PROJECT PROFILE

2T307: Co-operation of photomask reticule supply chain for improved yield, secured time to market and added life time (CRYSTAL)

LITHOGRAPHY

Partners:

Alcatel Vacuum
AMTC
ASML
Atmel
Carl Zeiss SMS
CEA-LETI
DMS
Entegris Cleaning Process (ECP)
Fraunhofer Institute IISB
Satin IP
STMicroelectronics
Toppan Photomasks
Xyalis

Project leader:

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Key project dates:

Start: January 2008
End: December 2010

Countries involved:

France
Germany
The Netherlands

Improvements to the photomask supply chain for 193 nm lithography in Europe are crucial, requiring co-operative research to reduce cycle times and optimise reticule qualification procedures. The MEDEA+ CRYSTAL project aims to decrease cycle time excesses and to simplify mask qualification procedures. This will involve improving design for manufacturability and reducing mask contamination while optimising mask costs, better securing cycle times in wafer fabs and cutting chip time to market. European chipmakers will benefit from faster product introductions, a competitive advantage that will become ever more important, especially for new system-on-chip (SoC) and system-in-package (SiP) products.

Photolithography has long been a key element in continuously improving semiconductor productivity. Europe is well positioned in the photomask field with leading mask producers, end users, metrology companies and suppliers for lithography, storage and other equipment. However, every day counts in a sector that requires huge investments and high returns on those investments.

In addition, the demands of the market place for ever faster ramp-ups to high yields leave less and less room for redesigning a product as its profitable lifetime may be as short as three to six months.

Meeting new challenges

While immersion techniques appear to be the only way to extend 193 nm lithography to the 32 nm half-pitch node, photomask technology faces new challenges related to design interaction, molecular contamination induced by high illumination energy and qualification cycle time resulting from increased reticle enhancement technology (RET) complexity.

These issues are major causes of unplanned cycle time excesses, although they are not linked to poor technology control. In fact, they depend strongly on interactions between design, process and arrangement of photomasks throughout the supply chain.

Administrative data-flow errors have halved in the past five years. The root causes for mask-yield problems and mask reclamations are now contamination. Although 193 nm lithography is still little used; it already contributes to 15% of reclamations in contrast to an initial 2%. If nothing is done to solve mask design for manufacturability (DFM), RET qualification or airborne molecular contamination (AMC) build up problems, huge difficulties may arise in the production chain with 193 nm lithography taking off.

The MEDEA+ 2T307 CRYSTAL project has therefore set out to obtain a substantial reduction in 193 nm lithography cost due to uncontrolled cycle time and product introduction times by optimising the mask supply chain. It has gathered a consortium of world-class chipmakers, mask shops, tool makers, material suppliers and software providers, with the support of selected research institutes and university departments, all experienced in successful co-operation in this area.

CRYSTAL will also build on the success of the MEDEA+ 2T302 MUSCLE project that has helped secure and standardise the information flow in the photomask supply chain.

The new MEDEA+ project is intended to shorten product cycle times further down to the 32 nm node by actions in three complementary areas of reticule DFM, molecular contamination control and reticule qualification procedures. It will work on optimising mask costs, securing cycle times better in wafer fabrication facilities and reducing the time to market for new chips.

Two key goals of CRYSTAL are to cut the risk of cycle time excesses by 50% and to halve mask qualification time to implement quicker yield ramp-up. Work will be split into three areas to achieve this:

1. Improving photomask DFM inputs for the electronic design automation (EDA) workflow;
2. Improve quality and availability of photomasks in advanced lithographic environments thorough full control of molecular contamination by aligning metrology and developing innovative processes; and
3. Development of innovative flow and metrology for photomask qualification.

Cutting cycle times

At least 10 to 15% of chip designs cause mask manufacturability issues and the time required to fix them has increased exponentially with growing complexity from just a few hours in the past to days now. When it cannot be done, a waiver specification or redesign is necessary. A decision for first solution is almost always taken, creating a potential yield burden in an environment where steep yields must be achieved within a few weeks.

The risk of induced contamination damage for 193 nm lithography is 10 to 20 times higher than for 248 nm and requires immediate mask maintenance, costly monitoring and higher costs for double masks, while creating a high risk of excess cycle times and additional costs. Indirect photomask inspection on wafer also causes productivity loss with use of additional lithographic tools. Short lifetimes mean mandatory mask maintenance, double mask sets or mask unavailability linked with cost, delivery and productivity issues.

It is also necessary to simplify mask-qualification procedure and so improve opportunities for yield ramp-up. Any routine mask introduction requires several days of testing to assess yield. A new technology node, a new product platform or a new mask process generally requires months.

In any case, yield improvements through better lithographic capability, cost improvements through improved mask processes or simply a new device is dependant on the successful qualification of the mask or mask set. This is because mask qualification does not rely only on mask data but also includes operations in the wafer fab, the most time consuming being the final electrical test used as the ultimate parameter to enable product release.

CRYSTAL will therefore extend the photomask supply chain to the design interactions. It will develop strategic approaches in 193 nm lithography designed to improve photomask manufacturability and availability at point of use, and enable implementation of any lithography capability improvement as fast as possible.

Boosting competitiveness

The successful outcome of this MEDEA+ project will have an impact on the competitiveness of the whole European semiconductor industry. It will not only enable project partners to achieve their own short-term goals but will also significantly improve European leadership in mastering reliability of cycle times and quicker new device and process introduction.

For semiconductor manufacturers, methods and tools developed and assessed in CRYSTAL will strongly improve 193 nm lithographic process reliability and therefore limit the overall cycle time excesses related to mask-availability issues caused by contamination or long and not sufficiently controlled qualification time.

These improvements will also have a direct impact on production costs by enhancing mask-usage rates, while securing yields through control of contamination. As a result, European chipmakers will be able to offer a better and more reliable customer service in terms of cycle time and yield performance. In this respect, the project will strongly enhance Europe as an attractive and competitive region for chip supply.

Several innovative techniques and advanced tools are being developed and firstly evaluated in Europe, which will open new markets for tool makers. And, for the European photomask industry, the project provides the key opportunity to stay at the forefront of a technology that is strongly differentiated from that of overseas competitors, by providing reliable cycle time advantages to customers.

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