



PRESS INFORMATION

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SHARP DEMONSTRATES WORLD'S FIRST CONTINUOUS WAVE VIOLET LASER DIODES BY MBE

Sharp Laboratories of Europe, a subsidiary of Sharp Corporation, Japan, has demonstrated room temperature continuous wave (CW) operation of violet laser diodes fabricated by molecular beam epitaxy (MBE). The devices are being developed to comply with the Blu-ray standard for next generation DVD storage and video application.

In January 2004 scientists at Sharp Laboratories of Europe were the first in the world to demonstrate violet lasers based on Nitride semiconductors, grown by the MBE technique. The first devices operated with pulsed electrical current and had a high operating current density of approximately 30kAcm^{-2} . The result demonstrated that the MBE technique was capable of demonstrating high efficiency nitride-based light emitters, but the operating specifications were not sufficient for commercial applications. Following on from this work, Sharp Laboratories has now demonstrated continuous wave (CW) operation of violet lasers grown by MBE. Continuous wave operation is a requirement for commercial application of this technology.

The devices were fabricated in a gas-source MBE system using Ammonia as a source of nitrogen and elemental sources for Gallium, Indium and Aluminium. The lasers are of the quantum well type and were designed to emit at 405nm in the violet part of the visible spectrum. This wavelength is also the standard for the new Blu-ray technology.

The lasers were grown on GaN substrates with a low dislocation density. The first CW devices operated at room temperature with a threshold current of 125mA, corresponding to a threshold current density of 5.7kAcm^{-2} , and an operating voltage of 8.6V. Initial devices operate continuously for several minutes without degradation.

Dr. Jon Heffernan, Director of Advanced Optoelectronic Devices at Sharp Laboratories of Europe, who leads the project, commented: "We have made rapid progress in reducing operating current and voltage since our first demonstration of violet laser diodes in January of last year. Achieving CW operation was a clear target, and this result confirms that MBE is a viable growth method for nitride lasers."

He added, "Sharp is now in the unique position of having both MBE and MOCVD technologies available to it for continued development of CW nitride laser diodes for future applications". The project is now concentrating on improving the operating characteristics of the devices and extending the operating lifetime.

Sharp Laboratories of Europe situated on the Oxford Science Park was established back in 1990. It carries out basic research on behalf of Sharp Corporation with core projects including LCD Technology, 3D LCD displays, system displays, opto-electronic devices and information and systems technologies.

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Note: Full technical details of the work are published in the IEE journal 'Electronics Letters', Vol 41, No.13, 23 June 2005.

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Background:

Blue light emitters and Blu-ray

The development of blue light emitters, LEDs and laser diodes, has led to the growth of a multi-billion dollar industry in lighting, display and optical storage devices. Blue-violet LEDs are becoming ubiquitous in existing indicator applications. There is also a growing market in replacing incandescent and fluorescent lighting systems with solid state LED technology based on blue LEDs with a white light phosphor. There is strong motivation aimed at improving reliability and reducing environmental impact.

Blue-violet lasers form the basis for the next generation of optical storage devices. The current generation of DVD systems uses a red laser diode to read and write information and has a storage capacity of approximately 4.7GB, or about 2 hours of standard video. The development of shorter wavelength violet lasers allows far higher storage capacity. Blu-ray, the next generation of DVD systems, will incorporate blue-violet lasers leading to a storage capacity of 27GB, or approximately 13 hours of video. Thirteen companies including Sharp, Sony, Matsushita, Hitachi, Pioneer, Samsung, Philips and Thomson are backing the new Blu-ray standard.

Semiconductor Growth methods

In the production of compound semiconductor devices such as semiconductor lasers, there are two principal fabrication methods. These are the two epitaxial growth techniques of molecular beam epitaxy (MBE) and MOCVD. Both techniques allow the deposition of precisely controlled layers of material with atomic layer accuracy. The principle difference between the techniques is that MBE is an ultra-high vacuum method of deposition, whereas MOCVD is a chemical process operating at atmospheric pressures.

The first InGaN blue-violet LEDs and lasers were developed in the mid-1990s using the Metal Organic Chemical Vapour Deposition (MOCVD) and the field has been dominated by this method since that time. In other compound semiconductor materials such as GaAs used in CD lasers, devices are equally produced by MOCVD and MBE with little difference in material quality and devices characteristics. The choice is often a matter of experience and reliability. Despite the success of the MOCVD method, corresponding attempts by a large number of groups worldwide to develop blue-violet lasers by MBE had been unsuccessful. Sharp Laboratories was the first to demonstrate pulsed operation of InGaN violet lasers by the MBE method in January 2004.

InGaN itself is a remarkable semiconductor material and the ability to produce efficient LEDs and blue laser diodes is still poorly understood, despite an enormous amount of research worldwide over the last ten years. The material is remarkable because it contains an unusually high number of crystalline defects. In other semiconductors, such as GaAs for CD lasers, the defect density must be about a million times lower to achieve bright LEDs and laser diodes. The efficiency of InGaN devices has been attributed to the formation of quantum dots in the material although this is still a subject of debate.

Sharp is a pioneer in the use of mass-production MBE for optical devices and currently produce a large share of the world's red DVD lasers by MBE at its semiconductor laser factory in Mihara, Hiroshima.