Characterization of gain and loss of In(Ga)As/GaAs quantum dot active region for high temperature operation

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Lasers integrated with electro-absorption modulators on III-V epitaxy have been reported, particularly using indium phosphide quantum well (QW) active regions. The use of quantum dots (QD) active regions is less reported. In this work, we investigate the possibility of integration of a laser and an electro-absorption modulator with the same In(Ga)As/GaAs QD active region. The main advantage of the use of QDs over QWs is a better tolerance to optical feedback [1], low threshold current [2], and temperature insensitivity [3]. The use of this QD active region could be exploited in low-cost uncooled short and medium reach optical interconnects with intensity modulation and direct detection.

We measured the behavior with temperature of an In(Ga)As/GaAs QD active region when used for light generation and modulation. The measurements were performed using the segmented contact method. A schematic is shown in Fig. 1. The net modal gain of the lasing active region and the net modal loss Δα of the absorbing active region as a function of temperature is shown is Fig. 2(a).

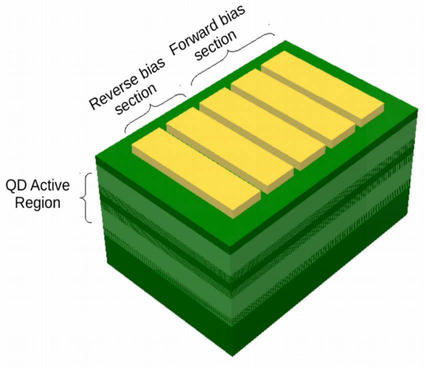

Figure 1: Segmented contact method

As shown in Fig. 2(a), the extinction ration of the modulator is 4 dB·mm^{-1} when reverse biasing the active region at -4.5 V and applying a peak-to-peak voltage ΔV_{pp} of 3 V. The extinction ratio and the insertion loss are shown in Fig. 2(b). Both values are constant up to 398 K. On the other hand, the net modal gain of the active region degrades from 5.65 cm^{-1} at 300 K to 2.65 cm^{-1} at 373 K. The wavelength taken for the net modal gain is the one that maximizes the extinction ratio in the modulator. The maximum gain which can be maintained over the entire temperature range is enough to overcome the loss of a 3 mm laser with as-cleaved facets. Additionally, the FP laser emission and the wavelength position at which the maximum extinction ratio was found shifts with temperature around 0.49 nmK^{-1}. These results open the possibility of a monolithic integrated QD laser and QD modulator for short and medium reach opti-cal interconnects capable of operating up to 398 K.

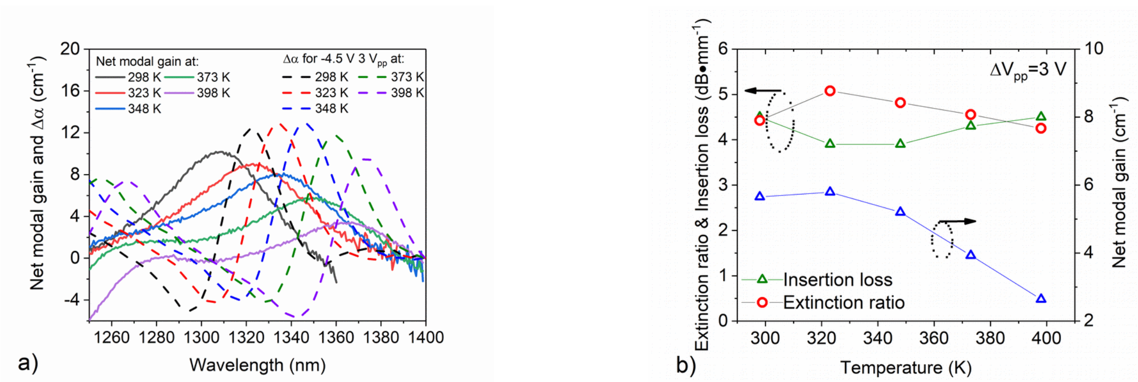

Figure 2: a) Net modal gain and change of absorption Δα of the QD active region, b) Insertion loss, extinction ratio and the net modal gain at the wavelength that maximizes the extinction ratio versus temperature

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