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

Development of 705/730 nm Wavelength Laser Diodes for Biomedical Measurement

100 mW output power in the fundamental-transverse mode achieved

Tokyo, 16th May 2007 - Hitachi, Ltd. (NYSE: HIT / TSE: 6501) has succeeded in the development of high-output 705 nanometer (nm) and 730 nm wavelength laser diodes with an output of 100 milliwatt (mW) using less than 110 milliampere (mA) in stable fundamental-transverse mode[*1] operation. As radiation from the 700 nm band, in the near infrared region of the electromagnetic spectrum, has low absorption in biological tissue, the development of an extremely small light source using laser diodes in this band is greatly anticipated in biomedical measurement systems. To fulfill the requirements of such a light source, i.e., high output with low power consumption and fundamental-transverse mode operation, laser diodes were developed using indium gallium arsenide phosphide (InGaAsP), a compound semiconductor, in the light emitting active layer, and a ridge waveguide structure was employed to reduce optical loss. In the past, 780 nm band fundamental-transverse mode laser diodes were developed for optical disc systems. This development opens the way to achieving low power high output laser diodes in the 700 nm band suitable for biomedical measurement.

In recent years, biomedical application of optical measurement methods has received much attention due to its non-invasive nature. The wavelengths employed are in the 700 nm band, which pass through biological tissue well but has a low absorption rate in water and hemoglobin. At the same time, in order to achieve a compact and low cost system, a compact and low power consumption laser diode light source is necessary. Until now, however, a 700 nm band laser diode with an output of over 20 mW and using fundamental-transverse mode required for high precision measurement was not available except for the 780 nm laser developed for optical disc systems. With optical measurement, as the optimal wavelength of the light source depends upon the measurement target, the development of a practical laser diode light source using wavelengths in the 700-770 nm region was desired for various applications in biomedical measurement.

In response to this need, Hitachi has developed high-output low-power 705 nm and 730 nm laser diodes. Features of the new diodes are as follows:

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(1) 700-nm band wavelengths achieved using InGaAsP in the active layer of the quantum-well[*2]

InGaAsP, adapted by adding arsenic (As) to InGaP, a semiconductor compound used in 600 nm band laser diodes, was applied in a quantum well structure comprising of a layer of InGaAsP sandwiched between AlGaInP. InGaAsP has the characteristics of not mixing uniformly (i.e. miscibility-gap problem) which degrades crystal growth. This problem was overcome by identifying the optimal crystal composition and growth conditions, thus enabling the development of 705 nm and 730 nm laser diodes.

(2) High output power achieved by adapting low-loss ridge waveguides

A ridge-type structure was employed in the laser waveguide as ridge waveguides have low optical loss, and thus, lasers can be oscillated under low operating current as well as enabling the fundamental-transverse mode to be maintained up to a high output level. This structure also has a cost advantage as the structure can be fabricated in one crystal growth.

Two prototype laser diodes with wavelengths of 705 nm and 730 nm were developed, and the device characteristics were measured. In fundamental-transverse-mode operation, a record-breaking high output of 100 mW (room temperature continuous wave) was achieved. The operating current at 100 mW output was found to be less than 110 mA, confirming that, compared to previously reported laser diodes using wavelengths in the same band, lower-power operation is possible. Further, the prototypes had excellent temperature characteristics with stable lasing operation confirmed up to 80 °C.

Metal organic chemical vapor deposition (MOCVD) technique, suitable for mass production, was employed in the crystal growth process. The crystal growth conditions identified were found to provide excellent wavelength control, enabling an arbitrary wavelength between 700nm and 730nm to be achieved by changing the composition of the InGaAsP layer. In the future, by further optimizing conditions, it can be expected that the wavelength region of laser diodes will be expanded.

The results were presented at the 19th International Conference on Indium Phosphide and Related Materials (IPRM 2007), held in Matsue, Japan, from 14th -18th May 2007.

■ Notes

*1 Fundamental-transverse mode: The intensity pattern of a beam where the optical intensity profile has a single-peak distribution, and the laser beam can be focused on a small spot using a lens. Fundamental-transverse-mode operation is required for increased measurement accuracy in applications such as metrology and spectroscopy.

*2 Quantum well: A thin layer of nanometer-scale thickness (one nanometer is one billionth meter) sandwiched between two wide-bandgap layers. Lasing characteristics are improved using the thin layer in which electrons are quantum-mechanically confined in one dimension.

About Hitachi, Ltd.

Hitachi, Ltd., (NYSE: HIT / TSE: 6501), headquartered in Tokyo, Japan, is a leading global electronics company with approximately 356,000 employees worldwide. Fiscal 2005 (ended March 31, 2006) consolidated sales totaled 9,464 billion yen ($80.9 billion). The company offers a wide range of systems, products and services in market sectors including information systems, electronic devices, power and industrial systems, consumer products, materials and financial services. For more information on Hitachi, please visit the company's website at http://www.hitachi.com.

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