Chapter 6 Future

Twenty years of progress

Looking to the future

Ever since we produced our first PAS 2500 stepper in 1986, we have been pushing optical lithography forward at a rapid pace. We have brought the line-width level down from 0.9 microns to 0.065 microns (900 nm to 65 nm). We have seen the wavelength of the light used in our machines drop from 436 nm to 193 nm. And we have improved the number of good wafers per unit of time.

The question now is: What next? The answer will affect more than just ASML. The entire semiconductor industry, and indeed the world, has become accustomed to the relentless pace of progress that the microlithography industry has set. But can it be maintained?

Exploring the next generation

In recent years, ASML, along with others in the industry, has been exploring a number of potential new technologies that could become next generation lithographies.

Following the logic that caused us to explore the use of light with increasingly shorter wavelengths, we also experimented with F_2 (fluorine) DUV, which has a wavelength of 157 nm. But this effort ran into two main problems. Not only were we unable to find a suitable photoresist, we were also confronted with the problem that light of such short wavelength begins to be absorbed by the glass lenses that are supposed to focus it — a problem that could only be overcome through a radical redesign of the equipment.

At the other end of the scale, we have also explored extending the use of electron beam lithography. Already used in creating masks, electron beams have a very high resolution (0.1 microns and below). But although electron beam lithography offers the potential of further great reductions in line width, it is currently too slow for mass-production purposes.

A third option we have been working on is Extreme Ultraviolet (EUV). This is light with a wavelength of around 14 nm. To overcome the problem of absorption,

EUV lithography machines will not use lenses to focus the image, but very advanced, flawless mirrors. And since the wavelength of EUV is so short that it is absorbed by air, the process will need to take place in a vacuum. Many in the industry believe EUV lithography — if it can be implemented in practice — could extend the validity of Moore's Law by ten years, creating microprocessors a hundred times more powerful than those we have today, and memory chips capable of storing a thousand times more information.

Meanwhile, we continue to look for ways of squeezing further mileage out of immersion lithography, exploring the use of different fluids, for instance, to improve depth of focus and perhaps take resolution down as far as 0.03 microns (30 nm).

Which way forward?

Over the coming years, the industry faces a substantial challenge if it is to bring new technologies, such as EUV lithography, to fruition. Microlithography seems to have reached a crucial juncture. Is the industry maturing, and should we therefore expect change to continue in a more incremental fashion? Or will it continue to advance in great leaps and bounds?

ASML survived a difficult start. It has established itself as a key player in the market. And with an unrivalled track record of innovation, it has demonstrated that it can lead the way forward. What will the next twenty years hold? Who can say? But one thing is certain: ASML will be there at the forefront, taking up the challenges, breaking new ground and developing the technologies the industry needs.

And who — back in 1984 — would ever have thought we would be able to say that today?

The introduction of immersion technology at ASML

ASML began working on immersion technology in 2002. Several factors contributed to ASML joining the immersion challenge. The momentum for 157-nm technology was diminishing. 157-nm was not ramping up as expected, the resist mask infrastructure was proving to be a problem, and the cost of goods was growing increasingly unfavorable.
In 2002, ASML, eager to demonstrate 193 immersion potential, worked on some experiments to test their theory.

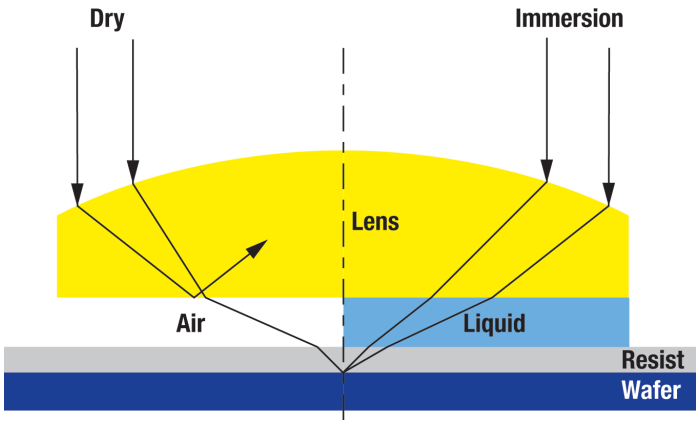
The group that focused on this work at first was Special Applications, who actually made and tested the first showerhead on a simple test-bench. Some theoretical study was needed alongside the experiments. A small project was set up at TNO to look into water flow, bubbles and stage forces. The results of the experiments and the theoretical studies together convinced Martin van den Brink to start a project at Zeiss to convert a lens for immersion application.

At that point, in the spring of 2003, we had the green light for immersion, and a formal project — an immersion feasibility project — was set up.

The project was composed of two teams working in parallel. One team of about 20 people in Veldhoven had the project goal of using ASML and Philips expertise to prove that the concept of scanning images under wet circumstances could work, and eventually modify an AT:1150 lens and a TWINSCAN body for the proof of concept. The first step was performing basic feasibility experiments in areas such as liquid containment, optical effects, and the chemical effects of resist in water.

This is where the second immersion project team comes in. In Wilton a team got to work testing the exposure of wafers under water and screening the resists for eventual use in the immersion scanner. Other liquids are also being considered for use in immersion.

The technical challenges that faced the immersion project can't be underestimated. How do you even contain water between the wafer and the lens? And if you can,



how do you control the effect of the resulting forces by the water from wafer scanning on the lens and imaging performance? If you manage to get great imaging performance, how do you image at the edge of the wafer without water pouring off the edge? Even more importantly then, how to change wafers? What happens to the water if you take the wafer away?

Thankfully, ASML already had the answer to one of immersion's trickiest challenges. The dual-stage of the TWINSCAN allows ASML to perform all our metrology in a dry environment, meaning we only have to concentrate on wet exposure. Without the metrology stage, we would also be facing the huge challenge of redesigning several major sensor systems that would also need to be adapted for the wet environment.

In October 2003, after just nine short months, ASML presented the AT:1150i immersion scanner — a working system producing excellent imaging results. This was a special project that didn't follow the standard development process. This was uncharted territory for ASML. We hand picked some employees, gave them a specific goal — they went for it and did it! As a result we were able to tackle this high tech, high-risk project, using a small but dedicated group of people both inside and outside the company, and be successful in a short time frame. This project shows once again that innovation is at the heart of this company.

Interview **Bill Arnold**

Bill Arnold, Executive Scientist and Vice President of the Technology Development Center (TDC), looks at the technological challenges ahead for ASML.

Resolve and resolution

As optical lithography continues to be pushed to its very limits, ASML's key challenge will be to further enhance resolution so that we're able to keep following the "shrink roadmap" for micro-chips. Our prospects are looking good: in 2002, we started pioneering immersion lithography, and development has been so fast that we shipped the first pre-production systems in September, 2004!

For the longer term, we have strong efforts in optics technology through resolution enhancement technologies ("low K1") and multiple exposures. Also we continue to be active in the development of EUV. Whatever technology our customers choose, we are trying to be ready first. And while there's no room for complacency, we seem to have a head-start on the competition. Our first EUV prototype is due to be ready by 2005. In comparison, unlike ASML, today neither Canon nor Nikon have any scanned images to show for their immersion programs. A related challenge, as usual, will be to achieve this resolution enhancement while simultaneously improving our equipment's productivity, so that customers can meet their cost targets.

Today, ASML is the biggest supplier of lithography equipment everywhere except Japan, and we have a great shot at growing our market further in the next few years. Although we're certain to have to brave another boom-and-bust cycle eventually, we're in a strong position to do so, and that's largely due to the expertise, enthusiasm, and resolve of our people.

In the Technology Development Center, where we collaborate with customers to plan for tools still in development, I'm privileged to work with a team of some of the best lithography experts in the world. Because every member of the team has worked in the chipmaking industry, we really have insight into the needs of our customers. The dozen people who work in the Center are in great demand by competitors and customers, so an important part of my job is to keep their jobs as stimulating as possible so they stay with us!

On a more personal note, I'm also constantly stimulated by the variety my various roles provides. As Executive Scientist, I act as an independent consultant to the Board of Management on core technology issues, and I also chair ASML's Fellows Committee, which recognizes outstanding scientists within the company. And as Vice President of the TDC, I get to work closely with leading companies such as Micron, AMD, TSMC, IBM, Sony and Samsung.

"I'm privileged to work with a team of some of the best lithography experts in the world"

Although a lot has changed since my first contact with ASML in 1985 when I worked for AMD, one of ASML's very first customers in the U.S., some things have stayed the same, including the company's pursuit of technological excellence — which is probably why AMD is still a key customer!

Interview **Sunny Stalnaker**

Sunny Stalnaker, Vice President of Accounts for Taiwan and Southeast Asia, describes ASML's business prospects and the priorities going forward.

Surfing the cycles

ASML is currently doing a phenomenal amount of business in Taiwan and Southeast Asia, which could well generate as much as €1 billion this year! Our challenge is not generating demand, but being able to supply enough systems when our customers want them. Addressing this will become increasingly important as the Taiwanese market is set to grow rapidly, with Southeast Asia following on a somewhat lesser scale.

Although the future's bright, we can't rest on our laurels if we're going to keep ASML's market share here growing. Not only do we need to maintain our technological leadership, but we also need to gain access to the memory maker fabs being planned in Taiwan — a new, more price-sensitive market for us. With our existing customers, such as TSMC, we will need to continue focusing on meeting their needs from a cost perspective as well as a technological one.

At the same time, ASML needs to organize itself in such a way that we're able to survive the cyclical ups and downs of our business intact. Potentially, over the next 3 to 5 years, there is some €2 billion of business in Taiwan alone, if we can execute!

Interview **Shamla Sharma**

Shamla Sharma joined ASML in April 2004 as Team Leader for the Reticle Handler Software Group in Wilton, responsible for the cost-reduction program for reticle handlers and the software activities for ASML's installed base.

Discovering ASML

When I joined ASML after a varied career in the semiconductor and other industries, I was struck by just how much the company has invested, not only in core technologies, but also in ensuring we provide excellent service to our customers. From the outset, I've been very impressed by the commitment of my colleagues and by ASML's focus on process and methodology development to maximize efficiency. I also like the fact that ASML gives employees like me the opportunity to combine their technical and managerial skills.

Our research and the many conferences we attend put us in a prime position to identify customer trends as early as possible, so that we can be first to offer equipment that best meets the market's needs. In the longer term, our excellent technology, research capabilities and global sales and service organization will allow us to diversify into attractive niche areas, perhaps in areas such as optics for healthcare or space applications, for instance. We could also build further on ASML's extensive expertise with regard to lasers and robots. All in all I'm excited by what the future holds for ASML. There's a lot on our horizon.

Interview **Martin van den Brink**

Martin van den Brink is Executive Vice President Marketing & Technology and a member of ASML's Board of Management. As an eyewitness and decision-maker who has been with the company for 20 years, he gives his views on what the future will bring for ASML.

Full speed ahead in the right direction

Over the past 20 years, I've seen this company struggle and grow. In terms of the number of employees, it's now 100 times bigger than when I started in 1984. In the mid-80s, we were really struggling to win new customers from outside Philips, and it was not until the 90s that we managed to gain major new customers such as Samsung and IBM, which then in turn attracted others.

Marketing a new ASML system has always been something of a challenge. Our machines are very expensive — the newest cost between €10 and €15 million each. Customers often can't wait until all the teething problems have been solved: they want to get them up and running as soon as possible. In the early years, this created serious problems. It meant that we were delivering products that were in effect not finished and/or commercially viable and were therefore unreliable and costly to produce. The investments we had to make to put those problems right — and keep customers happy — squeezed margins to unrealistic levels. In recent years, we've been getting steadily better at balancing speed, cost and performance, but when you're in such an innovative and fast-paced business, it will never be easy, and there is plenty of room for improvement.

As far as the future is concerned, our main challenge will be to stay competitive with our current product portfolio, while at the same time broadening our portfolio to create new, core-competence-related products. In addition, we will have to reduce costs and enhance our product value still further so that we can face the competition, which is becoming increasingly aggressive.

There are several technologies that I think will be important in the years to come, such as immersion, EUV and multiple exposure. Of course, the main driver will be what our customers are prepared to buy from us.

I'm really optimistic about ASML's future. I believe there will be a huge increase in

the use of chips in consumer products, phones, hand held mobile computers (PDAs), digital televisions, digital cameras and DVD players, to name but a few. This also means that there will be a huge demand from our customers for cost effective high-performance machines. I believe the chip market will still be strong for a long time to come, although it will be driven by consumer products.

"As far as the future is concerned, our main challenge will be to stay competitive with our current product portfolio"

Today, ASML is a grown-up company and a front-runner in the industry. In the old days, we were very busy trying to keep up with everyone else, but now I often have to look back to check if the competition is still following. If there's no one behind me, I start worrying. We know we can run fast, but our challenge now is to run in the right direction!

Interview **Don Crabtree**

Don Crabtree, Vice President of Asian Sales, is confident about ASML's future in Asia. He talks enthusiastically about the achievements of ASML in Asia.

A bright future in Asia

When I started in Asia back in 1992, our business was very small. We had only a few systems in China and Taiwan, and we still needed to develop the market. Now, more than 60% of our total business is in Asia, so things have developed very well. Of course, it's not always been straightforward. We're dealing with different countries, languages and cultures. Each area is unique and presents different challenges. Customers in Japan are very technically oriented, for instance. They want to know all the specifications, right down to the tiniest detail.

The Taiwanese, on the other hand, are mainly interested in how many wafers our machines can process.

Personal relationship selling is still very strong in Asia. It's not enough just having a good product to sell; your customers must feel comfortable doing business with you. Certainly in Japan, where our main competitors are headquartered, this is not an easy task. I think we still approach our business too much in a global way. Over the next couple of years, we should adapt more to the different styles of doing business in this market and employ more local managers, so that we become less reliant on expats and create truly local companies.

ASML is now a leading lithography supplier in Asia, and I think our future is bright. Of course, the success we have in Asia will be very much due to the efforts of our people here. They're a team of talented people working really hard to support the business, and I'm personally very proud to be one of their colleagues.

Eric Meurice CEO

Over the past 20 years, ASML has shown an ability to thrive and grow in a difficult, cyclical environment, where many others have faded away. In the light of the stories of the previous pages of ASML history, it's not hard to see why: since the early days, the company has kept its passion for technology and for excellence. When one talks to employees today, one can still see the fire in their eyes.

The way the company has matured into a real powerhouse in its field of microlithography is inspiring for the future. Global business success today means taking on challenges our company founders never dreamed of. Technology has grown at a pace that many thought impossible only a few short years ago, and business execution parameters are more demanding than ever. Staying ahead of the race in both of these areas of technology and business execution will allow us to create a future for ourselves that today we can only imagine.

This company has a rich heritage, and I am very proud to be a part of its future, because we have not only made a mark on our industry, but we have had a positive impact on the world around us.

Like you, I am stepping forward with eager anticipation to a very promising future.

This is a publication of ASML Internal Communications.
Names in blue are ASML employees

Managing editor
Jane Mitchell

Project manager
Danielle Marinelli

Project team
Lenette Woudstra, Astrid Meijer, Danielle Marinelli

Writers
Jane Mitchell
Baxter Communications

Photographer
Marcel van Dijk
ASML photo archives

Designers
Cecile van der Riet
De Heeren van Vonder

(Pre-)printing coordination
Dijkstra & De Bresser