THE SUMMARY OF Ph.D. DISSERTATION

Engineering		Ito, Toshio

Title Semiconductor optical amplifier based wavelength converters for photonic transmission systems
(光伝送システムにおける半導体光増幅器型波長変換素子の研究)

Increasing the bit rate per wavelength division multiplexing (WDM) channel, not only increasing the number of channels, is attractive for upgrading the traffic capacity of optical transmission systems. The remaining problems are the difficulties in connecting different types of WDM system, and the signal waveform distortion due to the polarization mode dispersion (PMD). Therefore, a simultaneous wavelength conversion and high bit rate PMD compensation are expected. Semiconductor optical amplifier (SOA) based wavelength conversion is the most promising device for those subsystems, because of its advantages of bit-rate-independent and format-independent operation.

Chapter 1: The background and the purpose of this work are described.

Chapter 2: The described SOA has an extremely low loss-less current of 5.4 mA, which is the lowest record so far reported. The scattering of the polarization dependence gain (PDG), which is due to the unintended stain in the active layer, is within 0.5 dB, while the scattering in conventional SOA is 2.5 dB.

An SOA array integrated with spot size converter (SS-SOA) has been fabricated for connecting the SOA to planar lightwave circuit (PLC). To reduce the evaluation cost, I have proposed a novel method of measuring the PDG. By averaging the signal gain over a wide wavelength range, the PDG can be accurately estimated with low reflection from gain ripples. The PDG of an angled-facet SS-SOA was successfully evaluated even before the AR coating process.

Chapter 3: Chapter 3 discusses hybrid integration of SS-SOA and PLC. Hybrid integration is attractive to fabricate practical modules with functional PLC, such as arrayed waveguide grating (AWG).

A 4-channel SS-SOA gate array was assembled on a PLC platform for the first time. It has an extinction ratio higher than 35 dB, operating at less than 50 mA. The PDG is less than 1 dB throughout an ultra-wide-band of 1530-1600 nm. The spot-size converting structure of the SS-SOA reduces the coupling loss to 4 dB, and improves the horizontal 1-dB down tolerance to 2 μm.

Using the SS-SOA gate array and AWG, first in the world, a high-speed wavelength selector was demonstrated. The rise- and fall-times were less than 1 ns, which is fast enough for packet switching.

Chapter 4: Chapter 4 describes photonic subsystems for upgrading transmission network.

I demonstrated, for the first time, a simultaneous wavelength conversion from C- to L-band using four-wave mixing (FWM) in a wavelength selector. Another type of simultaneous wavelength conversion, from equal to unequal channel spacing, was demonstrated using cross-gain modulation (XGM). My aim is not a random wavelength switching but a fixed wavelength shifting to connect different networks. This allows easy operation and control, which is necessary for practical use.

I proposed a novel technique in monitoring the state of the differential group delay (DGD) of an optical fiber. Thanks to the XOR operation of the cross phase modulation (XPM), this technique is bit-rate independent and format independent. The PMDs of 80-Gbit/s RZ format and 40-Gbit/s NRZ format were successfully compensated. The power penalty was only 0.9 dB.

Chapter 5: The main results of this study, which shows the possibility to solve the main problems of future high-speed WDM systems, the polarization mode dispersion (PMD) compensation and simultaneous wavelength conversion, are summarized.