Uncooled Directly Modulated Quantum Dot Laser 10Gb/s Transmission at 1.3µm, with Constant Operation Parameters

B. Dagens (1), O. Bertran-Pardo (1), M. Fischer (2), F. Gerschütz (2), J. Koeth (2), I. Krestnikov (3), A. Kovsh (3), O. Le Gouezigou (1), D. Make (1)

1 : Alcatel Thales III-V Lab, route départementale 128, 91767 Palaiseau, France,
beatrice.dagens@3-5lab.fr

2 : nanoplus Nanosystems and Technologies GmbH, Oberer Kirschberg 4, 97218 Gerbrunn, Germany,
marc.fischer@nanoplus.com

3 : NL Nanosemiconductor GmbH, Konrad-Adenauer-Allee 11, 44263 Dortmund, Germany,
igor.krestnikov@nanosemiconductor.com

Abstract *10Gb/s transmission at 1.3µm in the range 25-85°C is realised with a quantum dot directly modulated laser. The average current and current swing are unchanged during operation, demonstrating a fully temperature independent modulated light source.*

Introduction

High bit rate optical communication systems based on applications like OC-192 and 10Gb/s Ethernet will drive a high volume component market in the near future. Especially, compact and pluggable transponders and transceivers will be largely developed and will require low cost and compact optical components. Uncooled and isolator-free DFB lasers for direct modulation at 10 Gb/s are attracting attention as light sources for these applications. Such laser are used without thermoelectrical cooler and without isolator, presenting advantages to be compact and lower-consuming than cooled devices.

Up to now, uncooled edge emitting laser at 1.3µm have been developed using InGaAsP/InP MQW layers [1, 2] or InGaAlAs MQW structures [3, 4] showing 10Gb/s operation up to 115°C. In all cases, it was necessary to adjust at least one operation point parameter with the temperature, namely the bias current or the modulation depth, in order to obtain performing modulated emission on the considered temperature range. Such uncooled lasers present a behaviour not fully compatible with respect to temperature variations.

Here we present for the first time a 1.3µm DFB laser directly modulated at 10 Gb/s and operating on the 25-85°C range with unchanged bias current and modulation depth. This laser is based on a multi-stacked quantum dot (QD) layers structure, which provides low sensitivity to temperature and also to optical feedback [5]. Transmission up to 8km on standard monomode fibre is demonstrated in the 25-85°C range. This result is at the same time a significant improvement of directly modulated QD based laser performance at 1.3µm [6] and the demonstration of a new competitive device for 10Gb/s uncooled laser applications.

Device structure

The InGaAs/GaAs QD laser structure studied in this work was grown by MBE on a GaAs (100) substrate. It is designed to obtain high differential gain enabling high relaxation frequency, as well as high characteristic temperature T_0. The active region contains ten self-organized QD layers with p-type modulation doping. The laser ridge waveguide is 3µm wide and 600µm long. A metal grating is laterally defined, providing complex coupling. The material gain peak and the grating period were chosen so that the temperature induced gain decrease is compensated by the gain peak shift at emission wavelength. Both facets are high-reflection coated. The laser was mounted p-side up on a copper heatsink, and a Peltier cooler was used to maintain a constant temperature. The laser was electrically pumped by continuous wave (CW) bias.

Results and discussion

Typical CW light–current characteristics are shown in Figure 1. The threshold current, equal to 19+/-3 mA, remains almost unchanged in the 25-85°C range. The corresponding characteristic temperature absolute value is higher than 150K in the 25-85°C range and higher than 500K on 45-85°C. The efficiency of 0.06W/A drops down to 0.055W/A at 85°C. This temperature stability is obtained thanks to the particular QD properties associated with the accurate detuning of lasing wavelength with respect to gain peak.

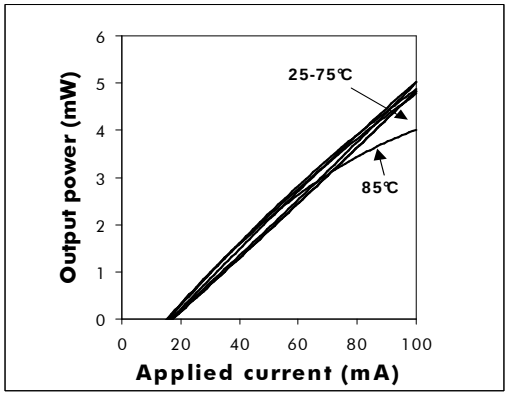

Fig. 1. Continuous-wave light–current characteristics of the QD DFB laser

The DFB laser emits at 1308 nm and 1314 nm respectively at 25 and 85℃ with a SMSR (side mode suppression ratio) higher than 60 dB in both cases.
The RIN (Relative Intensity Noise) of these lasers is measured on a similar device. The resonance frequency is extracted from these measurements, as well as the laser damping factor. Modulation efficiency of 0.7 GHz/mA$^{1/2}$ at 25℃ is obtained. The damping factor evolution with the squared resonance frequency gives the value of factor K, and thus the intrinsic maximum bandwidth of the device. Here the K-factor is measured to be 0.85ns, the related $2\sqrt{2}\pi/K$ damping limit of 10.5 GHz is compatible with 10 Gbit/s operation.

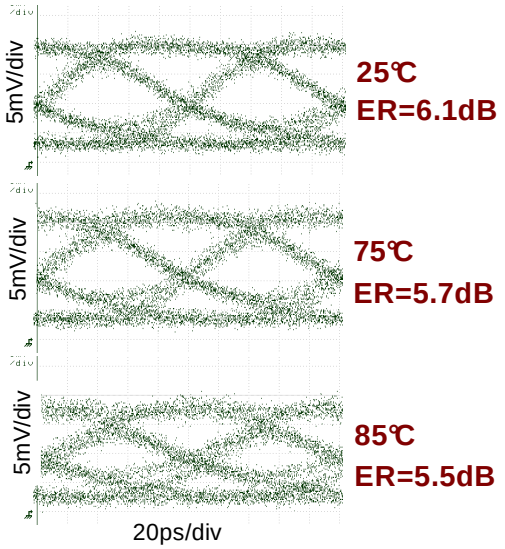

Fig. 2. Eye-diagram at 25, 75 and 85℃ resulting fr om a 10Gb/s direct modulation of 69.5 mA +/- 31 mA. Corresponding extinction ratio (ER)

The 10 Gb/s NRZ laser modulation is realized with a Pseudo Random Binary Sequence (PRBS) generator emitting 2^{31}-1 long words: the electrical signal modulation depth is controlled thanks to an amplifier and an attenuator and is fed in the laser through a bias tee. The emitted optical NRZ signal is sent to a 10 Gb/s SDH receiver, before error detection. No optical isolator is used in the setup.
For both temperatures 25 and 85℃, the applied current was 69.5 mA +/- 31 mA. This current swing is achievable by a TOSA current driver. The corresponding eye diagrams are clear and well open (Figure 2), with a slight degradation at 85℃ attri buted to the decrease of the efficiency. The resulting extinction ratio (ER) equals 6.1 dB and 5.5 dB respectively. As shown in Figure 3, floor free bit error rate at 10 Gb/s was measured with a 10^{-10} sensitivity of –13.25dBm and –10.75dBm at 25 and 85℃ respectively. No penalty was observed after a 8km transmission in a standard monomode fibre, at both temperatures. The transmission distance was limited by the output power of the laser. Further improvement is expected by optimizing the facet coating and the fibre coupling.

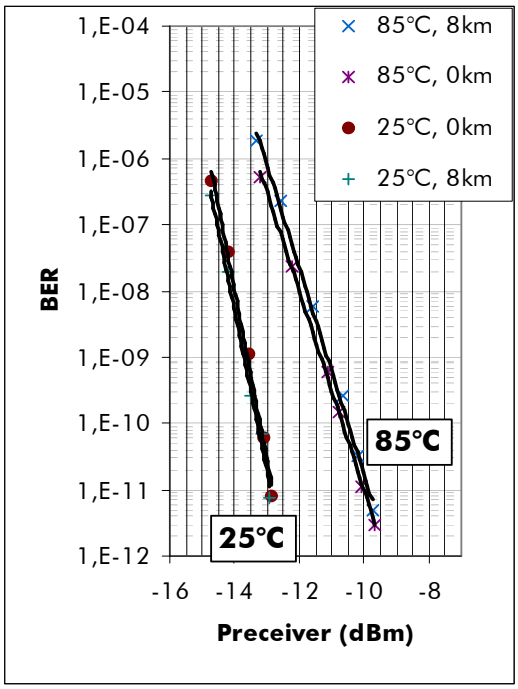

Fig. 3. Bit Error Rate (BER) measurement at 10Gb/s and at 25 and 85℃.

Conclusions

We have demonstrated for the first time a 10Gb/s transmission realized with a directly modulated DFB laser biased with constant current and current swing in the 25-85℃ temperature range. The temperature insensitivity of the laser operation makes this device independent on environmental influences. This performance represents a significant advance in the field of uncooled laser at 1.3µm. It also demonstrates the potential of QD based laser for 10Gb/s low cost applications at 1.3µm and confirms the competitveness of this technology.

Acknowledgement

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