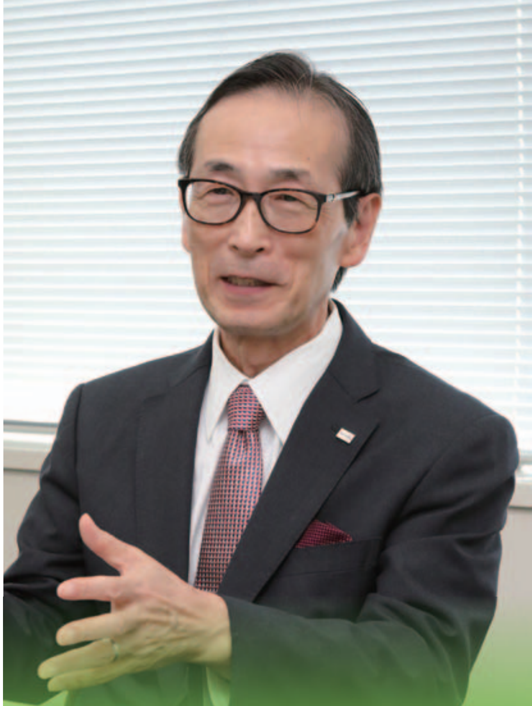
Program Director Interview

PD Interview

12 Leading Experts Who Accelerate SIP

Photonics and Quantum Technologies that Bottom Up Japan's Industrial Power



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Eliminate the bottlenecks of smart manufacturing to promote DX

The shift to CPS (Cyber Physical System) in the industrial world is accelerating on a global scale, and photonics and quantum technologies that are indispensable for establishing CPS are attracting more attention both in Japan and overseas. We interviewed PD NISHIDA Naoto about how the top-class excellent research outcomes created through SIP Photonics and Quantum Program will be expanded and contribute to the realization of Society 5.0 in the future.

Started model construction and practical verification of laser processing, which was thought to be impossible to realize

Q: Could you tell us what kind of demonstration you are working on for the establishment and social implementation of CPS?

PD: For the CPS-type laser material processing system theme, we are making efforts to construct a laser processing model, which was thought to be impossible to realize, and have already started practical application verification by utilizing AI. Specifically, Meister Data Generator (MDG) has been used to realize large amounts of automatic data acquisitions, which will be the key to smart manufacturing. Acquired large amounts of data are automatically stored in the database and analyzed using AI technology. Process modeling and simulation methods were established using this data.

In addition to that, we have developed the next-generation accelerator platform technology, which makes remarkably faster/more sophisticated processing and analysis possible compared to conventional calculation methods, in order to solve real problems concerning optimal allocation of operators in a logistics warehouse. Also, we have just begun studying the CPS platform concept so that we will be able to provide cutting-edge technology to companies, and we aim to make proposals two years from now. Furthermore, taking overseas expansion into view, we also started disseminating information to overseas research institutes and companies and strengthening cooperation with them.

High light-resistant spatial light modulator device and photonic crystal surface -emitting semiconductor laser-embedded LiDAR are projects that have a large impact on the global market.

Q: I heard that spatial light modulator technology has played very important roles for the construction of a digital twin for CPS establishment and simultaneous multi-point laser processing's feedback control technology. Could you tell us about the progress since last year, and achievements, if any?

PD: We succeeded in developing a high light-resistant spatial light modulator device (SLM) which has approximately 10 times the light resistance compared to conventional ones. This makes it possible to support industrial high-power ultrashort pulse lasers (wavelength 1 μm band), and it is now possible to expect a significant improvement in throughput, which is one of the processing bottlenecks. As a result, we can consider the practical application of high-precision and high-throughput processing technology such as non-thermal laser processing, which is effective for difficult-to-process materials. In addition, ultra-fine parallel machining with a width of 1μm level has been realized by digital feedback control technology using SLM, and based on this technology, multiple social implementation efforts in the field of microfabrication such as semiconductors, electronic components, and glass materials have been made in Japan. We have started with the manufacturer and are developing the key "digital feedback control technology" so that users can easily invest in it. From now on, we will aim to further expand the social implementation scope in collaboration with the University of Tokyo, that researches and develops CPS laser processing technology, and overseas research institutes.

Q: Could you please tell us about the progress from last year on the application to the automated driving field by embedding photonic crystal surface -emitting semiconductor laser (PCSEL) to LiDAR?

PD: Last year, we succeeded for the first time in the world in developing LiDAR equipped with a PCSEL, which has the features of high power output and narrow beam spot, and also realized lens-free and high-resolution operation. This year, we succeeded in achieving the smallest LiDAR in its class by making the most of the lens-free feature and reducing the volume to one-third that of last year. The temperature characteristics of the PCSEL have also been greatly improved, enabling stable operation over a wide temperature range (-40 to 100 degrees Celsius). The developed LiDAR was exhibited at the Society 5.0 Science Expo (at Tokyo Skytree) and received a great response.

Ensuring ultra-long-term security essential to Society 5.0

Q: I suppose that social implementation of "Quantum secure cloud" is aimed at in this SIP.

PD: If a quantum secure cloud is realized, it will be possible to ensure the ultra-long-term security of the cyber space that supports Society 5.0, and to realize safe distribution, storage, and utilization of data that will not be exposed to cybersecurity threats in the future. It is expected to bring benefits to various fields such as the medical field, biometric authentication field, and financial field, where high confidentiality and falsification resistance of information are required. Since the realization of a quantum secure cloud requires integration of secret sharing technology, physical random number source/quantum cryptographic technology, digital signature/authentication technology, and secure computing technology, the team is working as one to improve all technologies.

Q: With regard to the development of encryption devices, I heard that some devices have already been on the market.

PD: Last year, the participating institution, Toshiba, started commercialization of the BB84 quantum cryptography device. At the end of this SIP, we have been conducting R&D with the goal of reducing the device cost to one-fourth of the conventional one, but in the middle of the project period, we achieved half the cost and started early commercialization. From now on, we will accelerate the development of CV-QKD-type quantum cryptography equipment, which is expected to further reduce cost, while focusing on the sophistication of quantum secure cloud such as secret sharing and speeding up of secure computation, and we will pursue their improvement so that stable and highly reliable operation in the user environment will be realized.

Q: Last year, your recommendations proposals were adopted as fundamental recommendations by ITU-T in standardization of quantum cryptographic technology in the field of information security. Is there any new progress this year? Please tell us about future efforts toward standards and standardization.

PD: Last year, six fundamental recommendations were adopted by ITU-T. For ISO/IEC, discussions to establish Common Criteria (CC) relating to quantum key distribution have been active, and it is expected to be released in 2022. Japan also submitted 71 comments on CC proposals. At the same time, the European Telecommunications Standards Institute (ETSI) is in the process of formulating a protection profile (PP) for quantum key distribution devices by the end of 2021. Japan is also preparing its own PP proposal, and is accelerating the adjustment this year to improve its consistency with the ETSI proposal.

Q: In what specific situations and what kind of utilization are expected in the R&D of the next-generation accelerator platform?

PD: We have conducted the demonstration experiment of optimal allocation of operators in a logistics warehouse. We developed a prototype API, which led to superfast computing for ideal personnel allocation time. As its side benefit, work efficiency improvement of 30% or more was achieved. In addition, in the field of quantum chemistry calculation for the purpose of pharmaceutical and material development using NISQ computers, we started trial provision of cloud services to a consortium consisting of more than 50 major companies. In the future, as an inter-task collaboration, machine learning will be used for mechanical/thermal simulation of photo-physicochemical phenomena in laser processing and some of the calculating for appropriate processing parameters. Furthermore, we will actively utilize the consortium for scheduling optimization that efficiently executes various complicated processes in smart manufacturing, material design, and sensing data analysis.

It is important to match research results with market needs and have them utilized.

Q: When we think of DX promotion at manufacturing sites, there may be high barriers for social implementation of photonic and quantum technologies.

PD: Currently, excellent research results, which have the highest technological superiority in the world, are coming out ahead of schedule in this subject. One of the important issues is how to make these achieved benefits available to our customers. In order to sustainably strengthen Japan's international competitiveness, it is indispensable not only to strengthen its technological capabilities, but also to match its technological results with market demands and have customers actually utilize them. We believe that it is necessary to build a CPS platform matched with the DX era, and we are currently beginning to consider proposals for the concept.