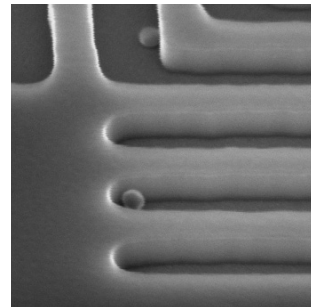
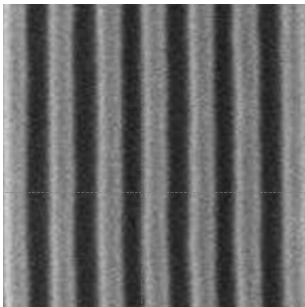


EUV Enables Low-cost Scaling



SEMATECH's Lithography Program



SEMATECH: The world's catalyst for accelerating the commercialization of technology innovations into manufacturing solutions.

The next technology revolution won't come from a lab. It won't be driven by a single company. It will come from effective collaboration and smart partnerships that translate today's innovative ideas into the products of tomorrow.

At SEMATECH the world comes together to speed the commercialization of technology innovation, from research and development to manufacturing.



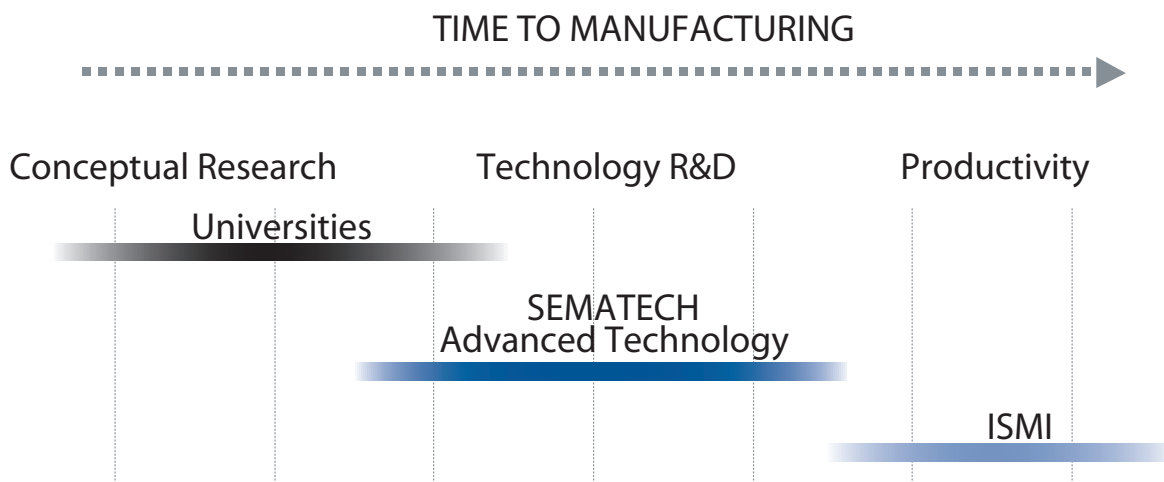
Lithography, Interconnect, Materials and Emerging Technology

SEMATECH conducts state-of-the-art research on the technical challenges and costs associated with developing new materials, processes, and equipment for semiconductor manufacturing. Advanced technology programs focus on immersion and EUV lithography, low-k materials and 3D architecture, and high-k materials and next generation transistors.

Manufacturing Productivity

International SEMATECH Manufacturing Initiative (ISMI) operates six programs encompassing a total of 30 projects—all focused on increasing productivity and decreasing costs for our members. They include:

- ESH Technology Center
- Continuous Improvement
- ISMI Councils
- Metrology
- Next Generation Factory
- 450 mm Transition



At SEMATECH, some of the biggest names in the semiconductor business come together to leverage resources, increase productivity, and lower costs.

We have a proven history of making sure member companies can afford to stay on the productivity curve.

We reduce cost and risk

We are a companion to members' R&D processes and help develop aspects of technology more quickly and economically than members could on their own by reducing options to the most workable solutions.

Rather than each member company funding solutions individually, we enable members, using what they learn at SEMATECH, to spend more resources on developing their own competitive advantage.

We deliver exclusive benefits to our members

First-to-market solutions – Members get full and detailed, actionable data.

Cost avoidance – Members avoid spending the full R&D costs of ultimately unworkable solutions and lower their learning curve for new processes.

Inside track – Members receive early evaluation of new materials and technologies without contamination and equipment risk in their fabs.

We are flexible both in memberships and programs

Members help shape the programs.

We offer a variety of ways to work with us.

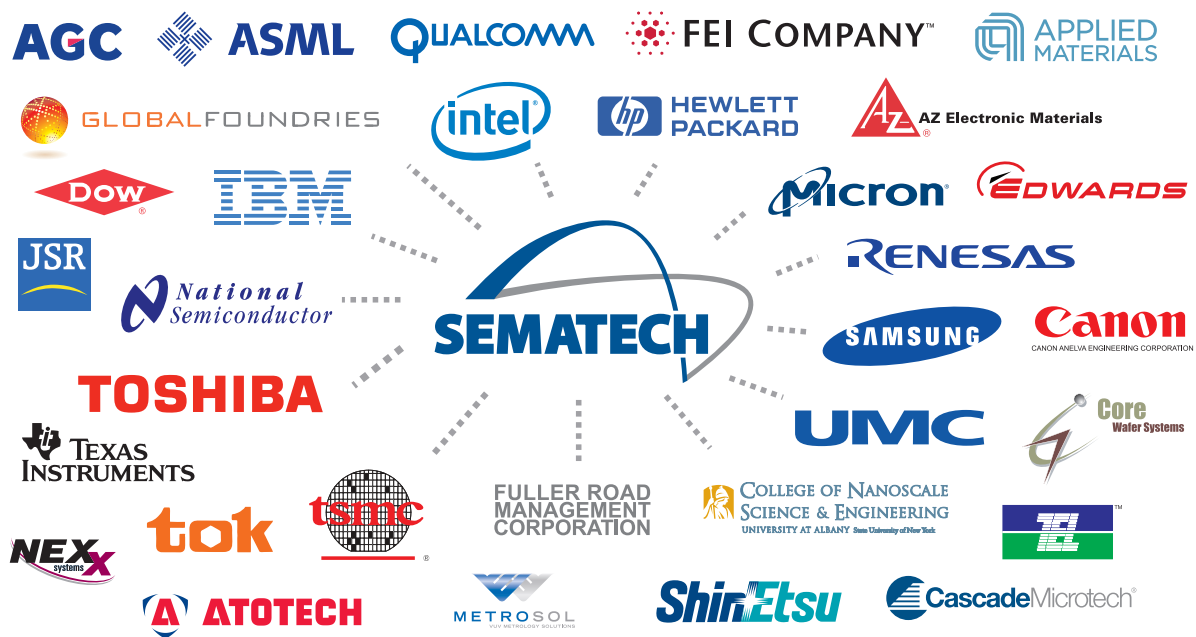
We span the timeline from research to development to manufacturing.

We have a proven record of success

We have nearly 20 years of experience in moving the industry forward.

SEMATECH is a well-cited and long-standing example of a successful public/private partnership.

During a period of rising industry uncertainty, it becomes increasingly important to spend R&D money wisely. SEMATECH believes that building strategic collaborations to avoid unnecessary costs while staying close to emerging innovations is the best way to keep your company moving forward as the industry creates the next technology revolution.



SEMATECH's Lithography Program

As a semiconductor industry leader, SEMATECH embraces its responsibility to extend existing lithography technologies for as long as possible, while developing next generation solutions and investigating alternative approaches.

Extreme Ultraviolet Lithography

Extreme ultraviolet lithography (EUVL) is an advanced form of lithography that uses extremely short wavelength (13.5 nm) light, mirrors, and reflective photomasks to image circuit patterns onto the surface of semiconductor wafers. The microchips that will be produced with EUV technology will contain features 32 nm wide or smaller, that are projected to be as much as 100 times faster, with 1,000 times the memory capacity of today's most powerful computer chips.

SEMATECH's vision is to deliver key capability that will enable defect-free EUV masks with linewidths of 22 nm and below while providing imaging capability to test resists at the same dimensions and to drive defect-free reticle carriers to commercialization. The program has been closing in on these goals with achievements that include:

A two orders of magnitude reduction in mask defects (from 1000 to 10 and below) at the EUV Mask Blank Development Center (MBDC) in Albany, NY

Demonstration of 22 nm linewidths in EUV resists using the microexposure tool (MET) at Lawrence Berkeley National Laboratory in Berkeley, CA

Additionally, SEMATECH's Resist and Materials Development Center (RMDC) works to develop solutions for 22 nm patterning technologies and beyond. EUV METs at the University at Albany's College of Nanoscale Science and Engineering (CNSE), and at the University of California, Berkeley, have enabled resist resolution below 20 nm linewidths. Other RMDC projects have succeeded in measuring outgassing in nearly 100 EUV resists and have delivered more than 150 exposure shifts to member companies.

Mask Program

A mask is a microscopically detailed, stencil-like device that is used with light or radiation to transfer microscopic circuit patterns onto the surface of a wafer. Masks are integral to the chip production process and can be very costly to make, especially as chip features shrink to just tens of nanometers.

The mission of this program is to provide SEMATECH's member companies and the industry with the capability to build infrastructure to keep masks cost-effective for current and future lithography technologies, as well as provide key mask tools needed to enable future technologies.

SEMATECH plays a unique role in supporting mask infrastructure development, spearheaded by its MBDC, the world's sole research facility devoted to improving mask blanks. SEMATECH has led industry advances in particle-free EUV mask handling and actinic mask defect inspection.

In February 2008, SEMATECH entered into a joint development partnership with Asahi Glass Co. to accelerate mask blank commercialization. Asahi, a dominant mask blank supplier in Japan, has been collaborating with SEMATECH at CNSE on ways to reduce EUV blank defectivity and to improve EUV mask blank yield for commercial manufacturing.

Alternative Lithography

Lithography has evolved through many technologies over the past 40 years, often defying the predictions of leading scientists. Mindful of this history, SEMATECH continues to look beyond conventional approaches to include alternative technologies such as nanoimprint lithography.

Analogous to a rubber stamp, nanoimprint lithography uses a nanoscale mold to form circuit patterns. Although the process is demanding because of the extremely small geometries involved, nanoimprint offers the potential to make chips without costly advanced projection lithography scanners.

SEMATECH is currently working to demonstrate whether nanoimprint can achieve quality litho imaging and will deliver an assessment of maskless lithography for possible insertion into the *International Technology Roadmap for Semiconductors*.

2010 Project Goals

EUV Infrastructure – Establish critical infrastructure elements to support EUV pilot line introduction for the 22 nm half-pitch in 2011 and EUV production in 2012–2013.

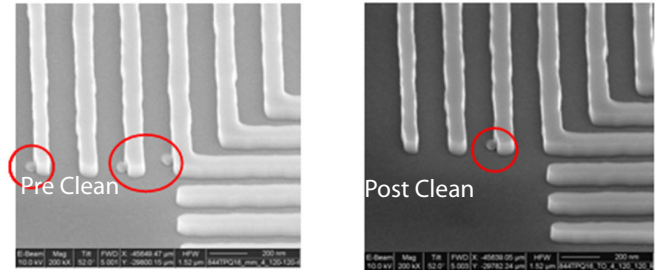
- Commence with EUV Mask Infrastructure Consortium
- Deliver 85 shifts on the LBNL actinic inspection tool to member companies.
- Deliver an EUV defect printability assessment of both programmed and native defects on substrate, blank, and patterned masks using optical and actinic inspections as well as imaging on the alpha demo tool (ADT).
- Determine defect density and composition of defects detectable with the M7360 inspection tool ($> \sim 30$ nm) on low thermal expansion material (LTEM) and quartz substrates and determine a particle removal strategy.

EUV Mask Blank Defect Reduction – Ensure availability of pilot-line quality EUV mask blanks for the 22 nm half-pitch by 2011.

- Demonstrate a 50% reduction of Si-based deposition defects
- Demonstrate a 15% reduction of AlOx based defects
- Obtain a champion mask blank with 2 or fewer total defects (pixel 4+ on M1350)
- Deliver EUV defect printability assessment of both programmed and native defects on substrate, blank and patterned masks using optical and actinic inspections as well as ADT imaging
- Demonstrate 45 nm SiO₂ sensitivity on quartz and 50 nm sensitivity on multilayer blanks using the SEMATECH M7360.

Resist and Materials Development Center – Provide world-class EUV resist and material imaging and characterization capability for the 22 nm half-pitch and beyond.

Alternative Lithography – Explore non-EUV alternative lithography options and litho extensions for the 22 nm half-pitch and beyond.



EUV mask pattern cleaning is currently able to remove a majority of particles without damaging the pattern.

Technical Milestones

2004 – Technologists achieved an extremely low level of added defects with as few as one defect per mask at an 80 nm resolution, which translates into 0.005 defects per square centimeter.

2005 – EUVL researchers achieved an important breakthrough in the complex process of cleaning mask blanks, which enabled removal of all particles as small as 43 nm, a dimension so small that 18 billion such particles could fit on the head of a pin.

2006 – Researchers successfully used 193 nm immersion technology (193i) at a 1.3 numerical aperture (NA) with azimuthal polarization to pattern features narrower than 45 nm half-pitch in multiple orientations simultaneously.

2007 – Technologists successfully detected and cleaned 10 nm particles from EUV mask blanks.

2008 – Technologists successfully demonstrated the world's best defect density of 0.04/cm² at 74 nm for EUV mask blanks, with a total of only eight defects combined from the substrate and the multilayer. SEMATECH researchers obtained the world's first 20 nm EUV resist images. SEMATECH began operating the world's first 300 mm nanoimprint tool.

2009 – The Resist and Materials Development Center opened with TOK as a charter associate member. The first non-reciprocal 193 nm-based double exposure material was demonstrated by SEMATECH research partners.

SEMATECH's Lithography Program

EUVL Mask Infrastructure Partnership

SEMATECH has launched a new global consortium to develop critical metrology tools for detecting defects in advanced EUVL masks, filling an industry need deemed too costly for individual companies to develop independently.

The new EUVL Mask Infrastructure (EMI) Partnership has drawn strong interest from seven semiconductor industry entities. Additional members are being sought for the consortium, which will pursue an ambitious metrology program to enable defect-free EUVL masks for high volume manufacturing by 2013.

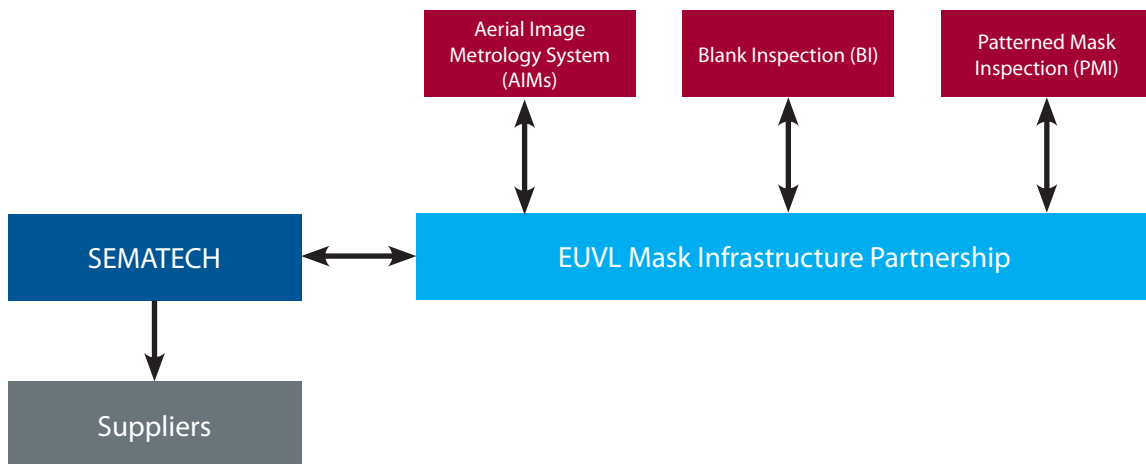
Optical lithography is unlikely to be able to pattern chips beyond the 22 nm technology generation, and EUVL, with a wavelength of only 13.5 nm, is widely considered the best replacement for optical lithography. The EUV masks used for sub-22 nm patterning must be virtually free of defects to avoid transferring them onto chip circuits. Current metrology tools, however, are generally ineffective at finding defects below 32 nm.

The EMI Partnership will address this metrology gap in phases by funding the development of three metrology tools. First efforts will focus on developing an aerial

imaging metrology system (AIMs) for EUV in 2013, followed by enabling an enhanced EUV mask blank inspection capability by 2011 and finally an EUV mask pattern inspection tool able to work at 16 nm by 2015. Producing prototypes of these tools is estimated to cost \$200 million or more. Additional infrastructure gaps may be addressed in the future if warranted.

Since 2003, the semiconductor industry has ranked defect-free EUV masks among its top three technical issues, and SEMATECH has led technical programs to drive defect reduction. At the request of the industry, SEMATECH began pursuing a consortial solution for the required metrology infrastructure with a special workshop at SEMICON West in July 2009, continuing with working groups to develop proposals and efforts to sign up initial members. Going forward, SEMATECH will facilitate consensus-building among the EMI partners, providing crucial data and a discussion forum for reaching conclusive agreements.

The EMI Partnership is open to mask and chip-makers, mask blank suppliers, other consortia, and regional governments.



The EMI has currently seven industry partners plus SEMATECH. The program scope includes three major infrastructure development projects, aerial image metrology system (AIMs), blank inspection (BI), and patterned mask inspection (PMI), in which SEMATECH facilitates consensus building among the partners, providing crucial data and a discussion forum for reaching conclusive agreements.

Resist Materials and Development Center

SEMATECH's RMDC was opened in April 2009 with the mission to develop resist and materials for 22 nm patterning technologies and beyond. The RMDC comprises both EUV exposure capability and a portfolio of sponsored university research programs. TOK is teaming with SEMATECH researchers to develop and demonstrate EUV materials and resists for the 22 nm node and beyond.

RMDC tools include the ASML ADT currently at CNSE, the Exitech MET, and the Lawrence Berkeley National Laboratory MET in Berkeley, CA. Through the RMDC, leading resist and materials suppliers have access to SEMATECH's two METs and can participate in focused, cooperative R&D with SEMATECH member companies.

With its impressive portfolio of resist research projects employing dozens of academic and industry researchers from around the world, the RMDC provides the hardware and research expertise required by materials suppliers and member companies to develop EUV resist processes to meet the stringent resolution, linewidth roughness,

and sensitivity specifications for EUV insertion at member companies. To expedite and facilitate the transfer of knowledge from research to production, the RMDC has adopted an associate membership model, formalizing the relationship between SEMATECH and resist suppliers.

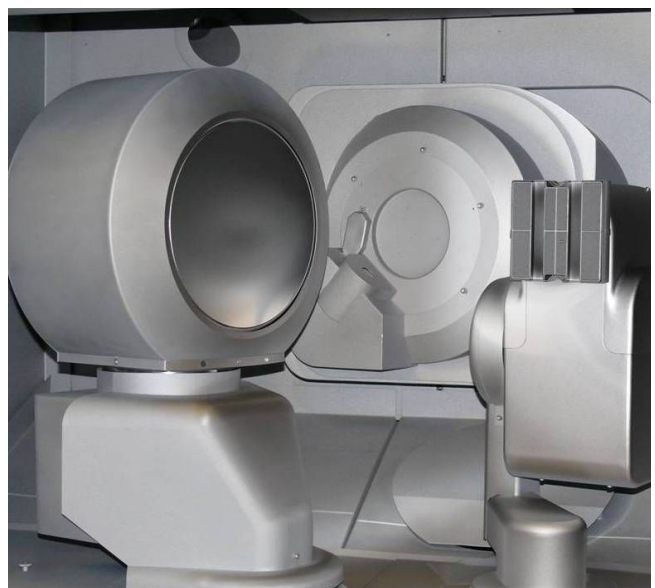


Mask Blank Development Center

Defect-free masks are critical to enabling EUVL, which is projected to be inserted for the 22 nm half-pitch node in 2012–2013 at leading IC manufacturers. To meet the goal of defect-free masks, a concerted effort is required that emphasizes mask blank development and mask infrastructure readiness.

SEMATECH's MBDC was established to focus on driving down the defect density of EUVL mask blanks by providing a collaborative environment for EUVL mask substrate and equipment suppliers and a state-of-the-art analytical toolset for them to improve their products.

To meet the pilot-line defect density goal of 0.04 defects/cm² at a 18 nm sensitivity by the end of 2011, SEMATECH and its partners have defined a strategy that includes setting mask standards and enabling the mask-making infrastructure.





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