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Quantum Dot Lasers

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Abstract

For semiconductor laser modules applied to relatively-short-distance optical fiber communication such as optical access systems and LANs, compact size, low power consumption and low cost are required. In the lasers currently used, the light output power strongly depends on the surrounding temperature. This is one big issue for optical communication lasers in 1.3 and 1.55 µm wavelength for a long time. By applying a three dimensional semiconductor nanostructure called quantum dot in the active layer of semiconductor lasers, unique characteristics including suppression of temperature dependence were first predicted by Prof. Arakawa of the University of Tokyo in 1982. Based on the investigation of quantum dot formation technology so-called self-assembled technique since early 90's, we recently realized 1.3-µm-wavelength quantum-dot lasers with temperature insensitive 10 Gbps operation without driving current adjustments.

Technology

Fabricated quantum-dot lasers have self-assembled InAs quantum dots formed by crystal growth on a GaAs substrate (Figure 1). The quantum mechanical effect makes discrete electron energy states in quantum dots and this provides unique laser characteristics. We increased the optical gain, by stacking up to ten quantum-dot layers as well as by introducing p-type doping in the vicinity of the dots, to achieve temperature-insensitive 10 Gbps operation above room temperature.

Application Examples

Figure 2 shows the light-current characteristics of a developed quantum-dot laser. Almost identical characteristics were obtained between 20 and 50°C and even at 90°C the degradation was slight. The temperature stable characteristics provides unchanged waveforms under 10 Gbps modulation under fixed driving condition at wide temperature range (Figure 3). Therefore, current adjustment according to temperature, which is inevitable for currently used lasers, is not necessary for quantum dot lasers. To commercialize quantum-dot lasers, Fujitsu established a venture company called QD Laser, Inc., through a joint capital investment with Mitsui Venture Capital Corporation in April 2006. We will continue the development to release quantum-dot lasers to the market soon and also to realize superior quantum-dot lasers.

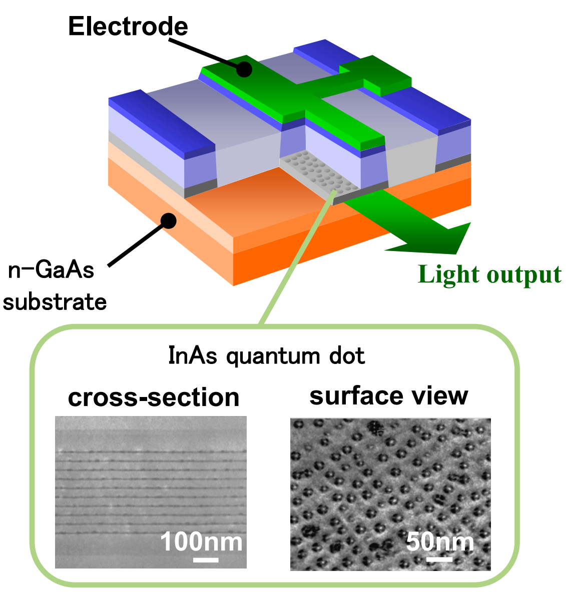

Figure 1. Quantum-dot laser

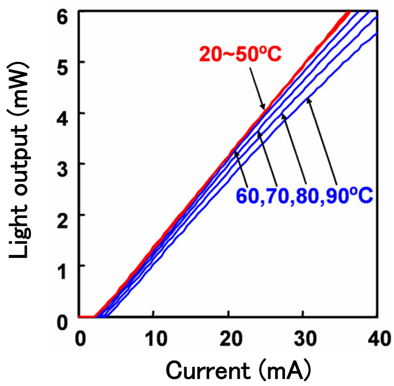

Figure 2. Light-current characteristics of quantum-dot laser

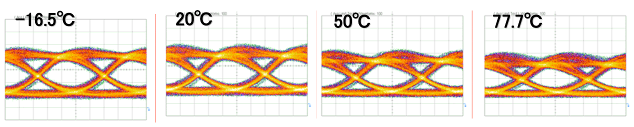

Figure 3. 10 Gbps modulation waveforms under fixed driving condition at various temperatures

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