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Passively Modelocked 20 and 40GHz Bulk InGaAsP Lasers

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Abstract *Passively modelocked linear lasers have been fabricated using bulk InGaAsP/InP material. Modelocking in 20 GHz self colliding pulse modelocked lasers and 40 GHz colliding pulse lasers has been demonstrated and the devices have been characterised. Pulse lengths down to 1.6 ps have been observed.*

Introduction

In this paper we report on the first passively modelocked linear cavity lasers using a bulk 1.5 μm InGaAsP gain region. Modelocking is achieved using a short reversely biased section of the ridge waveguide as a saturable absorber. The bulk InGaAsP active material is the same used in our active-passive integration technology. The large confinement factor of bulk material is preferable for all-optical switches such a wavelength converter [1]. We demonstrated 20 GHz self colliding pulse modelocked lasers as well as 40GHz colliding pulse modelocked lasers using such active bulk material. It allows us to design passively modelocked lasers in our active passive integration scheme and integrate them with other devices such as an integrated pulse compressor [2].

Fig.1 Picture of 20GHz SPCM modelocked lasers.

Fig.2 Picture of 40GHz CPM modelocked lasers.

Design and fabrication

Two series of lasers have been realised. The first series consists of self colliding pulse modelocked (SCPM) lasers with different saturable absorber (SA) lengths at one side of the chip (figure 1). The second series consist of colliding pulse modelocked (CPM) lasers. The saturable absorbers (20 or 40 μm long) are shifted gradually from the centre (figure 2). This guarantees that we have one laser with a perfectly centred SA for each SA length. Both chips are 1985 μm long in order to obtain 19.9 GHz and 39.8 GHz repetition rates. A 2 μm wide ridge waveguide defines the laser channel. The electrical isolation between SA and the amplifier is realised by

a 15 μm long section where 500nm of the top cladding have been etched ($R = 400\text{k}\Omega$).

All epitaxial layers were grown by Low-Pressure Metal-Organic Vapour Phase Epitaxy (LP-MOVPE) at 625°C. The SOA active layer consists of a 120 nm thick $\lambda = 1.5 \mu\text{m}$ bulk InGaAsP layer between two 190nm thick $\lambda = 1.25 \mu\text{m}$ InGaAsP layers. The structure was covered by a 1500-nm thick p-InP cladding layer with gradual doping levels and with a 50 nm p-InGaAs contacting layer.

20GHz SPCM laser

Modelocked lasers with 10, 16, 23 and 37 μm long SA have been characterised. The threshold currents do not exceed 110 mA even for the laser with the longest absorber. The absorption of the 120nm thick active layer is higher than for Multiple Quantum Wells structures, thus shorter SA are required. Indeed the largest operating range of modelocking has been obtained for the shortest saturable absorbers. The different lasing regimes of the 20GHz modelocked laser with the 10 μm long SA are plotted in figure 3. Modelocking is achieved for a continuous range of reverse voltages on the SA between 0.9 and 2.4 V and a range of amplifier currents between 110 and 125 mA. For higher current self pulsation is observed in the RF spectrum.

Fig.3 Lasing regimes vs. the amplifier current and the 10 μm long SA reverse voltage.

Short pulses down to 1.6 ps have been measured from the device with the shortest SA. The RF spectrum is plotted in figure 4. A 50MHz wide peak is visible at 19.65 GHz. The relaxation oscillation peaks at 1GHz are 40 dB lower. The autocorrelator trace and the optical spectrum are plotted in figure 5. The optical spectrum shows some extra components at the lower wavelengths. The time bandwidth product is 0.76 which means the pulses are chirped. For larger

pulses widths (2-3 ps) the spectrum is symmetric and the time-bandwidth product is 0.65.

Fig 4 RF spectrum of a 20GHz 10 μ m long SA modelocked laser ($I = 121.7$ mA $V = -1.9$ V)

Fig 5 Autocorrelator trace of a 1.6ps pulse from a 10 μ m long SA modelocked laser ($I = 121.7$ mA, $V = -1.9$ V) with its corresponding optical spectrum.

40GHz CPM laser

CPM lasers with 20 and 40 μ m long SA have been characterised. It appears that the colliding pulse configuration makes the modelocking mechanism more difficult to achieve. This is illustrated by the evolution of the intensities of the longitudinal modes versus the amplifier current in figure 6. Modelocking occurs when the 40 GHz modes become dominant. This is the case for currents below 147 mA and between 167 and 180 mA. When the 40 GHz modes are not sufficiently dominant, a background is visible on the autocorrelator traces and the peak at 40GHz in the RF spectrum is broader (currents between 150 and 160 mA). As for the 20 GHz SCPM, higher current through the amplifier leads to self pulsation regime.

The largest operating range for modelocking has been found with the 40 μ m long SA laser with reverse voltages between 0.6 and 1.1 V. The reason for the fact that the CPM lasers that have a longer SA perform better, as opposed to the SCPM devices, is under investigation.

Pulses of 2.4 ps have been measured from the 40 μ m long SA device. On the 42GHz RF spectrum only a narrow peak at 39.75GHz is visible. In detail there are two 5MHz wide peaks spaced by 10MHz. We conclude the laser operates with an overall intensity modulation at 10 MHz. The autocorrelator trace shows well defined peaks spaced by 25ps without

background. Pulses down to 2.0 ps have also been measured with a higher reverse voltage on the absorber ($V_{abs} = -1.1$ V) however with some background.

Fig.6 Evolution of the intensities of the CPM laser modes versus the amplifier current ($L_{abs} = 40\mu$ m $V = -0.9$ V).

Fig 7 RF spectrum from a 40GHz CPMML with 40 μ m long SA ($I = 175.7$ mA $V = -0.7$ V).

Fig 8 Autocorrelator trace of 2.4ps pulses from a 40GHz CPMML ($L_{abs}=40\mu$ m $I=175.7$ mA $V=-0.7$ V).

Conclusions

Results on bulk InGaAsP passively modelocked linear cavity lasers have been presented. The layer stack is compatible with active-passive integration. Both 20 GHz SCPM lasers as well as 40GHz CPM lasers have been demonstrated. Pulse lengths down to 1.6 ps have been observed.

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References

- 1 R.G. Broeke et al, Proc. ECOC'02, (2002) PD 3.2
- 2 M.J.R Heck et al, Proc. ECIO'05, (2005) p. 351