14.30 CWG2

Harmonic modelocking at up to 440GHz repetition rates in InGaAs-InAlGaAs quantum well lasers.

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The InGaAs-InAlGaAs quaternary quantum well material system forms an alternative to the conventional InGaAsP based diode lasers for use in 1.3μm and 1.55μm fibre optic systems. Larger conduction band offsets and a greater thermal stability compared to the InGaAsP system makes InAlGaAs material attractive for both high speed modulators[1] and room temperature high power lasers. In this paper we present the first demonstration to our knowledge of monolithic modelocking action from InGaAs-InAlGaAs laser diodes.

The laser (shown in figure(1)) consists of a standard wet-etched ridge waveguide structure, with the p-side contact split into several electrically isolated sections which form a gain section and three saturable absorbers placed at a 1/4, 1/2, and 3/4 of the cavity length. The MBE grown material used to fabricate the modelocked lasers contains six 7nm InGaAs quantum wells with 8nm InAlGaAs barriers, the outer cladding p- and n-doped InAlAs, all grown on an n+ InP substrate.

Modelocked diode lasers are important sources of high repetition rate ultra short optical pulses for future communications systems. Generation of pulses at up to terahertz frequencies from diode lasers relies on modelocking at harmonics of the fundamental cavity repetition rate[2]. Here we present the operation of a 400μm long InAlGaAs laser, where the multi-section contact design allows modelocking at the 2nd and 4th harmonic of the fundamental repetition rate in the same device simply by altering the bias configuration. When operated with all sections forward biased the device output consists of a single longitudinal mode around 1.55μm. Figure (2a) shows the lasing spectrum in a conventional colliding pulse modelocking (CPM) laser geometry (only central absorber is reverse biased). Here the doubling in the mode spacing indicates the CPM action at 220GHz. The spectrum in figure (2b) shows the same device operating with only one end absorber reverse biased: asymmetric colliding pulse modelocking (ACPM). Here the longitudinal mode spacing is quadrupled, the characteristic of harmonic modelocking at a repetition rate of 440GHz.

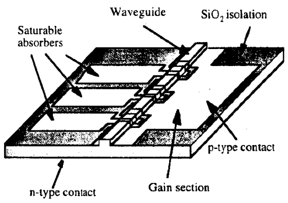

Figure (1): Schematic diagram of four section laser.

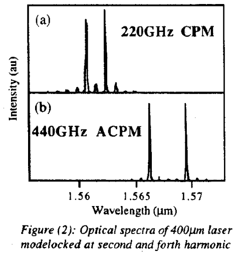

Figure (2): Optical spectra of 400μm laser modelocked at second and forth harmonic of fundemental repetition rate.

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14.45 CWG3

Monolithic integration of InGaAs-InAlGaAs optoelectronic devices for 1.55μm emission by quantum well intermixing

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A novel quantum well intermixing (QWI) technique[1] has been used to achieve substantial band gap shifts in the InGaAs-InAlGaAs material system enabling the first demonstration of monolithically integrated devices in this system. Wavelength tuned lasers have also been fabricated, displaying a tuning range up to 150 nm.

The intermixing technique has been applied to the fabrication of extended cavity oxide stripe lasers, in which a broad area laser is integrated with two passive slab waveguides. As previously demonstrated in InGaAs-GaAs material[2], such devices exhibit significantly improved far-field patterns, ascribed to diffraction within the passive waveguides leading to a suppression of filamentation in the active section. In addition, with this device configuration the laser facets are rendered non absorbing, which has been shown to improve power outputs and increase device lifetime, due to an increase in the threshold for catastrophic optical damage of the facet. Fig. 1 compares the far-fields obtained for a 600 μm long InGaAs-InAlGaAs all active laser (AAL) with that obtained for an extended cavity laser (ECL) of 600 μm active length with two 300 μm long passive waveguides. The addition of the passive waveguides leads to a clear transformation from a relatively broad (FWHM=10°) multi-lobed pattern for the AAL to a narrower (FWHM=2°) single lobed pattern for the ECL. Such improvements in far-field are obtained for power outputs up to 70 mW per facet, demonstrating the potential of the technique for fabricating high power lasers with improved beam quality and a potentially extended device lifetime.

The technique has also been used, for the first time in InGaAs-InAlGaAs, to fabricate single mode extended cavity ridge lasers, in which an active ridge waveguide is integrated with a passive, intermixed waveguide. Such devices are an essential feature of any optoelectronic integrated circuit. Fig. 2 shows light current (L-I) curves obtained for a 500 μm long AAL and an ECL having the same active length and a 1500 μm long passive section. A relatively small increase in threshold current is observed from 30 mA for the AAL to 50 mA for the ECL, compared to a value of 100 mA obtained for a 2 mm long AAL. This demonstrates the viability of the technique for the routine fabrication of low-loss optoelectronic interconnects, providing an important component for lightwave communication systems.

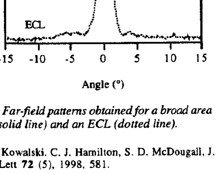

Fig. 1. Far-field patterns obtained for a broad area AAL (solid line) and an ECL (dotted line).

Fig. 2. L-I curves obtained for single mode AALs (solid line) and ECLs (dotted line).

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[2] K. McIlvaney, J. Carson, A. C. Bryce, J. H. Marsh and R. Nicklin, Elec. Lett. **31** (7), 1995, 553.