Lateral confinement's optimisation of 1300 nm InGaAlAsP/ InGaAsP Fabry−Perot Lasers

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Introduction.

The increasing demand of high performance long−wavelength lasers without cooling systems leads towards the study of new material structures: in this work we propose novel 1300 nm InGaAlAsP/InGaAsP designed for high−temperature operation. The effect of aluminium on the InGaAsP system leads to a larger conduction band band offset ($\Delta Ec= 0.7\ \Delta Eg$) that improves the electron confinement in MQWs laser devices, and consequently the high temperature performance.In this work the first results on 1300 nm InGaAlAsP/InGaAsP Fabry−Perot lasers have been shown and lateral confinement has been studied and optimised. Lateral structures have a terrific influence on the high temperature performance of buried structures, since they should prevent current leakage paths at high temperature, as well as introduce as low as possible parasitic effects.

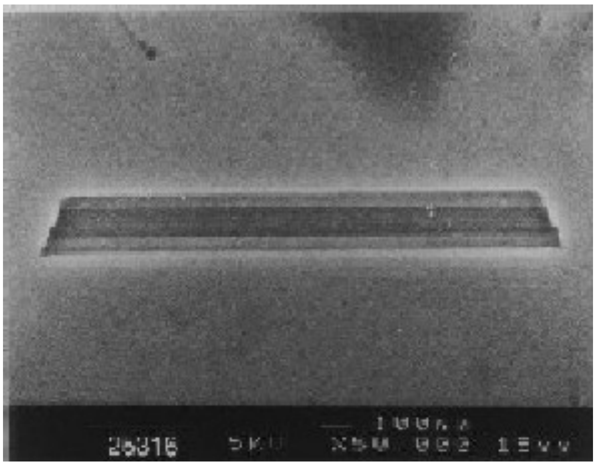

Figure 1: SEM photo of the Buried Ridge structure.

Experimental procedure.

Epitaxial structures were fabricated by low pressure metal organic vapor phase epitaxy (MOVPE) at 710ºC and 50 mbar on InP:S <100> substrates. The 1300 nm strained quantum well structures consist of seven periods of 6nm−thick 0.8% compressively−strained InGaAsP wells and 9nm−thick 0.07% tensile−strained InGaAlAsP barriers. The laser structures InGaAsP included 65 nm InGaAsP (λ = 1070 nm) separate confinement heterostructure (SCH) layers on each side of the QW stack. InP cladding and InGaAs contact layers were grown in a separate epitaxial step. High resolution X−ray diffraction (XRD) and photoluminescence (PL) were used for the material evaluation. A high and uniform PL intensity and sharp XRD satellites over the wafer was used as the criterion for optimisation of the MQW structure. The high and sharp satellite peaks as well as the good agreement between simulation and measurement indicates high sample quality and reasonable reliability of the structure.

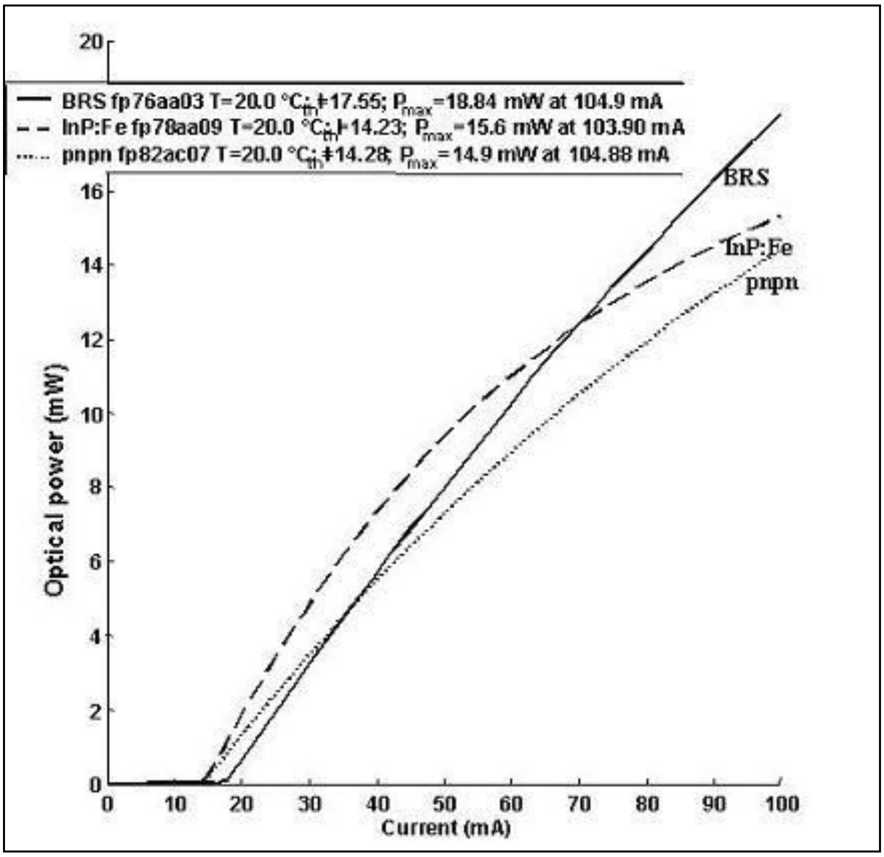

Figure 2 : Comparison at 20°C among the three devices of P−I characteristic: BRS, Semi−Insulating, PNPN structures.

Results.

After the first work [1] where the MQW active region with InGaAlAsP material as barrier was optimised Fabry−Perot lasers with different lateral confinement structures have been realised. First a Buried Ridge Structure (BRS) has been processed to study the technological steps, where the critical point is the oxidation of the Al−containing layers. As one can see from the SEM photos (Figure 1) no voids on the mesa walls after the regrowth have been seen. Good static performances have been measured: threshold current as low as 17.8 mA at 20 °C, good efficiency (around 20mW at 100 mA) and linearity. Considering it's a Buried Ridge Structure the lateral leakage at high temperature is negligible (Figure 2); that's also confirmed by the flatness of the series resistance plots (Figure 3). The internal losses are 18.1cm^{-1} and internal quantum efficiency 0.83 The temperature dependence was investigated at different temperatures: in the range of 20−70°C, the characteristic temperature T_0 value is 69 K for a 500 mm−cavity length. The signal modulation bandwidth at 20°C has a roll−off due to the high capacitance of the BRS that causes big parasitic effects. Since the results gave 6.8 GHz bandwidth it's possible to believe that by using a more efficient lateral blocking structure the signal modulation bandwidth can be increased. Therefore a Semi−Insulating lateral structure has been regrown around the InGaAlAsP/InGaAsP active mesa. As supposed, the first pole frequency increased up to 5 GHz, even if the resonance frequency is lower, and higher bandwidth was reached, 10 GHz (Figure 4). As the iron−doped InP resistivity decreases over temperature, leading the PI curves bending a multijunction lateral structure has been used to increase the performances at high temperature.

References.

[1] "MOVPE growth of strained 1300 nm InGaAlAsP/ InGaAsP quantum well structures", Roberta Campi, Amit Patel and Gunnar Landgren", Proceeding of IPRM 2000.

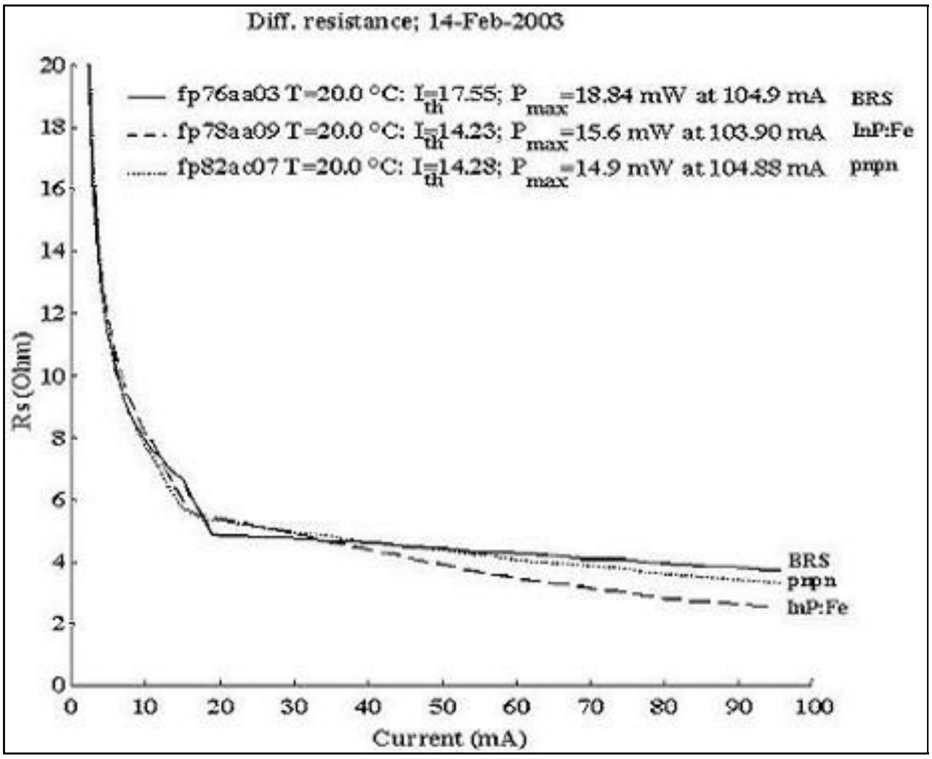

Figure 3 : Comparison at 20°C among the three devices of Series Resistance characteristic: BRS, Semi−Insulating, PNPN structures.

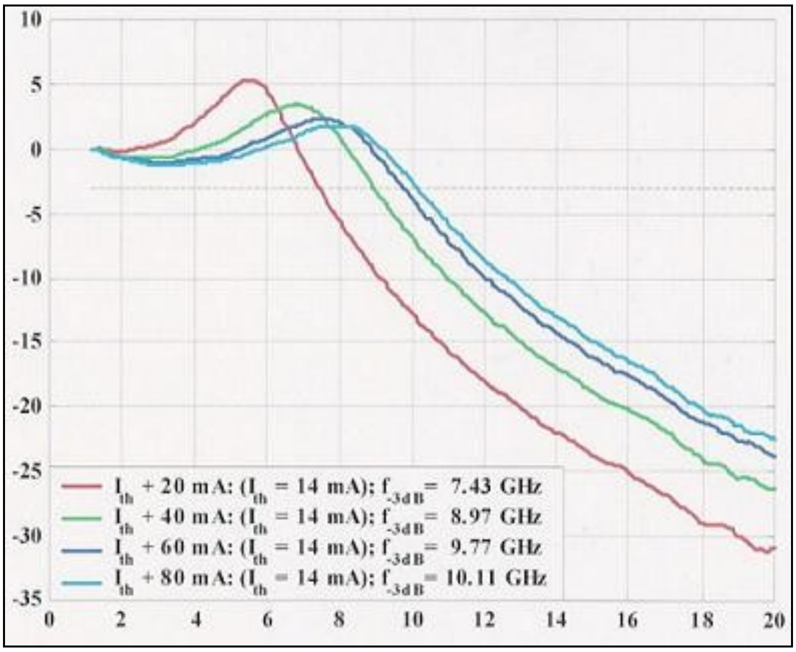

Figure 4: Modulation bandwidth at 20°C with the Semi−insulating lateral confinement.