

Report: Optical Semiconductor Device - 5

Traveling-wave-electrode Mach-Zehnder modulator monolithically integrated with SOA

A traveling-wave-electrode InP Mach-Zehnder (MZ) modulator monolithically integrated with a semiconductor optical amplifier (SOA) was developed. Loss-less operation and full C-band 40-Gbit/s DPSK modulation with a low driving voltage of $3 V_{pp}$ was successfully demonstrated.

We have been developing a high-speed InP MZ modulator with a small chip size and a low driving voltage so that it enables us to fabricate a compact transceiver with a low power consumption.

For enlarging the capacity of the next generation optical network, long-haul transmission systems will have to handle a line rate of 100 Gbit/s or more. Advanced modulation formats such as a multi-level signal with a polarization multiplexing have recently been receiving a lot of attention as key technologies supporting these systems. Since the optical modulators for these formats will be large-scale and have a complex configuration using several MZ modulators, optical insertion loss will be a serious issue.

Against this background, for the first step, we developed a MZ modulator with a SOA. Figure 1 (a) shows a photograph of the fabricated device. The SOA

has a ridge-waveguide structure, and the InP MZ modulator employs traveling-wave electrodes for high-speed operation. The chip size is only 5.2 mm x 0.8 mm. Figure 1 (b) shows fiber-to-fiber gains for various wavelengths across the C-band as a function of the injection current into the SOA with a fiber input power of 0 dBm. We obtained lossless operation for the entire C-band when the injection current was more than 180 mA. We then performed the 40-Gbit/s NRZ-DPSK modulation experiment, as shown in Fig. 2. The insets show the eye diagrams received using a 1-bit-delay MZ interferometer and a balanced photodiode for the back-to-back configuration. Clear eye openings and error-free operation for all wavelengths were achieved. The driving voltage was only $3 V_{pp}$. We believe that this device is a significant step toward realizing a compact, low-loss, high-speed modulator module for advanced modulation formats.

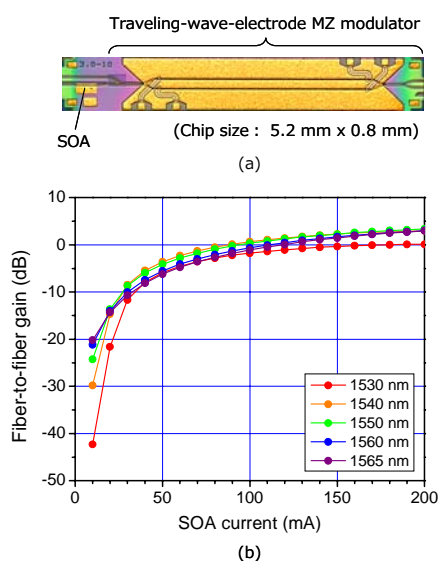


Fig.1 (a) Traveling-wave-electrode MZ modulator with a SOA
(b) Fiber-to-fiber gain characteristics.

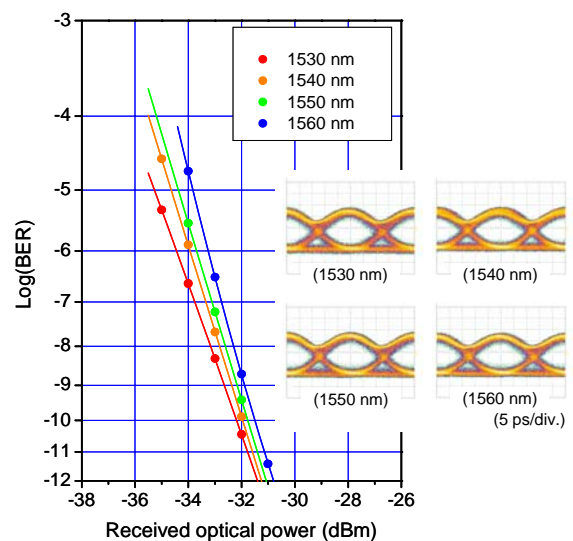


Fig.2 40-Gbit/s NRZ-DPSK modulation characteristics.