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DEVELOPMENT OF THREE-DIMENSIONAL NANOPRINTING TECHNOLOGY, INTRODUCING INNOVATION TO INDUSTRIAL MANUFACTURING

Case Study

Location: South Korea, Seoul, Gwanak-gu
Founded: October 15, 1946
Industry: Academia



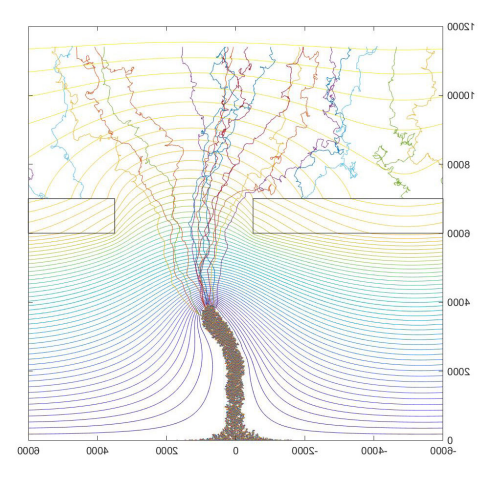
Researcher Kwangyeong Kim, Seoul National University (SNU), Building 313, Institute of Advanced Machines and Design, Room 204

Software:

MATLAB

Research group led by Professor Mansoo Choi from Seoul National University (SNU) and Professor Junsuk Roh from Pohang University of Science and Technology (POSTECH) developed a three-dimensional nanoprinting method which can create 3D structures in a size of hundred nanometers and the article was published online on the world-renowned scientific journal 'Nature' on April 1st (https://doi.org/10.1038/s41586-021-03353-1).

The researchers successfully developed practical technology that can create more than thousands of 3D nanostructures concurrently. No polymers or inks are used in the printing process which differs the technology from others. High-purity structures can be established by generating charged metal nano aerosols in dry atmospheres then using an electric-field that controls and assembles the structure. Since it causes a difference in the conductivity or properties of metals, the inclusion of impurities is highly crucial in applications based on metallic properties.



The current 3D printing method is a key element technique in the fourth industrial revolution, resulting in a tremendous advancement in manufacturing technology. This technology is expected to go beyond the boundaries. In terms of revolutionizing industrial manufacturing technology, it has the capability to efficiently print three-dimensional metal nanostructures.

Numerous researchers participated in this hefty research and Kwangyeong Kim was specifically in charge of simulation based on actual experimental conditions. At a time when he encountered limitations in performing structure simulations with the workstation acquired by an investment of about 10 million KRW, he was introduced to 'Rescale, HPC Cloud Platform for Simulation Research' by a fellow researcher. Rescale enables HPC based simulation via remote access through the cloud platform without pre-requisite of software installation or hardware deployment.

From the initial submission to Nature in 2019, this study took enormous time and effort of many researchers. The biggest advantage of conducting simulations on the Rescale platform is its ability to carry out multiple jobs simultaneously based on various experimental conditions, which results in a substantial reduction of the time spent on trial and error. For example, the Particle Trajectory simulation which had taken 40 hours on the previous workstation, could be shortened to less than 3 hours on Rescale using HPC, demonstrating time-efficient results.

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> Mansoo Choi, a professor at Seoul National University, said, “I am happy that development of three-dimensional nano-printing technology with aerosol jets which took about a decade has resulted in superb results. Additionally, Kwangyeong Kim could deliver fast and accurate simulation results by utilizing the Rescale Platform”.

In addition, unlike carrying out simulations using the workstation, only possible inside the lab, Rescale enabled simulations to be carried out anywhere with an internet connection. Even when access to the lab was restricted due to the COVID-19 situation, results could be produced expeditiously and seamlessly without interruption. Simulations could be handled through remote access with no need of staying in the lab.

Recently, in the process of advancing the two-dimensional simulation to three dimensions, performances related to memory/speed/storage has presented the greatest challenge in obtaining linear equation solutions for Poisson equations in electric fields from three-dimensional matrices. Rescale consistently offered support in determining optimized memory and core types for the research performance. Luna, the core type recommended through benchmark, was used in the initial stage of the research. As the simulation got advanced, Kim shared the circumstances with Rescale, and were recommended Topaz, the coretype with up to 2TB of memory per node and Chromium, the one with high CPU performance. This has accelerated improvement in the research.

- Luna 48 core (2nd Generation Intel Xeon Scalable Processors (Cascade Lake) @ 3.6 GHz, 192GB memory/node, 1.73 TB Storage/node)
- Topaz 32 core (Intel Xeon E7-8880 v3 (Haswell) @ 2.3 GHz, 976GB memory/node, 1.8TB storage/node)
- Chromium 32 core (Intel Xeon Platinum 8272CL (Cascade Lake) @ 2.5 GHz, 504GB memory/node, 2.4TB storage/node)

The most convenient feature of the Rescale platform is its ability to offer recommendations for memory and core based on the simulation. Furthermore, Kim was able to successfully conduct three-dimensional simulation research thanks to consistent assistance from engineers.

With the achievement of this research, it has now become possible to simultaneously develop nanometer-sized three-dimensional nanostructures in parallel, which had been difficult with the existing three-dimensional printing technology. Therefore, it is expected that the research will be able to bring breakthroughs in industries that require nanoprocessing, such as three-dimensional nanosensors with high sensitivity or three-dimensional nanoelectronic devices with small size and high intensity.

When it comes to optimization of simulations, it was important to observe the progress of multiple cases of structures under various conditions. Rescale enabled Kim to closely monitor the progress by providing the option to use MATLAB in a GUI environment, while utilizing the performance of cloud HPC.

Researcher Kwang-Yeong Kim is joining Samsung Electronics’ semiconductor DS division by the time of publishing the thesis in Nature. He plans to pursue researches in his field after completing his degree course.

> Lastly, researcher Kwangyeong Kim delivered his words with gratitude, “I started using the Rescale platform by suggestion from my fellow researcher, and was able to complete the simulation successfully with outstanding performance of the Rescale platform and Rescale team’s support. Although I will be working at Samsung Electronics Semiconductor, I will keep supporting my colleagues to carry out successful follow-up research through the Rescale platform”.

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