High-power 1.625-μm strained multiple-quantum-well lasers as a light source for optical time-domain reflectometers

T. MUNAKATA, Y. KASHIMA, S. KUSUMOTO, A. MATOBA, H. TAKANO
Optical Device Division, OKI Electric Industry Co., Ltd, 550-1 Higashiasakawa, Hachioji, Tokyo 193, Japan

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An optical output power of 160 mW has been successfully achieved in 1.625-μm strained multiple-quantum-well lasers at a forward current of 800 mA under pulsed operation. Such a high output power has been achieved by optimizing the separated confinement heterostructure layer thickness. The operating life of high-power 1.625-μm lasers has been estimated from the results of accelerated ageing at an ambient temperature of 45°C and 500 mA under continuous-wave operation. No significant change in the optical output power was observed up to 2000 hours. The mean time to failure is estimated to be about 4.5 × 10⁴ hours at 500 mA and 45°C.

1. Introduction
Development of Er³⁺-doped fibre amplifiers (EDFAs) has led to the extension of the non-repeated transmission distance [1, 2]. Fibre transfer-and-test systems for the longer distance have become necessary. Recently, high-power 1.625-μm lasers have become required as a light source for new optical time-domain reflectometers (OTDRs) [3, 4], owing to their non-disruptive transmission of light, which allows testing to take place during normal optical fibre usage. Light at a wavelength of ~1.625 μm is more sensitive to bending loss than at shorter wavelengths. There have been many reports on InGaAs/InGaAsP strained multiple-quantum-well (MQW) lasers emitting in the infrared region (1.5–2.0 μm) [5–8]. Most previous works have concentrated only on high-power characteristics, and fibre coupling has been neglected, despite its importance in applications for OTDR systems.

The maximum optical output power can be increased by introducing a compressive strain into the well layers. Such an increase is attributed to the suppression of Auger nonradiative recombination and intervalence band absorption (IVBA). In designing high-power MQW lasers, optical confinement in the separate confinement heterostructure (SCH) is one of the most important factors, because the optical confinement factor in the SCH layers is much larger than that in the wells [9]. We discuss here the relationship between SCH layer thickness and...
laser characteristics, and show the optimum design for high-power operation. In the final part of the paper, we describe reliability test results.

2. Structures and fabrications
A schematic diagram of the strained MQW structure is shown in Fig. 1. The MQW structure consists of five 6-nm-thick In$_{0.62}$Ga$_{0.38}$As strained quantum wells separated by 10-nm-thick barrier layers of lattice-matched InGaAsP ($\lambda = 1.2 \mu m$). To investigate the relationship between SCH layer thickness and the maximum output power, four samples with SCH layer thicknesses of 15 nm, 30 nm, 45 nm and 60 nm were fabricated.

The MQW lasers were fabricated on n-InP substrates using a low-pressure metal-organic vapour-phase epitaxy (MOVPE) system. Trimethylindium (TMIn) and triethylgallium (TEGa) were used as the sources for group III elements, and phosphine (PH$_3$) and arsine (AsH$_3$) were used for group V. The growth temperature and reactor pressure were 610°C and 55 torr, respectively. In the first growth step, an n-InP buffer layer ($n = 5 \times 10^{17} \text{cm}^{-3}$), the undoped-MQW layers, a p-InP cladding layer ($p = 1 \times 10^{18} \text{cm}^{-3}$) and a p-InGaAsP cap layer ($p = 1 \times 10^{18} \text{cm}^{-3}$) were successively grown. After formation of oxide stripes along

![Figure 1 A schematic diagram of the strained MQW structure.](image1)

![Figure 2 Dependence of threshold current on the SCH layer thickness. ($T_a = 25\degree C$; AR (5%)/HR (95%); $L = 700 \mu m$.)](image2)