Hirata Corporation

Using scSTREAM to Evaluate Airflow in Production Facilities Improves the Technical Staff's Understanding and Enables More Effective Presentations to Clients

Airflow control is crucial in the production of equipment used for semiconductor assembly. These processes require a clean environment and delicate control of the facility air-conditioning system. As a total manufacturer of production facilities, Hirata Corporation uses scSTREAM, a thermal-fluid analysis tool, to simulate the principal flow mechanisms for different types of manufacturing facilities and equipment. Using the tool is beneficial in many ways. It is used for product development and to more effectively communicate the results in presentations.

▲Kumamoto plant
Kumamoto headquarters

Hirata Corporation
http://www.hirata.co.jp/en/

Founded	December 29, 1951
Business	Manufacturing of production systems, industrial robots, and logistics equipment
Representative	Yuichiro Hirata, President
Employees	1940 (consolidated)* 64 (non-consolidated)*
Locations -	Headquarters in Shinagawa-ku, Tokyo, Japan Kumamoto Headquarters in Uekimachi, Kita-ku, Kumamoto-shi, Kumamoto, Japan
Capital	Approx. 2.6 billion JPY*

* Figures are as of March 2014

Hirata Corporation is one of the largest manufacturers of production facility equipment in Japan. They mainly specialize in manufacturing tools and equipment for the vehicle, semiconductor, and home appliance industries. They manage operations for the Japanese domestic market from seven facilities throughout the country, including their Tokyo headquarters and Kumamoto Operations Center. They also have affiliated companies in nine countries including the USA, Mexico, and Germany. Production facility start-up projects managed by the Hirata Corporation are highly regarded both domestically and internationally. They are recognized for providing immediate solutions using a diverse range of core technologies, including robotics, carrier control, equipment control, cleaning, and precision instruments.

Picture 1: Mr. Takahiro Motoyama (left) and Mr. Michitaka Matsumura (right) from the Development Division, Development Department

The company's prominence is closely linked to their policy to conduct development, design, component production, assembly and evaluation of their products, and facility startups using Hirata Corporation resources. The biggest strength of the Hirata Corporation is having the capability to manufacture components, which smoothens the transition to the later assembly processes. This results in stable delivery of high-quality products. To achieve this strength, the Hirata Corporation introduced large-scale engineering machinery, such as a machining center with a 5-face Machining Center, laser machines, and aluminum die casting machines. Having these manufacturing capabilities in-house has enabled them to minimize cost and delivery time as well as provide first-class, reliable production facilities.

Picture 2: Hayate, a flexible assembly system

At their Development Department, the Hirata Corporation exploits new engineering fields and undertake research development in highly specialized topics. One of these research concerns is Hayate, a flexible assembly system (Picture 2). Mr. Takahiro Motoyama and Mr. Michitaka Matsumura from the Development Department (Picture 1) are analysis specialists who conduct advanced research in specialized subject areas. Mr. Motoyama specializes in airflow analyses, and Mr. Matsumura is an expert in structural analyses. Simple analyses, like linear analyses, are handled individually by each division, whereas the analysis specialists are responsible for more complicated cases. These include material non-linear, contact non-linear, and fluid analyses.

Introducing scSTREAM to Visualize Airflow

The Hirata Corporation started using scSTREAM in 2007, in response to their engineers' requests to develop capabilities to visualize airflow, which is basically invisible. Although they had tried using flow visualization techniques during experimental tests, the findings were not sufficient to answer many of their design questions. Visualizing the flow using a computational simulation would promote greater understanding of physical phenomena, leading to quality improvements and cost reduction. The Hirata Corporation assigned this responsibility to Mr. Motoyama, and he led the search to find the right fluid analysis tool.

The team initially looked for an analysis tool that could simulate moving objects, such as large-scale substrate transfer robots. Since many of the company's end products were large-scale, simple-shape equipment, the Hirata Corporation searched for a structured mesh analysis tool equipped with a fast solver. After performing extensive due diligence, the team decided to use scSTREAM, which satisfied their product and budget requirements.

Airflow Analyses of Equipment Used for Semiconductor Production

One series of analyses Hirata Corporation conducted was for the EFEM (Equipment Front End Module), which is used in semiconductor production (Figure 1).

Picture 3: Mr. Matsumura

The EFEM is implemented throughout the wafer manufacturing process, and is used for wafer transfer from the FOUP (Front-Opening Unified Pod), a container of dozens of wafers, to the manufacturing equipment. "The space used for semiconductor production must be absolutely clean. The larger the space becomes, the higher the cost to maintain cleanliness. As a solution to this, we applied the concept of 'mini environments', which maintains the cleanliness only around the wafer's immediate surroundings," explains Mr. Matsumura. EFEM uses the concept of mini environments to transfer wafers. The process for fabricating semiconductor devices consists of seven phases, which can be divided into more than 100 steps. EFEM is used in many phases including patterning, etching, and ion beam infusion, to transfer wafers and keep the space around the wafers clean.

One example that illustrates the concept is for the etching equipment connected to the EFEM, which is linked to an interface called the load port. When the FOUP (container containing wafers) is placed on the load port, the port opens or closes the FOUP, allowing the EFEM carrier system to dispatch wafers to the etching equipment.

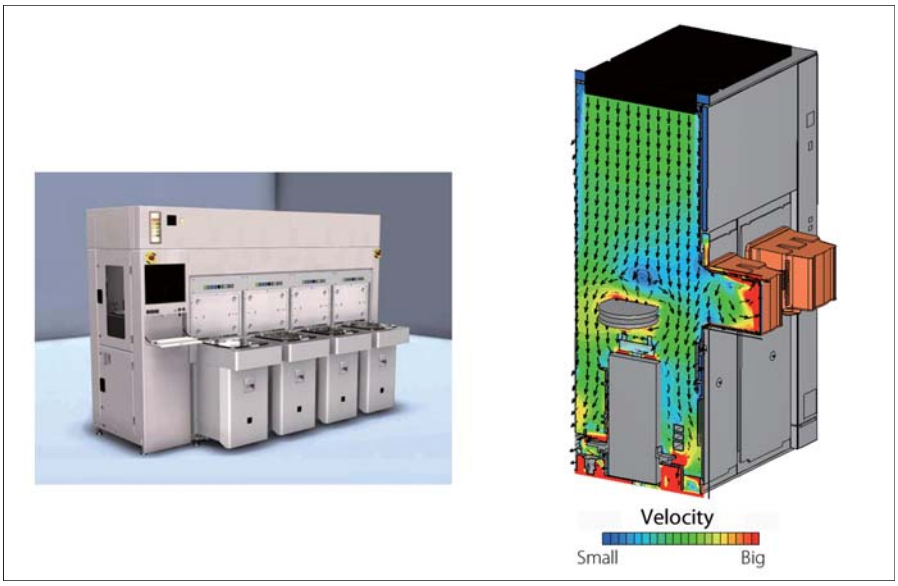


Figure 1: EFEM used in the prior process of semiconductor production (left)
Analysis example of EFEM showing the velocity vectors and contours (right)

Presentation of the Density Distribution of N2 to Clients

Hirata Corporation conducted flow analyses to investigate nitrogen dispersion within the EFEM. To avoid oxidization of the wafers, the EFEM is equipped with a nitrogen purge function to fill up the FOUP interior with nitrogen. A large amount of nitrogen leakage to the surrounding environment can be harmful to human operators. Consequently Hirata Corporation found that one of the first questions a client had early in the buying process was the amount of possible nitrogen leakage. At the same time, Hirata Corporation engineers were eager to understand how effectively the nitrogen could be distributed within the EFEM by positioning sensors at the ideal spots.

The EFEM is 2 m in width and length. The depth is 1 m. The nitrogen enters through 20 mm diameter holes. With holes this size, the computation domain dimensions are two orders of magnitude greater than the holes. This means a high mesh density will be needed near the holes to properly resolve the jet dynamics. Hirata Corporation engineers successfully identified the ideal size of the mesh elements after consulting with Cradle support engineers. Moving objects in the model were output in Nastran format and imported to the scSTREAM pre-processor. Approximately 7 million mesh elements were needed to properly represent the EFEM which contained several hundred components.

Hirata Corporation engineers conducted analyses of the FOUP to determine how the nitrogen would disperse from two outlets in the lower section during the purge process. They also wanted to know how the dispersion changed as the carrier device moved horizontally and vertically (Figure 2). Hirata Corporation believes that this assessment and the visualization results were crucial for helping them demonstrate the effectiveness of the equipment and to ultimately secure the sale.

Diversifying the Application of scSTREAM

With the success of the EFEM and FOUP analyses, Hirata Corporation now uses scSTREAM for development of many of its other products. Another product is the FFU (Fan Filter Unit), which is designed to permit clean air to move downward. This produces less blockage while keeping the inner pressure 3-5 Pa higher than the surroundings and maintaining a flow velocity between 0.3 to 0.5 m/s. Hirata Corporation used scSTREAM to identify the ideal geometry and allocation of the holes. They also performed simulations of the FFU for the carrier devices used for glass circuit boards.

Using scSTREAM led to cost reductions and shorter development time. The visualization results have also proved effective for both internal and client presentations. Hirata Corporation expects to apply scSTREAM during development of more and more products.

Excellent Support Increased User Satisfaction

Hirata Corporation engineers highly regard the quality and speed of Cradle support. Responses to inquiries were within one day. Mr. Motoyama says that it was much faster than the other tool developed by an international CFD software firm outside Japan. The complicated inquiries are first submitted to the agencies, which are then forwarded to the developer. In the end, it took two to three days to receive a response. "As we are a manufacturer based in Japan, using the software developed in Japan meant

Picture 4: Mr. Motoyama

greater benefit. Their support helped us tremendously when we first started using the software. Back then we tried to start with very complicated analyses that involved moving objects even though we had very little understanding of the software. Thanks to the support Cradle engineers provided, we could learn how to make the most of the software," says Mr. Motoyama.

Mr. Motoyama attended scSTREAM seminars organized by Cradle. "I remember that the Cradle sales engineer suggested I take the examination for the Certificate for Computational Mechanics Engineers. That inspired my motivation in learning about CFD (Computational Fluid Dynamics)," recalls Mr. Motoyama. He studied CFD theory using the Cradle software user guide and various papers.

This also helped him better understand what the software could and could not do. Mr. Motoyama says: "I needed to acquire the ability to judge the results correctly, so I revisited the basics of CFD and fluid engineering." Although he covered the fundamental topics of CFD in college, he says that he was much more focused after being assigned to analysis team at Hirata Corporation.

Further Challenge Using New Features

When scSTREAM was first introduced, Hirata Corporation conducted analyses of large, square-shaped equipment which worked well using the conventional structured mesh capabilities of scSTREAM. They are now ready to move on to analyzing curved targets using the cut-cell function in scSTREAM. "If we can use the cut-cell function correctly, I think that we will be able to analyze curved objects without using the unstructured mesh SC/Tetra software. We are looking forward to further advancement of the cut-cell function," says Mr. Motoyama.

Hirata Corporation has made steady progress in incorporating scSTREAM into their product development processes. And they expect to extend the range of applications even further in the future.

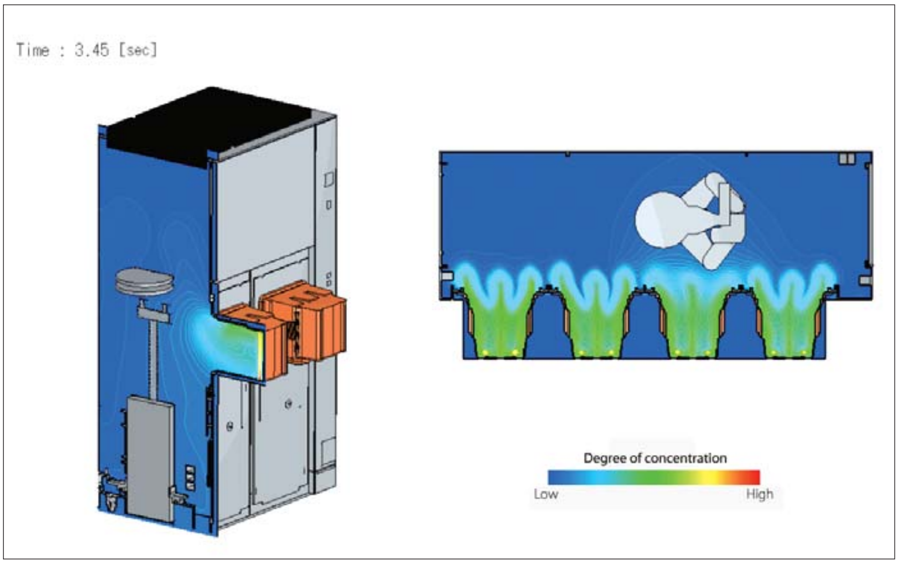
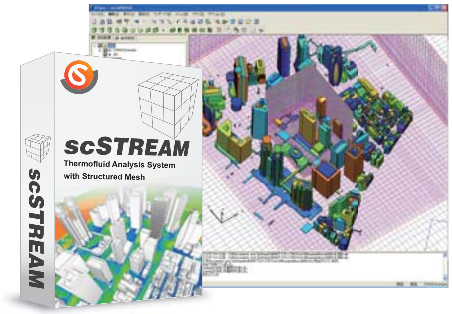


Figure 2: Visualized cross section of N2 concentration during the purge
Side view (left) and top view (right)



scSTREAM

scSTREAM uses a structured mesh to model general purpose thermal/fluid applications where tiny details and curved surfaces are not critical for an accurate simulation. scSTREAM can both create the mesh and calculate the solution quickly and efficiently using the finite volume method. A ten million element model only consumes 5.5GB of RAM. In addition to highly capable models for simulating complex physics, scSTREAM also includes a set of Visual Basic interfaces and table/function inputs that make it customizable.

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