

Photonics and Quantum Technology for Society 5.0

Creating the future with photonics and quantum technologies

Enhancing the global competitiveness of Japan's strengths in photonics and quantum technologies

A Cyber Physical System (CPS) that fuses cyber space with physical space is key for achieving Society 5.0. However, there are some bottlenecks that are impeding investment in society and industry during the age of smart manufacturing using IoT/AI technologies. The SIP project, "Photonics and Quantum Technology for Society 5.0," has carefully selected important technologies in laser material processing, information processing, and communication to clear the bottlenecks and will realize "recapturing a market share in laser processing by commercializing Japanese core technologies," "accomplishing smart manufacturing by optimizing design and process in production," and "starting a highly secure cloud service." The challenge will hasten the coming of Society 5.0.



Program Director

Fellow **Toshiba Corporation** Profile

NISHIDA Naoto obtained an M.E (Electrical Engineering) in 1978 from Keio University. He joined Toshiba Corporation and worked at the Corporate Manufacturing Engineering Center. He successively held the positions of Director of Corporate Manufacturing Engineering Center, General Manager of Corporate Productivity Planning Div., General Manager of Technology Planning Div., Executive Officer, Corporate Vice President, Executive Officer, Corporate Senior Vice President, Director, Executive Officer, and Corporate Executive Vice President. At present, he is a Fellow at Toshiba. D. Eng.

Research and Development Topics

(1) Laser processing

- (i) Proof of smart manufacturing based on advanced integration of cyber (simulators) and physical (laser material processing systems): Development of CPS-type laser material processing system for specific uses
- (ii) Smart processing based on Japan's core spatial light modulator technology: Development of high-power-resistant and highly accurate space control technologies
- (iii) High-power operation of Japan original photonic crystal lasers

(2) Photonic quantum communication

Development of quantum secure cloud technology and demonstration of world-leading secure cloud services with critical data such as electronic medical records, genomic and related information, smart manufacturing information, and so on by integrating quantum cryptography, secret sharing, and secret computation into a network with security that cannot be compromised, even against advances in decryption technologies.

(3) Photonic and electronic information processing

Development/implementation of next-generation accelerator base that enables high-speed optimal utilization of quantum computers and other computational resources necessary for the realization of smart manufacture

Implementation Structure

The promotion committee, which consists of experts from related ministries and agencies and controls operations, is set up under the program director (PD) at the Cabinet Office.

The management council is set up in the National Institutes for Quantum Science and Technology (QST), the management entity, to support the PD's decisions. The council will decide the policies and goals of the whole program, manage progress, and review research subjects and harvesting strategies based on the progress in order to ensure social implementation.



Supplying a test platform and using examples for research and development

We will establish a hub to extract important research subjects, to share plans, etc. for harvesting strategies and implementing results into society, and for enhancing the synergistic effects. The hub will supply a test platform for business networks in Japan and overseas, gather technical data, and hold discussions with businesses to help with implementations. Some laser processes tested or adopted by businesses will be fed back into research and development to help businesses get results from commercialization.

🖌 Promoting standardization activities

We will operate a quantum secure cloud on a trial basis jointly with users who handle highly confidential data in the medical and smart manufacturing fields. We will promote standardization activities in quantum cryptographic technology and establish a model eco-system with evaluation, validation, and certification in the future in conjunction with formulating operation guidelines.

Y Provision of opportunities to companies to use the results on a trial basis.

An open test bed will be accomplished after implementation of the software developed which realize the next-generation accelerator base. The software enables high-speed processing for optimization of resource combination on networks and other issues. It will contribute companies to accelerate their commercialization.

Yromoting program achievements

We will publicly announce the achievements of research and development proactively and strategically in order to spread them not only to businesses, but also to society as a whole in order to expand world market share and establish a leading position in related industries.

Past Milestones and Anticipated Outcomes

- Prototype of "Meister Data Generator" that automatically acquires high-quality big data to build the CPS-type laser material processing system, which is the key to the world's top productivity in processing in the manufacturing industry has been realized, and searching for autonomous machining parameters by AI-driven decision has succeeded. As a result, we have set a goal of reducing the lead time required for selecting initial laser processing conditions by 90%. We will accelerate and promote the building of partnerships toward the realization of network-type manufacturing.
- We have succeeded in developing a highly light-resistant spatial light modulator device for social implementation of digital feedback light modulators, and have made progress in mounting and demonstration experiments on laser processing machines installed at the University of Tokyo, Utsunomiya and Hamamatsu bases. In addition, we confirmed good benchmark results using industrial high-power lasers, and have built a base for promoting POC/pilot projects for core companies in Japan and overseas by leveraging capacity of overseas research institutes.
- The development of high-brightness photonic crystal surface-emitting lasers has been promoted, and brightness approaching 10 times that of conventional semiconductor lasers was achieved by pulse operation. Also, we succeeded in constructing a lens-free, compact, high-resolution, high-precision LiDAR system, etc., taking advantage of its high brightness. As a result, simplification and sophistication of the system by the photonic crystal surface-emitting laser has been clearly confirmed. In the future, we will accelerate cooperation with user and manufacturing companies to promote smart mobility that supports a safe and secure life and the ripple effect of ultra-compact light sources for future smart processing.
- In the development of the quantum cryptographic apparatus (BB84 protocol), the technology to achieve a 50% cost reduction was realized, and the participating organizations made it their intention to become entrepreneurs, therefore, we decided to aim to achieve the subsequent goals by individual companies and this SIP project itself was completed. For the quantum secure cloud technology development, we have completed the implementation and verification of a system that can communicate GB-class genome analysis simulation data distributed and stored on a network with 3 bases in a 10km area constructed in Sendai City at 50Mbps or higher. In the future, POC in finance and medical care fields will be promoted together with assumed users.
- We have developed prototype software for the next-generation accelerator platform that utilizes Ising-type computers and NISQ (small and medium-scale quantum computers with errors) devices. As a result, it is expected that various social issues will be solved by the next-generation accelerator platform, such as the solution of problems concerning optimal allocation of operators in a logistics warehouse and the application of quantum chemistry calculations. From now on, we, looking ahead to the realization of Quantum Transformation (QX), will search for solutions to social issues to broadly contribute to Society 5.0.

