PRESS RELEASE

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Keio University
Pioneer Micro Technology Corporation
Koshin Kogaku Co., Ltd.
Optoquest Co., Ltd.

Development in the Newly Defined "T-Band" Communication Wavelength Band using Quantum Dot Technology

—Enabling wavelength routing system with over 1,000 wavelength channels—

Professor Hiroyuki Tsuda, Associate Professor Ryogo Kubo, and other members of their research group at Keio University's Faculty of Science and Technology, together with Pioneer Micro Technology Corporation, Koshin Kogaku Co., Ltd., and Optoquest Co., Ltd., successfully performed a verification test of a wavelength routing system capable of exploiting the massive wavelength resource of about 80 THz of the T- and O-bands.

The T-band used in optical communication has wavelengths of between 1,000 and 1,260 nm. Compared with the C-band (1,530–1,565 nm) and L-band (1,565–1,625 nm) that are normally used in optical fiber transmissions, the T-band has greater transmission loss, making it impractical to send communications over long distances. There has been a rapid increase in demand for high-capacity and large-scale wavelength routing systems accompanying the increase in communications traffic of recent years, especially where the application range for optical communication is several kilometers at most, such as for networks within data centers and local area networks (LAN). In this research, a quantum dot gain chip, wavelength tunable laser, semiconductor optical amplifier, and arrayed waveguide grating that can operate in the T-band and the adjacent O-band (1,260–1,360 nm) were developed, and using these, the potential to construct a large-scale wavelength routing system that can accommodate over 1,000 wavelength channels was demonstrated.

The outcomes of this research were presented at the Optical Networking and Communication Conference and Exhibition (OFC 2018), an international conference held in San Diego, USA on March 15, 2018 (local time).

1. Main Points of Research

- Development of a wavelength tunable laser and a semiconductor optical amplifier (SOA) that can operate in the T-band (*1) and the O-band (*2) using quantum dot technology.
- Development of an arrayed waveguide grating (AWG) that can operate in the T- and O-bands and proposal of a router architecture capable of routing over 1,000 wavelength channels

through multi-stage connections of the AWGs.

- Building of a large-scale wavelength routing system that mobilizes the massive wavelength resource of the T- and O-bands using the developed wavelength tunable laser, SOA, and AWG, and verification of the achievement of error-free transmissions at 10 Gbit/s per wavelength.

2. Background of Research

Optical communication technology using single-core optical fibers that can transmit optical signals at speeds of over 100 Gbit/s are currently being developed to cater to the increase in network traffic due to the popularization of cloud computing and services that provide ultra-high-definition videos. However, wavelength bands used in optical networks have been mostly limited to the C-band (*3) and L-band (*4), which have small transmission loss, and the E-band (*5), which includes the zero-dispersion wavelength of the standard optical fiber. On the other hand, if proactive use of the T- and O-bands, which have remained largely unused up to now, were achieved, it would be possible to expand transmission capacity, increase scalability, and deploy new services. For this, the development of a light source with appropriate characteristics and reliability, optical components such as optical circuits, and wavelength routing technology, is essential.

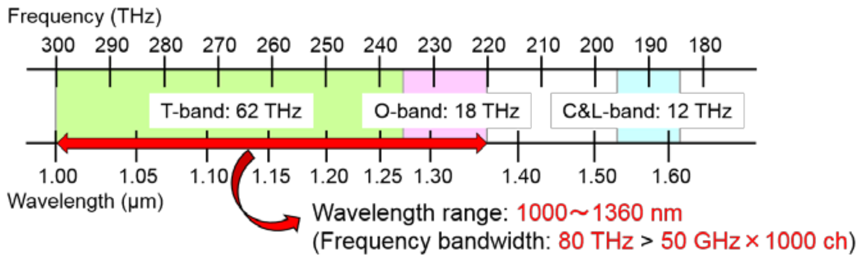

Figure 1: Optical communication wavelength bands: Compared to the 12 THz wavelength band of the C- and L-bands, which have been the predominant optical communication wavelength bands up to now, the new T- and O-bands have a massive 80 THz wavelength band. T- and O-bands can provide over 1,000 wavelength channels at 50 GHz intervals, and the expansion of transmission capacity through parallelization can be anticipated.

3. Content of Research and Results

This research built on the quantum dot technology owned by the National Institute of Information and Communications Technology (NICT) and a gain chip that can operate in the T- and O-bands was delivered. The developed gain chip has broadband capabilities covering the wavelength range of 1050 to 1300 nm with three elements, stable operational capability in high-temperature environments of 95 degrees Celsius or higher, and reliable operational capacities of 1 million hours or more. Wavelength tunable lasers and SOAs equipped with this gain chip were also developed. Furthermore, AWGs that can operate in the T- and O-bands were manufactured, and the architecture of the wavelength router was configured to route 1,081 channels through multi-stage connections composed of sub-waveband switching AWGs with 1 input and 23 output ports (1×23 AWGs), channel switching AWGs with 47 input and 47 output ports (47×47 AWGs), and sub-waveband switching AWGs with 23 input and 1 output ports (23×1 AWGs). Using the developed wavelength tunable lasers, SOAs, and wavelength router, a wavelength routing system that exploits the massive wavelength resource of the T- and O-bands was built, and transmissions at 10 Gbit/s per wavelength were successfully transmitted. In this experiment, a cost-effective and low-latency intensity modulation direct detection (IMDD) technique was used.

The feasibility of a high-capacity and large-scale wavelength routing system that effectively makes use of the massive wavelength resource of the T- and O-bands that amounts to 80 THz was demonstrated from the outcomes of this research. Compared to the C- and L-bands which had been used in long-distance optical communication up to now, the T- and O-bands have frequency bandwidths that are 5 times greater or more, allowing for the number of wavelength channels to be increased by a factor of 5 or more. This means that even if cost-effective and low-latency IMDD techniques are used, it is possible to achieve high-capacity communications that are equal to those that make use of coherent transmission techniques. There is a need to increase the speed and capacity of networks as well as to improve their scalability to cope with the surge in numbers of communication devices and communication traffic that is expected over the coming years. The outcomes of this research are significant in the sense that they pave the way to the development of this new communication wavelength band that could offer one possible path to address this issue.

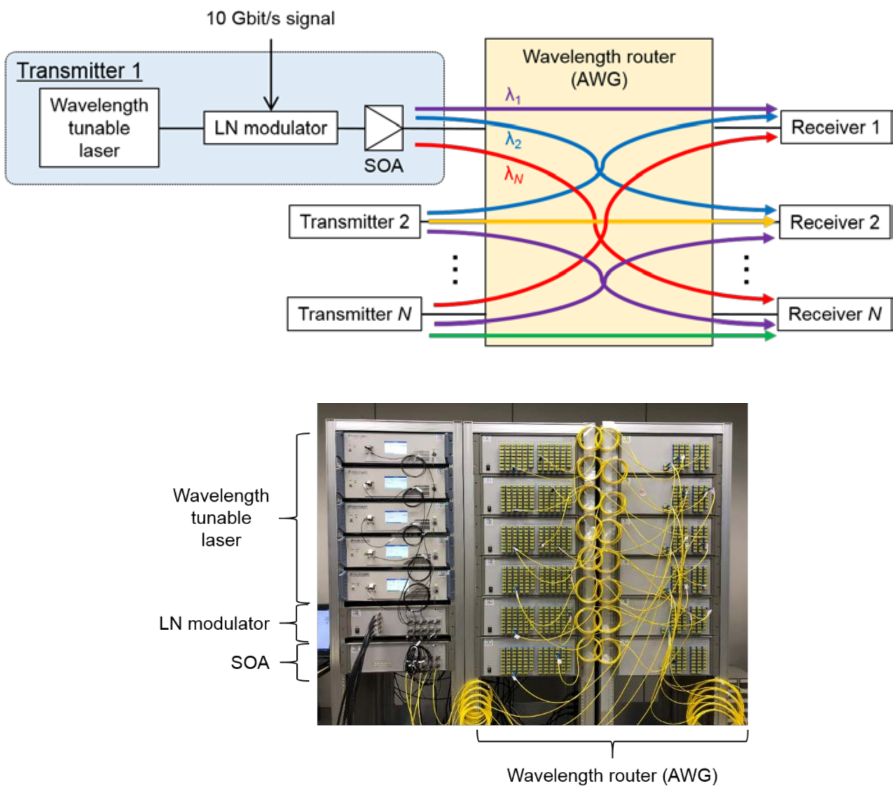

Figure 2: Wavelength routing system: Considering a comparatively short distance local area network (LAN), optical transmission experiments at 10 Gbit/s per wavelength in the T- and O-bands were conducted. Capacity increase through wavelength division multiplexing (WDM) technology can be expected.

4. Future Developments

A rapid increase in demand for high-capacity optical communication systems is expected to support technologies associated with developments in the Internet of things (IoT) and the diffusion of 5th generation wireless systems (5G). By mobilizing the T- and O-bands, which can provide 1,000 or more wavelength channels, the capacity of optical transmission networks and the number of users that can be accommodated will be increased. In addition, the lowering of latency through flexible wavelength changes and energy-saving through the increase or decrease of the number of wavelengths in use in accordance with the amount of communication traffic will become possible. There are high expectations that this technology will be adopted in the optical communication systems that will support the next generation of data centers and mobile networks. Next, further improvements to the functions and performance of the devices and systems developed, as well as expansion of the applications of the optical components that were developed to areas other than optical communication will be considered.

Details of Conference Paper

Ryogo Kubo, Takuto Fujimoto, Takahiro Shobudani, Yudai Okuno, Masaki Suzuki, Hiroyuki Tsuda, Makoto Sudo, Tadashi Hajikano, Yasunori Tomomatsu, and Katsumi Yoshizawa, "T/O-band wavelength routing system using quantum dot semiconductor devices and 1081-channel AWG router," The Optical Networking and Communication Conference & Exhibition (OFC 2018), San Diego, CA, USA, paper Th3H.4, March 2018.

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Glossary

*1 T-band: in optical communication, a wavelength band ranging between 1,000 to 1,260 nm. The "T" in T-band stands for "thousand."

*2 O-band: in optical communication, a wavelength band ranging between 1,260 to 1,360 nm. The "O" in O-band stands for "original."

*3 C-band: in optical communication, a wavelength band ranging between 1,530 to 1,565 nm. The "C" in C-band stands for "conventional."

*4 L-band: in optical communication, a wavelength band ranging between 1,565 to 1,625 nm. The "L" in L-band stands for "long wavelength."

*5 E-band: in optical communication, a wavelength band ranging between 1,360 to 1,460 nm. The "E" in E-band stands for "extended."

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