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# Demonstration of a Semiconductor-based Multi-Wavelength Light Source and its Application to Optical Label Processing

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**Abstract** A semiconductor-based multi-wavelength light source for optical label processing scheme is demonstrated. Two cascaded electroabsorption modulators generated multi-wavelength optical spectrum, and coding could be achieved with one of sidebands filtered by a fiber Bragg grating.

## 1. Introduction

Optical label processing scheme is one of the most technical key points for realizing optical label switching techniques[1]-[5]. We have proposed and demonstrated time-domain separated wavelength division multiplexed (TS-WDM) label scheme[6] as shown in Fig.1. In this scheme, each bit of optical label is wavelength-multiplexed in the same time slot, and it is separated with payloads in time. Therefore, optical labels with slower bit rate than that for payloads does not cause network efficiency degradation. And wavelength bandwidth of optical labels can be shared with that of payloads, and this suppresses the degradation of wavelength utilization efficiency. However, discrete DFB lasers were used as a multi-wavelength light source in Ref.[6], and realization of the compact light source is desirable.

In this paper, we propose the optical label generator using semiconductor-based multi-wavelength light sources. Multi-wavelength generation and optical coding using one of the generated sideband will be presented.

## 2. Structure of Semiconductor-based Multi-Wavelength Light Source

Schematic structure of the optical label generator and label processor using the multi-wavelength light source is shown in Fig.2. Optical label is coded by separating each sideband emitted from the multi-wavelength light source using an arrayed waveguide grating (AWG) and gating each signal with optical gates such as electroabsorption modulators (EAM's). In the label processor, each wavelength signal for optical label is separated with an AWG. After optical-to-electrical (OE) conversion, signal levels are recognized by comparators, and then the label pattern is processed by the address table. Slow electronics can be used because bit rate of optical label is slower than that of payloads as shown in Fig.1. The multi-wavelength light source we propose is indicated in the inset of Fig.2. CW light emitted from a DFB laser is modulated with two-stage EAM's by sinusoidal RF signals with frequency of the same as the bit rate of optical label. By intensity and phase modulation in the EAM, multi-sidebands are generated just like a comb generator

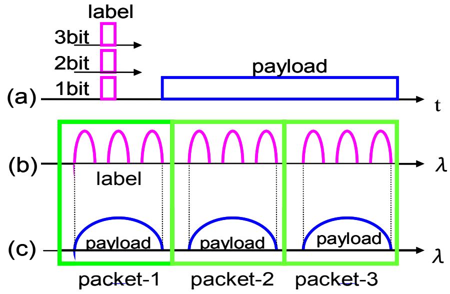


Fig.1 Conceptual image of optical packet frame.
(a) Time-axis: Each bit of multi-wavelength optical label is wavelength-multiplexed in the same time slot, followed by payload.
(b) Wavelength-axis: optical label is assigned within the payload bandwidth.
(c) Wavelength-axis: Payloads are wavelength-multiplexed.

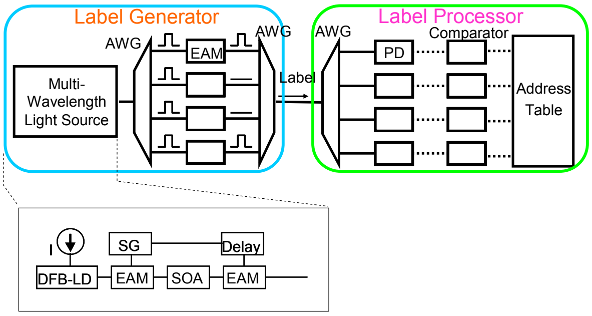


Fig.2 Schematic structure of a multi-wavelength optical label generator, label processor, and a multi-wavelength light source.

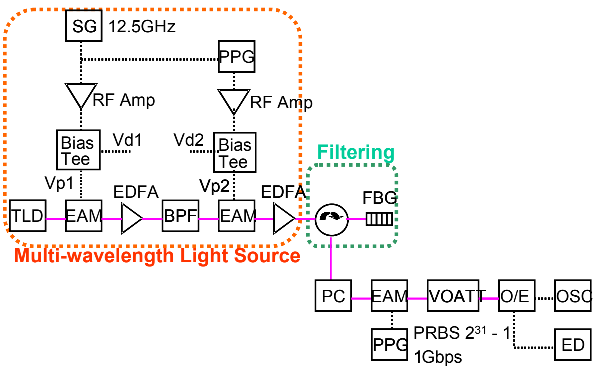


Fig.3 Experimental setup of optical label generation using a semiconductor-based multi-wavelength light source, a fiber Bragg grating and an electroabsorption modulator.

with $LiNbO_3$ modulators. All components are made of semiconductor, and so integration in one chip and resultant compact size could be realized.

## 3. Experimental setup

Experimental setup for optical coding using multi-wavelength light source is shown in Fig.3. The 1st stage EAM was modulated with a RF synthesizer with frequency of 12.5GHz. The bias voltage and the RF voltage amplitude were -2.4V and 5.0V, respectively. In the 2nd stage EAM, the bias voltage of -2.0V and the RF voltage amplitude of 4.5V were used. In these experiments, generated multi-wavelength signal was injected into a fiber Bragg grating (FBG) with the center wavelength of 1551.6nm and the reflection bandwidth of 0.1nm instead of an AWG. The reflected signal was coded with an EAM with 1Gbps $2^{31}$-1 PRBS format. After OE conversion, the waveforms were observed with a sampling oscilloscope and bit error rate (BER) was measured with a BER tester.

## 4. Experimental results

Optical spectrum of the generated multi-wavelength signal is indicated by the solid line in Fig.4(a). Peak to valley ratio of more than 20dB and the power difference between the center and 0.4nm-separated sideband of 15dB were observed. Optical spectrum after filtering 1551.6nm wavelength signal with a FBG is shown in the dotted line in the same figure. Side-mode suppression ratio of more than 30dB could be obtained, and this is large enough for optical coding.

Eye diagram of the coded signal is shown in Fig.4(b). In comparison, CW light was coded with an EAM and its eye diagram is indicated in Fig.4(c). In both cases, clear eye openings could be achieved.

BER measurement results are indicated in Fig.4(d) for both cases. We could see no power penalty between them, and this indicates that there is no noticeable degradation in coded signal using the proposed multi-wavelength light source.

In summary, we proposed and investigated the characteristics of semiconductor-based multi-wavelength light source consisting of a DFB laser and two-stage EAM's. We could obtain multi-wavelength signals, and we confirmed that the coding signal with 1Gbps PRBS format had no power penalty and no noticeable degradation.


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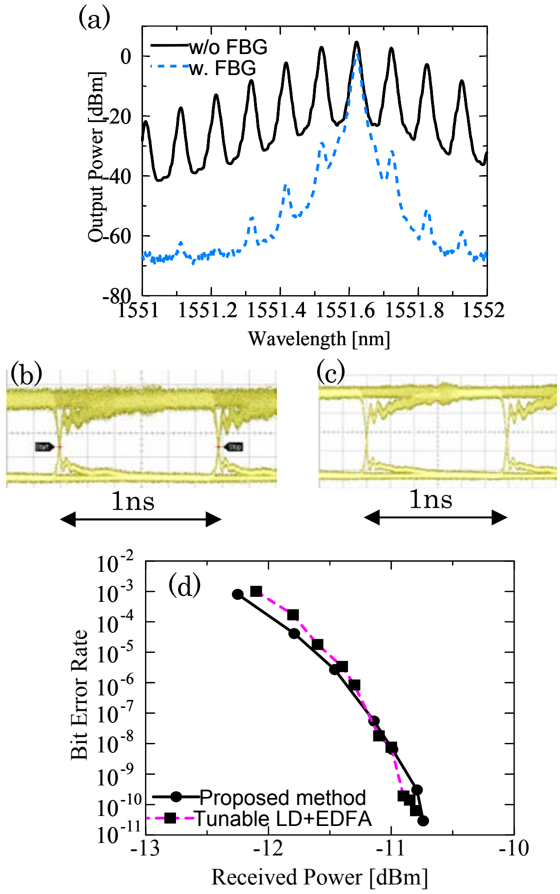


Fig.4 Experimental results of optical code generation.
(a) Optical spectra of the multi-wavelength light source with and without a fiber Bragg grating.
(b) Eye diagram of 1Gbps optical coding with the multi-wavelength light source and a FBG.
(c) Eye diagram of 1Gbps optical coding with CW tunable laser and an EAM.
(d) BER measurement results.

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