❖*This article has been translated from the original release in Japanese for your convenience*❖

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Development of optical transmitter/receiver devices for cost-effective 10Gbit/s metropolitan area networks

- Significant improvement in semiconductor laser high temperature characteristics and photodiode sensitivity -

The Central Research Laboratory of Hitachi, Ltd., (General Manager: Dr. Toshikazu NISHINO) has succeeded in the development of optical transmitter (InGaAlAs buried heterostructure (BH) semiconductor laser) and receiver (InAlAs mesa-type*1) avalanche photodiode (APD) *2)) devices for cost-effective 10 Gbit/s metropolitan area networks. The technology developed provides stable high temperature operation in the laser and high sensitivity in the optical receiver. These improvements eliminate the need for a temperature control cooler in the transmitter and the optical amplifier in the receiver, contributing to a large cost reduction in optical sub-systems. Further, the world's highest sensitivity of -29.8dBm was achieved in an APD receiver module with a SiGe-HBT preamplifier.

With the rapid spread of the Internet, trunkline networks mainly between metropolises have increased in data transfer speed and capacity. The recent increase in user access, such as mobile phones, is now making it necessary to improve the capacity of the metropolitan area networks, which link cities. As a result, the introduction of 10Gbit/s large capacity optical transmission systems, which until now has mainly been installed in trunkline networks, into the metropolitan area networks, is being accelerated.

In a trunkline network, a temperature control cooler is used for the stable operation of semiconductor lasers, and an optical amplifier is used to amplify the weak optical signals received after optical fiber transmission. In metropolitan area networks, however, cost-reduction is a strict condition. Thus, the development of optical transmitter/receiver devices that could dispense with these components was desired.

The Central Research Laboratory of Hitachi, Ltd., undertook this challenge to realize a cost-effective metropolitan area network through component reduction, and developed an optical transmitter with good high temperature characteristics and a high sensitivity optical receiver.

Features of the technology developed are as follows:

(1) InGaAlAs buried heterostructure semiconductor laser
InGaAlAs crystal which has excellent high temperature characteristics was used in the active layer of the semiconductor laser, and a buried heterostructure (BH)*3) which has lower power consumption characteristics was employed. Further a process was developed to control oxidation of the Al in the crystal material, and, for the first time in the world, operation at 85°C for over 5,000 hours was achieved. As a result, realizing

an InGaAlAs BH-type laser is in sight.

(2) InAlAs mesa-type avalanche photodiode (APD)

InAlAs which has a high amplification efficiency and a small leak current (large leak current reduces detection sensitivity), was used as the material for the multiplication layer of the photodiode. Molecular beam epitaxy*4) that enables high precision impurity concentration control, was used in the crystal growth, and a mesa-type device structure was fabricated. Further, to increase reliability, a protective structure was made to bury the mesa-type device. As a result, a gain bandwidth of 120 GHz was achieved, and operation of 10Gbit/s was confirmed for a wide amplification range of 2-12 times.

The configuration of optical transmitter/receiver modules can be simplified by use of the semiconductor laser and photodiode developed, thereby reducing costs.

Details of this technology will be presented at the European Conference on Optical Communication (ECOC'02), from 8th September 2002.

ⓘExplanation of Terms

*(1) Mesa-type: device structure whereby the active portion of the device is cutout like a plateau.

*(2) Avalanche photodiode (APD): light-detecting device with the ability to amplify its photocurrent by using the avalanche multiplication phenomenon, advantageous in constructing sensitive receivers. The avalanche multiplication phenomena is seen when an electron generated in a semiconductor subjected to a high electric field, is accelerated by the field gaining fairly high kinetic-energy. When the electron impacts with the atom of the semiconductor, it can kick additional electrons out of the atom. These additional electrons are also accelerated by the electric field and can then generate more additional electrons by impact, resulting in a large current. This chain-reaction like mechanism is called the avalanche multiplication, and a large internal gain can be obtained.

*(3) Buried heterostructure (BH): after the active layer, which generates the laser beam, is processed to a stripe geometry, both sides of the stripe are buried by highly resistive semiconductor layers. As the injection current concentrates only in the active layer, it has excellent emitting efficiency and modulation characteristics.

*(4) Molecular Beam Epitaxy: a thin crystal film growth technique in which atoms or molecules of a semiconducting crystal are stacked layer by layer on a substrate in a high vacuum. The thickness and the concentration of impurities of the film can be controlled precisely.

*(5) Gain Bandwidth (GB) product: one performance indices for APD. As APD gain becomes larger, theoretically the product of the gain and bandwidth becomes constant. The larger the GB product, a larger amplification can be obtained despite a high frequency.

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