All done by mirrors

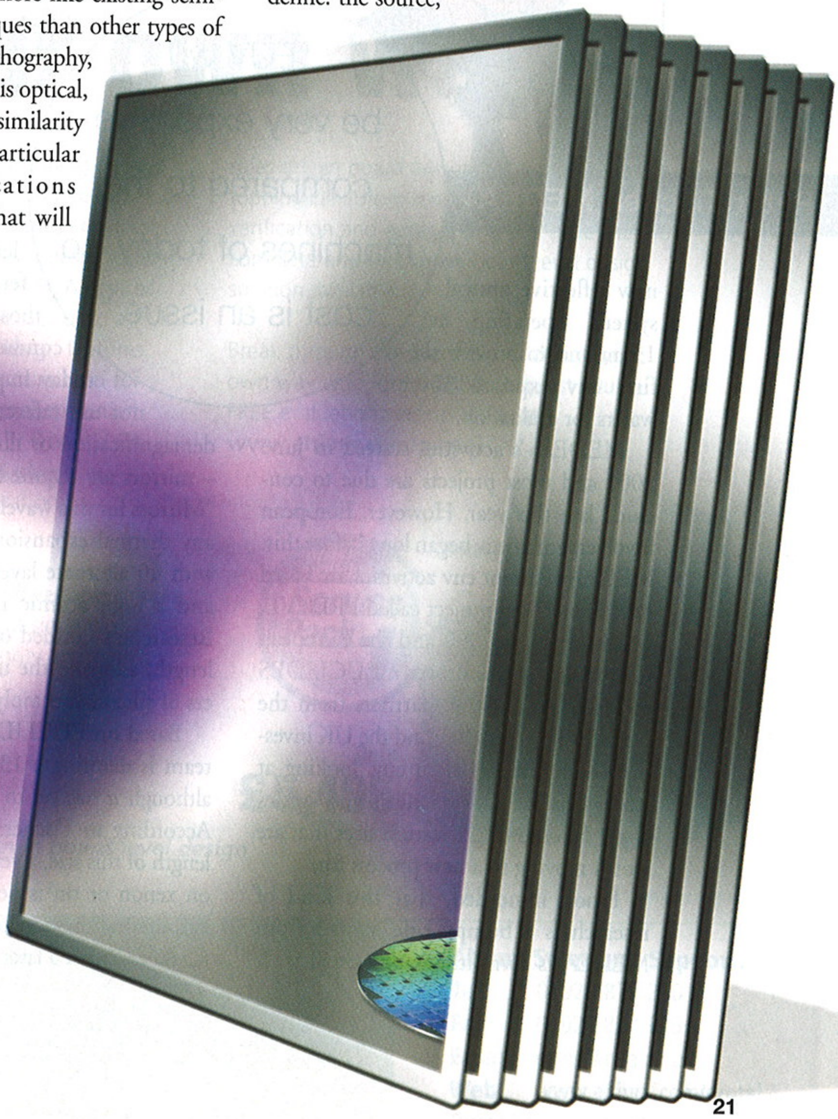
Collaboration is key to furthering euv research. By **Vanessa Knivett**.

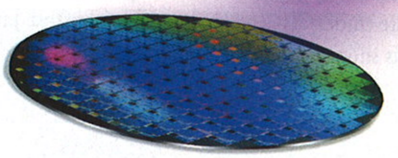
The quest for a semiconductor process that can be used to define smaller features is focusing the minds of many researchers – particularly in Europe. One of the most promising techniques to replace current photolithography techniques is extreme ultraviolet (euv) lithography. EUV has shorter wavelengths than visible or uv light and can therefore be used to make feature sizes of 45nm and smaller.

Whilst euv is more like existing semiconductor techniques than other types of next generation lithography, in the sense that it is optical, that is where the similarity ends. EUV has particular complications that will make machinery development as challenging as process development. EUV can be absorbed by air and by the types of lenses currently used in chip making. To get around these limitations, the process will need to take place in a vacuum, with sophisticated mirror systems to project chip patterns on to the silicon wafers.

Commercialising the fundamental euv research being carried out by a variety of academic consortia and private companies will be a multibillion dollar exercise and is therefore only feasible through partnership and collaboration. The potential rewards, however, are significant for Europe.

Enter MEDEA+, a scheme that breaches European boundaries, bringing large and small companies together on mutually beneficial research projects. The scheme addresses the financial and organisational aspects of challenging, but strategic, research for Europe. There are four euv projects currently underway in Medea+ to define: the source;





the masks; the resists; and the machines.

In the first, known as T405, 13 European organisations are examining two potential euv sources – electric discharge and laser excited plasma. The group has also been charged with investigating alternative technologies. Project T404 will concentrate on making the masks required for reflective euv exposure at 13.4mm in an industrial environment. With a goal to define all aspects of euv lithography by the end of 2005, project T406 hopes to realise 45nm node patterning on a full field alpha tool. Meanwhile, T403 aims to develop a new reflective optical system operating at 13nm and to provide the first euv exposed 300mm wafers for evaluation.

Peter Tischer, MEDEA+

"EUV will be very expensive compared to the machines of today, so cost is an issue."

MEDEA+'s activities started in June 2001 and most projects are due to conclude late this year. However, European involvement in euv began long before this. MEDEA's current euv activities are based on a French euv project called PREUVE, which began in 1999 and the European Commission sponsored EUCLIDES project. In the latter, partners from the Netherlands, Germany and the UK investigated the feasibility of euv, looking at what kind of a wavelength and optics could be used to get feature sizes that are worth moving to a new process for.

Proof, if needed, that this kind of research is a bumpy ride, comes from MEDEA+'s own lithography projects. It ran a three year project starting in 1997 to investigate ion projection lithography, an alternative to euv,. Peter Tischer, vice chairman of MEDEA+'s technologies stream, noted: "Good results were achieved about the principal capabilities. However, European R&D activities (concentrated mainly around IMS, ASML and Infineon) were not strong enough, so the method did not achieve world wide consensus, which is necessary when introducing a completely new technique." Similarly, Intel abandoned research on 157nm lithography, opting to move straight from existing 193nm lithography to euv.

EUCLIDES, according to Tischer, confirmed euv was a worthwhile investment. Notes Tischer: "People want to make a big step in the wavelengths, not 10% or so. This means that if you go from 150nm, you are expecting a factor of 10 performance improvement – so 15nm feature sizes."

EUCLIDES also established the level of complexity that researchers would have to overcome in their efforts to commercialise euv. The materials used at this wavelength have very different properties to those used by the semiconductor industry today. In particular, you cannot use refractive optics for the demagnification or illumination systems – mirrors are required. Tischer explains: "Mirrors for this wavelength mustn't have any thermal expansion. This is achieved with 40 alternate layers of a low atomic and a high atomic number material." Researchers decided on a 13.4nm wavelength, allowing the use of alternate layers of silicon and molybdenum.

Based on EUCLIDES, the MEDEA+ team is defining a 13.4nm light source, although it has yet to decide which type. According to Tischer: "To emit a wavelength of this size, a very hot plasma based on xenon or tin is needed. Two ways of evaporating these materials are under discussion – either a laser beam is shot onto a small sphere of the material or it can be produced by electrical discharge. The first method provides greater intensity, whilst the latter would be much cheaper."

Intensity is a priority for the working group as the roadmap to which it is working specifies a final power of 100W. Today, source strengths of about 15W have been developed.

But it is not just the source used to illuminate the mask in euv that is proving challenging. EUV lithography also requires a multilayer mirror between the mask and the substrate. Depositing the 40 layers of material that comprise this mirror will require work on how to introduce the material to the system and to recognise how defects will affect the pattern printed on the wafer. Also, the machines required to guide the etching beam to the wafers will have to be even more accurate. With perhaps 25 layers used for one microprocessor, the challenge is in aligning each pattern to existing patterns on the wafer.

Says Tischer: "EUV will be very expensive compared to the machines of today, so cost is an issue."

A recent survey of members of the semiconductor industry consortium International SEMATECH confirmed that euv is one of the greatest challenges facing lithography. MEDEA+'s plan is to have a prototype euv machine by the end of 2005. Notes Tischer: "Even if source power isn't finalised – we may have achieved 30W by then – semiconductor companies will be able to use this to develop the process further."

Success in euv, suggests Tischer, could reaffirm Europe's status within the semiconductor industry. Three major toolmakers – ASML, Nikon and Canon – set the initial euv standards to which the industry is now working. There is strong competition from the likes of Intel, but the race to commercialise euv is not over yet.

Whilst there may be some duplication of research, Tischer believes it is vitally important that Europe has its own lithography research at this level. He concludes: "SEMATECH will concentrate primarily on masks and will look to Europe and Japan to build the machinery." NE