Division of Advanced Science and Biotechnology,
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Recent progress on Photonic Analog-to Digital Conversion

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Our research and education cover the multidisciplinary fields of ultrafast photonics, signal processing and various measurements. We are exploring optical system solutions based on novel concepts for a wide range of signal processing applications including next-generation photonic networks, remote sensing, astronomy and so on. Here, multi-dimensional property of light in time and space domains suggests the latent potential of ultra-fast and massive parallel optical signal processing.

High performance analog-to-digital convertors (ADCs) for high-speed and flexible signal processing is strongly coveted for recent tremendous growths of ultrawide-bandwidth applications such as digital coherent communication as well as remote sensing [1,2]. While current electrical ADCs have achieved excellent performances, there is a trade-off between sampling rate and resolution due to electrical jitter of the sampling aperture and ambiguity of the comparator. Since the above issues would limit the bandwidth of electrical ADCs, photonic ADC has attracted much attention recently and very low jitter comes from optical sampling enables to drastically improve a jitter issue and realize a high speed ADC over 100 GS/s. To align current electronic ADC performance and photonic technologies, we focus on various photonic approaches for high performance ADCs and have experimentally demonstrated the potential of Photonic ADCs [3-8].

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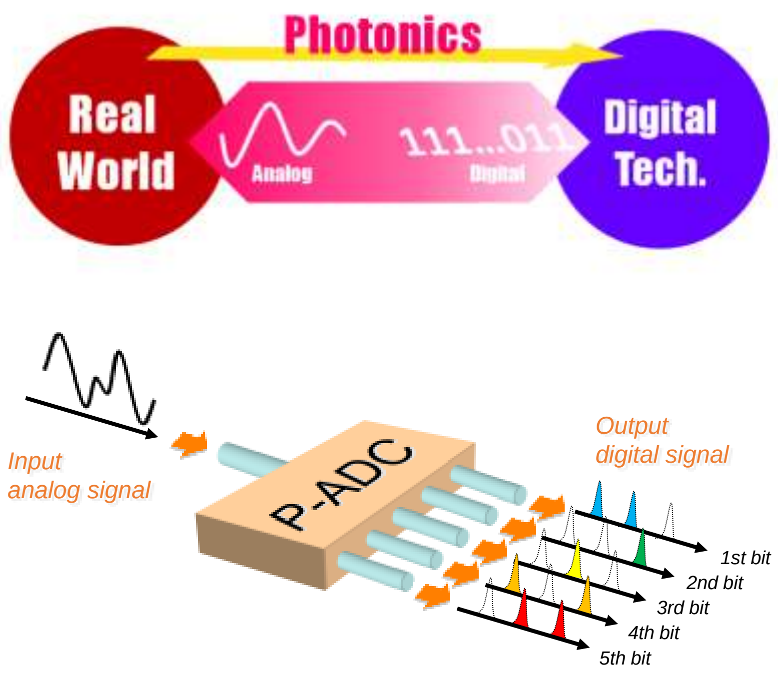

Schematic of Photonic Analog-to- Digital Conversion system

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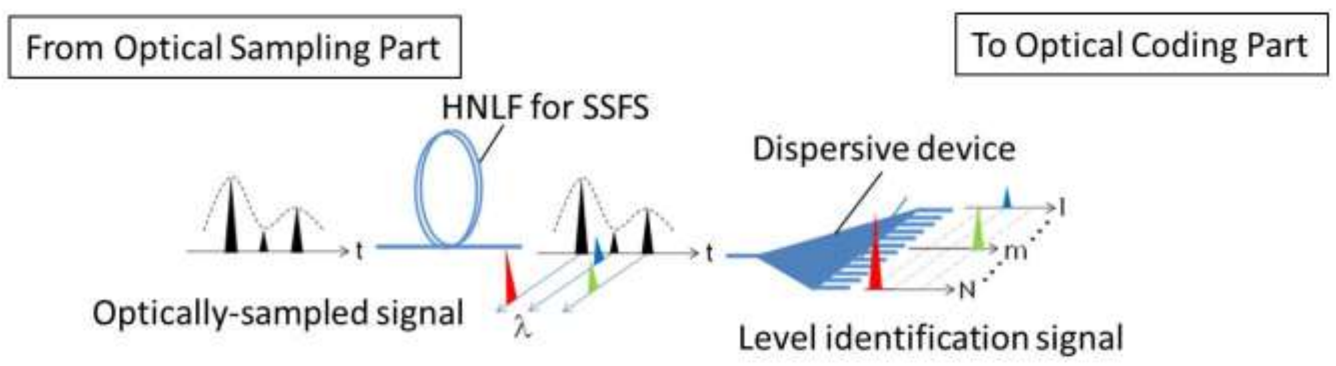
TOPIC 1

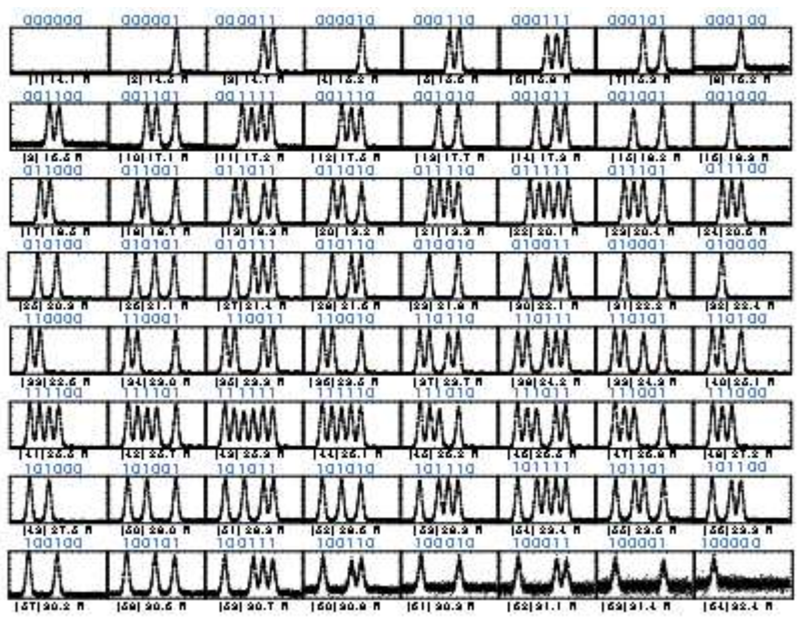
Principle of Optical Quantization and Coding[3-6]

An optically sampled pulse from an optical-sampling part induces Self-Frequency Shift (SSFS) in a high nonlinear fiber (HNLF). SSFS realize power-to-wavelength conversion. The optically quantized signal is fed to a subsequent optical coding part. This approach can be easily connected to any optical coding subsystems such as optical interconnection so as to generate a binary pulse signal for a desired digital signal output.



Photonic Analog-to-Digital Conversion based on SSFS

TOPIC 2



Digitized 6bit optical codes

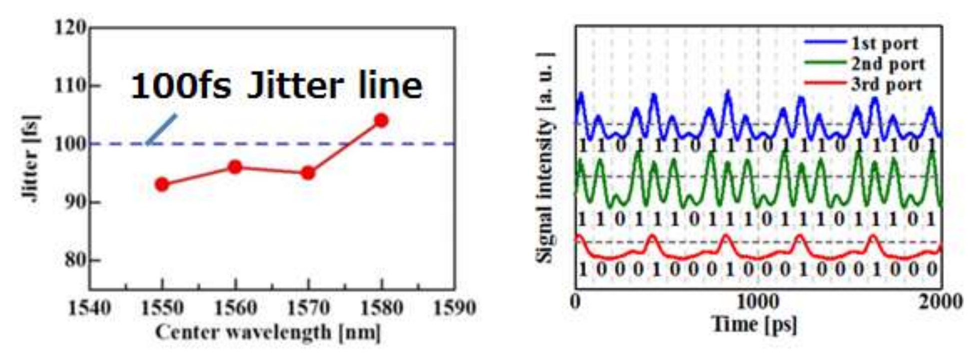
6bit optical Quantization[7] and Coding

We experimentally demonstrated 6 bit optical quantization and coding by expansion of the FSIR in conjunction with reduction of the QSS. Experimental results show the appropriate variance of the center wavelength shift, 64 output spectra, and 64 optical codes which input peak power is set at regular interval of QSS, respectively. Both integral nonlinearity error (INL) and differential nonlinearity error (DNL), obtained from experimental results, are less than 1 LSB, resulting in no missing error and the error-free operation in simulation guarantees the reliability of the system.

TOPIC 3

Below 100fs jitter Optical Sampling, Quantization and Coding[8]

We experimentally realize seamless operations with below 100-fs timing jitter in a 10-GSample/s 3-bit photonic analog-to-digital converter (ADC) with an input 2.5-GHz sinusoidal electrical signal. This demonstration could address the energy efficiency by reduction of the number of devices, including electrical ADCs for subsequent operations after optical sampling in existing high-performance photonic ADCs.



Below 100fs Jitter and Digitized 3bit optical codes