CASE STUDY
Intel® Xeon® Processor E5 v2 Family
High-Performance Computing
Manufacturing

Look Inside.™

Intel® architecture shortens semiconductor manufacturing cycle

Semiconductor Manufacturing International Corporation (SMIC) mask factory deploys high-performance computing solution to reduce costs and shorten the semiconductor manufacturing cycle

"Intel has a wealth of experience in semiconductor manufacturing. Close cooperation between SMIC and Intel determines the optimal HPC solution, helping improving SMIC's semiconductor manufacturing process. We establish regular exchange and communication mechanisms to promote our testing program, gradually adjust according to the increasing computing demands of mask manufacturing, and provide HPC references and field experience."

Eric Guo
Senior Director,
Semiconductor Manufacturing,
International Corporation

"We are collaborating with Intel to carry out real workload testing of our mask manufacturing for 65, 40, and 28 nm chips in a real manufacturing environment in different stages to determine an optimal HPC solution. We need to balance on computation, network, and storage performance and apply the most advanced technology. The solution provides significant references to SMIC's operating HPC cluster of 28 nm mask manufacturing and its HPC center planning in the future."

Sherry Zhu
IT Manager,
Semiconductor Manufacturing,
International Corporation

Mask manufacturing, a key part of semiconductor manufacturing to fabricate the chip design into the final product, depends on large-scale mathematical calculations. Semiconductor Manufacturing International Corporation (SMIC) provides mask manufacturing services for its customers as well as other chip plants and institutions with one of the largest and most advanced mask manufacturing facilities in China. To respond to innovations in the semiconductor manufacturing process, the increasing number of customers, and more complex demands, SMIC deepened its cooperation with Intel and deployed a high-performance computing (HPC) center based on Intel® architecture to deal with the challenges of computing performance, improving the mask manufacturing process, shortening the semiconductor manufacturing cycle, and providing quality service to its customers.

CHALLENGES

- **Improve semiconductor manufacturing process.** HPC is the foundation for mask manufacturing in the semiconductor manufacturing process. Advancements in each generation of the semiconductor manufacturing process create great challenges to the HPC system, since the computation requirements for mask manufacturing increase exponentially.
- **Shorten semiconductor manufacturing cycle.** SMIC needed to shorten the mask manufacturing cycles to address the growing customer base and more complex design demands, while ensuring mask quality and on-time delivery.
- **Reduce costs.** SMIC needed to upgrade the HPC solution with higher performance per CPU core to reduce software licensing costs, which are on a per-core basis.
- **Achieve sustainable development.** SMIC needed to develop an HPC solution with sustainable development for the future to meet the rapid growth of compute and business demands.

SOLUTIONS

- **HPC center based on Intel architecture.** Replace the compute server nodes in the existing HPC cluster with over 30,000 processor cores to meet the computational demands of 40 nanometer (nm) chip manufacture and research and develop (R&D) for the 28 nm manufacturing process.
- **Use Intel's experience.** Develop medium- and long-term plans for HPC capability by optimizing the system based on Intel's HPC experience.

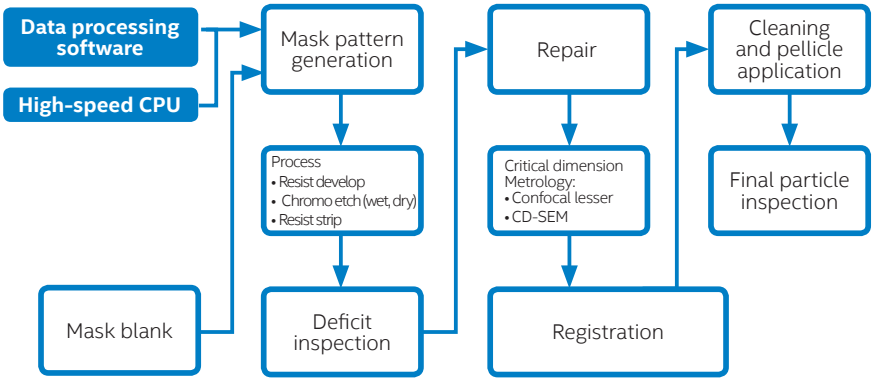
IMPACTS

- **Manufacturing process for 28 nm chips.** SMIC is achieving mask manufacturing capabilities of 28 nm chips and providing 5-, 6-, and 7-inch masks to meet the demands of different customers.
- **Improved mask manufacturing and service capabilities.** The latest HPC technology shortens the mask manufacturing circle to provide a one-stop integrated circuit foundry service with on-time delivery for more customers. This enables SMIC to fully open its mask service to the domestic semiconductor and integrated circuit industry in the future.
- **Significantly reduced TCO.** The high-performing Intel® Xeon® processor E5 2600 v2 family helped SMIC create an HPC solution with higher single-core performance and significantly reduce the total cost of ownership (TCO) by lowering the licensing cost for commercial software.

SMIC is one of the leading integrated circuit (IC) foundries in the world and the largest and most advanced foundry in mainland China. SMIC gives its customers a competitive advantage with its strong technical capabilities, the abundant availability of intelligent modules, highly flexible service, dedicated service orientation, and China's ample supply of human resources. Founded in June 2001, SMIC provides a one-stop IC foundry service of 350nm to 45/40nm chip design and semiconductor manufacturing for global customers.

Rapid development of IC technology, guided by Moore's Law and advancements in the semiconductor manufacturing

HPC solution based on Intel® architecture increases computation capability for semiconductor manufacturing and shortens manufacturing cycles



Application of HPC in Mask Manufacturing

process over 40 years, led to smaller chip size and more complex chip features. The semiconductor manufacturing process depends on massive computation. In the past, SMIC needed to refresh the server processes in its HPC cluster every two years to improve computing performance. The new 28nm manufacturing process posts even higher challenges to HPC solution, compute performance, and refresh cycles.

As feature size of the integrated circuit approaches resolution limit of the lithography exposure system, resolution enhancement technology (RET) and optical proximity correction (OPC) are applied to reduce the influence of the optical proximity effect. As a result, the lithography mask pattern becomes more complex, the amount of corresponding data and computation grows, the manufacturing costs increase, and the manufacturing cycle lengthens.

Sherry Zhu, IT manager for SMIC, said, "Moving from a 40nm to a 28nm manufacturing process, the data volume of chip design drawing will increase from hundreds of megabytes to gigabytes, and significantly increase the amount and scale of computation needed in generating mask patterns. SMIC needed to update its HPC solution to deal with these tougher data computing challenges."

In addition, as a chip design is finished, the data volume during mask data preparation (MDP) will grow exponentially, reaching the terabyte level. The data-intensive MDP process creates greater challenges to the storage and network performance of the HPC cluster.

"More importantly," Zhu added, "expensive third-party commercial software applied during the computing process is charged on per-core basis. Obviously, higher single-core computing performance leads to higher overall cost/performance of the solution." Meanwhile, with the Chinese government increasing emphasis on developing the semiconductor industry with policy support, the market for mobile computing devices, including tablets and smartphones, is flourishing. SMIC's product plans were unable to catch up with the growing business demands from the growing customer base and manufacturing complex chip designs. SMIC needed to shorten its manufacturing cycle to meet customer demands.

In 2014, SMIC explored and developed an optimal HPC solution with help from Intel.

Based on factors like single-core cost/performance, memory capacity, and memory bandwidth, Intel helped SMIC define a new solution to upgrade its HPC cluster to meet the needs of lithography mask production for the 28nm semiconductor manufacturing process. Over 30,000 Intel Xeon processors E5 2600 v2family were deployed in the upgraded cluster, preparing for the mass production of 28nm chips.

SMIC and Intel are increasing their collaboration in developing new and optimized HPC solutions for the semiconductor industry. The areas of collaboration include:

- Evaluate the latest Intel Xeon processors to achieve optimal single-core cost/performance, memory capacity, and memory bandwidth.
- Evaluate solutions based on Intel® Solid-State Drives (Intel® SSDs) for high-volume data caching to remove I/O bottlenecks.
- Evaluate the benefit of Intel® Enterprise Edition for Lustre* software in improving the storage performance and reliability of the HPC cluster.
- Evaluate solutions based on Intel® True Scale Fabric and Intel® Omni-Path Fabric to increase HPC cluster network bandwidth, reduce network latency, and increase scalability.
- Test performance with real workloads using the latest Intel® Server Systems.

Collaborating with Intel, SMIC looks forward to continuing to advance its manufacturing process, developing reference models for the semiconductor industry and moving the industry forward in China.

LESSONS LEARNED

- Get the power you need. SMIC's HPC solution meets the demands of large-scale, complex mathematical calculations to improve mask manufacturing in the semiconductor manufacturing process.
- Keep it agile. Based on Intel® architecture, SMIC's agile compute solution has industry leading reliability and scalability.
- Work with the leader. Intel brings a wealth of knowledge and technology in HPC to help enterprises address their HPC challenges.

Find the solution that's right for your organization. Contact your Intel representative, visit Intel's **Business Success Stories for IT Managers**, and check out **IT Center**, Intel's resource for the IT industry.

0315/SHA/PMG/XX/PDF 332171-001EN