【Grant-in-Aid for Scientific Research (S)】

Broad Section C

Title of Project : Study on digital frontier photonic sensing based on omnipotent fiber lasers

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Research Project Number : 18H05238 Researcher Number : 40239968
Keyword : Sensing devices, Signal processing

【Purpose and Background of the Research】

In future Society 5.0, mutual interactions between physical space and cyber space are expected to create new industry/service. There, sensing technologies are indispensable.

In this project, we aim at realizing omnipotent fiber lasers, and the innovative digital frontier photonic sensing by integrating the omnipotent fiber lasers and digital coherent signal processing technologies, as depicted in Fig.1.

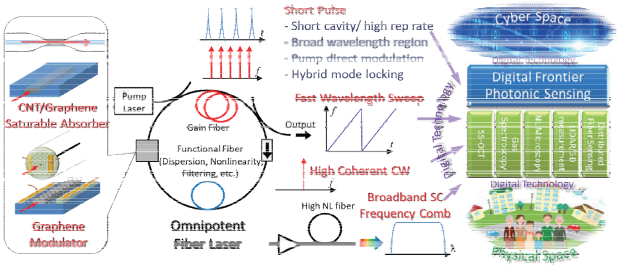

Fig.1 Digital frontier photonic sensing based on omnipotent fiber lasers

【Research Methods】

This project is based on our two original technologies. One is the passively mode-locked fiber lasers using carbon nanotube (CNT) and graphene. CNT and graphene are ultrafast, nano-size, and low-cost saturable absorbers, compatible with fiber/waveguide, and features broad wavelength operation. The other is the dispersion tuned actively mode-locked fiber lasers, which can sweep lasing wavelength with the use of active mode locking and fiber dispersion. It does not require any optical filters, as the result not limited by the speed or bandwidth of optical filters.

We have been developing omnipotent fiber lasers, as shown in Fig.1, which are actively or passively mode-locked fiber lasers having, not only intense short pulse output, but also digital features and high functionalities, such as, high repetition rate, broad bandwidth, and fast sweep, by fully utilizing functional (dispersion, nonlinearity, etc.) fibers. Omnipotent fiber lasers elicit various high functionalities in lasers from a single technique, mode locking.

Here we promote digital frontier photonic sensing. In the conventional analog photonic sensing, physical quantities are measured by interference of laser light beams in free space, and only the amplitude of interfered signals is processed in analog circuits. By contrast, in digital frontier photonic sensing, they are measured not only in free space but also in waveguides or fibers, and both amplitude and phase of interfered signals are digitally processed using digital coherent receivers. The digital signals are processed further with higher-level processing, such as compressed sensing or deep learning, to bridge between physical and cyber spaces. Thus, it is an innovative photonic sensing technology that fully utilizes lasers with digital features and high functionalities, and digital signal processing.

【Expected Research Achievements and Scientific Significance】

By applying the digital frontier photonic sensing to various sensings, such as optical coherence tomography (OCT), gas spectrometry, nonlinear microscope, LIDAR/3D measurement, and optical fiber sensors, as listed in Fig.1, we expect to contribute to realization of Society 5.0.

【Publications Relevant to the Project】

・S. Yamashita, A. Martinez, and B. Xu, “Short pulse fiber lasers mode-locked by carbon nanotube and graphene (Invited),” Optical Fiber Technology, vol.20, no.6, pp.702-713, Dec. 2014.
・S. Yamashita, “Dispersion-tuned swept lasers for optical coherence tomography (Invited),” IEEE Journal of Selected Topics in Quantum Electronics, vol.24, no.3, 6800109, May 2018.

【Term of Project】 FY2018-2022

【Budget Allocation】 144,800 Thousand Yen

【Homepage Address and Other Contact Information】

http:// www.cntp.t.u-tokyo.ac.jp