Cross-ministerial Strategic Innovation Promotion Program (SIP)
"Photonics and Quantum Technology for Society 5.0"

Establishment and social implementation of Japan's manufacturing platform in the era of DX and decarbonization

New system to bolster and expand business competitiveness

Digital transformation (DX) and decarbonization are crucial to business competitiveness. This is also true for Japan's manufacturers: the industry needs to build a new platform to follow recent megatrends. Going with the flow of the times, the Cabinet Office is promoting a national program, the "Cross-ministerial Strategic Innovation Promotion Program (SIP)". One of the programs under the SIP program is "Photonics and Quantum Technology for Society 5.0", aiming to bolster industrial competitiveness through establishing a system using Japan's cutting-edge photonics and quantum technology. This project is now accepting applicant companies who will join it to promote social implementation of technologies to be developed.

New manufacturing platform to propel DX and decarbonization

DX and decarbonization are more than just buzzwords. Currently, both affect business competitiveness directly. More than that, the investment amount regarding digitalization and decarbonization has been sharply rising since the start of the COVID-19 crisis. The urgent demand for more advanced technologies and more products that serve DX and decarbonization has been rising.

In the global market, the technological competitiveness of Japan's manufacturers is acknowledged for its high efficiency, quality, and reliability. However, there is no assurance that this competitive edge will be always effective in the global megatrend derived mainly from DX-decarbonization. The competition principles have changed. The industry needs to reestablish a system to secure the supply of cutting-edge semiconductors that is indispensable for DX and decarbonization technologies.

Creation of CPS that bolsters Japanese competitiveness

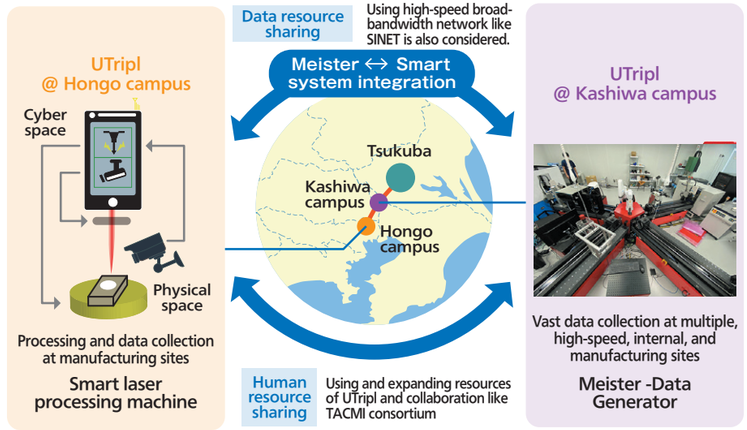
Recently, an increasing number of research agencies and companies worldwide are trying to develop and socially implement new systems that enable paradigm shifts in the manufacturing industry. This is known as CPS (Cyber Physical System) . In this concept, computer models called "digital twins" are reproduced from real objects on production lines to forecast slightly ahead of real events through analyzing the characteristics and movements of the digital twins. Also, it is possible to optimize and improve the manufacturing conditions at higher speed, higher accuracy and lower risk.

Japanese automakers, one of the core industries of Japan, and semiconductor businesses are both in a drastic reforming phase technologically and commercially. To keep their global leading positions in product development, manufacturing, and supply, it is essential to establish CPS to bolster their conventional edge by creating new values. At the manufacturing sites, human resources such as highly professional engineers and highly skilled workers have been fostered and practical experience has been accumulated based on daily improvements. Such efforts result in high-quality industrial products acknowledged worldwide. With CPS, Japan will be able to keep and enhance its edge and competitive power through bolstering and expanding human resources and experience.

In corporation with universities, research agencies, and industries, SIP aims to bolster near-future manufacturing competitiveness through establishing, applying and socially implementing CPS. The SIP's Director, NISHIDA Naoto Ph.D., says, "When Japanese manufacturers master CPS, they will achieve three different advantages".

The first: optimizing manufacturing conditions via digital twins will allow less time-to-market of high-quality products, possibly without making prototypes. The second: more process and manufacturing condition validations, more advanced techniques like ultrafine processing, and wider application range including difficult-to-machine materials will be possible. The third: digital twins for the whole supply chain or production lines will provide appropriate and prompt actions even in sudden events like natural disasters or unforeseen failures.

Figure1 The University of Tokyo's academic-industrial cooperation platform with the core "Meister -Data Generator", a processing parameter auto-search system



It aims to establish a large-scale high-quality database for laser processing. The database is to be used for auto search, theory building, AI learning, etc.

Bottleneck removement for CPS realization and utilization

Deputy Program Director YASUI Koji Ph.D. emphasizes, "We are in the 4th year of this 5-year project. We already have ideas about how to remove bottlenecks and are ready to shift into the social implementation phase." SIP focuses on two technological challenges to pave the way for CPS implementation in Japan's manufacturing industry.

The 1st challenge: inside phenomena of some types of equipment and products on production lines are difficult to model. For example, the physical phenomenon of laser processing has been less well understood. A research team from the University of Tokyo has tried to tackle this challenge. Using AI technology, this team is already developing the method to model the phenomenon (Figure 1). A team from Kyushu University has been demonstrating a method to apply laser processing modelling technology to annealing and quality checking of semiconductors.

The 2nd challenge: the method to find optimal manufacturing conditions via digital twins is not fully developed. It is an intricate problem like "the traveling salesman problem" where the optimal solutions should be found in the vast amount of condition combinations. Conventional computers take too much time to find optimal solutions. A research team from Waseda University and Keio University suggests various methods including a method using quantum computers. The team has been establishing the environment to select optimal methods to find optimal solutions.

Besides tackling the challenges above, SIP plans to establish a "CPS platform" concept to implement CPS in various manufacturing sites on the platform. As a start point, SIP will create a format of practical CPS-type laser processing, which is considered one of the most difficult ones to be create. As a part of this project, Hamamatsu Photonics K.K. developed a high-quality high-throughput laser processing control device for processing difficult-to-machine materials such as carbon fiber reinforced plastics (CFRP). The company has already demonstrated this device, mounted on a laser processing system. A research team from Kyoto University has developed a laser diode light source that emits a high-quality high-output beam. The light source is designed for precise CPS control and also applicable to small-scale lens-less LiDAR. The National Institute of Information and Communications Technology (NICT) has been developing quantum cryptography and quantum secure cloud. These technologies are essential to safeguard confidential industrial data when several companies share CPS.

Deputy Program Director SASAKI Masahide Ph.D. showed his enthusiasm, saying, "To meet the demands of globally competitive industries, we expect to realize globally competitive data communication and storage systems".

Using rigorous independent assessment by overseas institutes for establishing practical technologies

It is rare for national programs to use paid independent assessments, but SIP has obtained objective and straightforward comments without any diplomatic niceties by entrusting said assessments to overseas institutes. The contracted agencies were Fraunhofer-Gesellschaft, a German institute renowned in advanced R&D in the global auto industry; the Industrial Technology Research Institute (ITRI), a Taiwanese institute with ample knowledge of semiconductors; and Nederlandse Organisatie Voor Toegepast Natuurwetenschappelijk Onderzoek (TNO), a Dutch institute who closely collaborates with a unique semiconductor exposure apparatus supplier. YASUI says, "Besides frank comments, we received valuable insights for promoting practical use and implementation." Based on these assessments, SIP will aim to improve the developed technologies. SIP also plans further international collaboration with the U.S., the U.K., Canada, etc.

NISHIDA says, "We are now ready for realizing social implementation of these technologies to bolster manufacturers' competitiveness by attracting companies in a greater variety of fields who are willing to join technological validation and development and partner companies who are willing to use CPS." For Japanese manufacturers, the SIP activities must have significant meaning. The gate is wide opened for them.

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