has its own advantages and disadvantages.
Worldwide competition is hotting up in this area. Many companies and research facilities are already well into development of EUV sources. In the USA, PLEX and Cymer are active in electrical discharge technologies, while Sandia National Labs, TRW, AES and J-mar are developing laser-produced plasma sources. In Japan, Gigaphoton is thought to be working on concepts that combine laser-produced and electrical discharge sources.
E-beam and X-ray lithography are still on the list of competitive technologies. However, more and more companies are now concentrating just on EUV and have stopped supporting the alternatives. This makes it more likely that EUV will be established as the future lithography technology.

High power source essential

The principal challenges of EUV lithography involve developing a high power source, illumination and demagnifying optics working at 13.5 nm, and appropriate manufacturing techniques for EUV masks. A high power yet very narrow waveband source is essential as, at the required 13.5 nm wavelength, materials used to make refractive lenses have too strong an absorption and it is necessary to use optics based on carefully designed systems of mirrors which reflect only a single wavelength.
Highly excited plasmas are the answer. The main challenge is to apply the very high energy input to the plasma and to achieve very high energy conversion efficiency at the desired wavelength. Consortium partners are investigating two different ways of exciting plasmas – high power laser or electrical discharge.
Various alternatives are being explored and results compared on a continuous basis. Once the most promising source concept has been established, it will be further developed in the second part of the project.
The consortium plans to commercialise its chosen technology and match it to a lithography development roadmap. Several related applications are being used and developed further; source performance at the different project partners will be benchmarked to compare the characteristics of the different sources by the so-called ‘Flying Circus II’ activities. Metrology tools are being developed that can assess source concepts from the participating partners.
Close collaboration between the project's manufacturers and scientific institutions should result in new ideas. There is also a good interaction between source developers, optical manufacturers and prospective customers. This will lead to new patents and publications appearing in internationally recognised journals, providing continuous information and assistance to all partners in their development work.
Alcatel, CEA, Innolite, Philips Extreme UV, Thales Laser and XTREME technologies (a joint venture between Lambda Physik and JENOPTIK LOS) are investigating source concepts. Philips Extreme UV and XTREME are pursuing evaluation of gas discharge sources. Alcatel Laser, CEA, Innolite, Thales Laser and XTREME are investigating plasma sources. FOM is carrying out benchmarking, while also working with AIXUV and JENOPTIK Mikrotechnik to develop metrology further. A separate work package investigating EUV sources with low output power for metrology is being pursued by AIXUV, GREMI, IOE Warsaw and FOM.

Market potential

The stepper-lithography market is expected to be worth about 1,000 units per year for the next 10 years or so. Assuming that EUV will account for a 30% share of the market from 2007 and later, more than 300 EUV sources per year are needed for lithography. EUV sources are also needed for materials investigations, optics and mask characterisation and testing.
Activities will lead to a variety of powerful EUV sources for different applications, which meet the industry requirements. The European stepper manufacturer will have access to a market leading technology in the face of stiff competition from other, equally respected companies in the USA and Japan. This will generate and secure many high technology jobs within Europe at the companies and institutes.
The overall objective of the MEDEA+ project partners is to enable Europe to maintain a global leadership in lithography. This can only be realised through strong European co-operation involving all available resources from the user and supplier industries, including talent from the specialised institutes and universities.

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