In-Situ Etching of InP Based BH Laser Structures in MOVPE

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InP based buried heterostructure (BH) laser diodes are promising candidates for low cost key components for the deployment of optical access networks and optical subscriber systems. In a conventional BH laser fabrication process, however, *ex-situ* etching has to be performed, which may result in material damage and contamination yielding a deterioration of the process controllability and device reliability. For more economic processing, *in-situ* etching should be applied. This has been explored for InP in an MOVPE reactor with HCl (1, 2) and PCl_3 (3). A novel precursor, tertiarybutyl chloride (TBCl) is less corrosive, exhibits long term stability and highest purity. It was first used in a chemical beam epitaxy system for GaAs (4) and most recently in MOVPE based etching of InP/GaInAsP (5). In the present study we demonstrate the successful application of this novel precursor for the fabrication of 1.3 μm BH laser structures in MOVPE.

The basic strained MQW laser structures (6) were masked with Si_3N_4 stripes parallel to the [011] direction. The etching temperature was varied between 510 and 600 ^oC. Selective embedded growth with p-/n-blocking layers was performed at 600 ^oC, the final overgrowth of the p-cladding and contact layers at the same temperature. As n- and p-type dopants sulfur and, respectively, zinc were used. The reactor pressure was kept at 100 mbar.

The etch rate is directly proportional to the TBCl flow. For etching of the laser ridge, a TBCl flow yielding $8.2x10^{-5}$ mol TBCl/min was chosen leading to an InP etch rate of 1 nm/s. The etch rate is decreasing with increasing Ga content, as also reported in Ref. (5). It is essential to maintain a good surface morphology during etching. Therefore, surface diffusion has to be increased, which can be achieved by reducing the PH_3 flow. Consequently, we performed etching of InP and GaInAsP layers without the presence of any PH_3 at an optimized temperature of 580 ^oC, which is high enough for sufficient surface diffusion, and low enough to avoid surface degradation. From the SEM cross section view of a fully processed BH laser structure in Fig. 1 it can be recognized that smooth {111} planes are formed during TBCl etching.

Typical cw light-current characteristics are shown in Fig 2. In as-cleaved devices at room temperature an output power up to 50 mW and threshold currents around 7 mA were achieved, at 100 ^oC an output of 10 mW was obtained (cw operation, active stripe width w_a = 1.5 μm). Further results are summarized in Table 1. These first device data along with very first reliability data (extraplolated lifetime of 7000 h @ 80 ^oC and 15 kA/cm^2) are comparable with best data from devices of the same design fabricated by the conventional ex-situ dry etching process.

References

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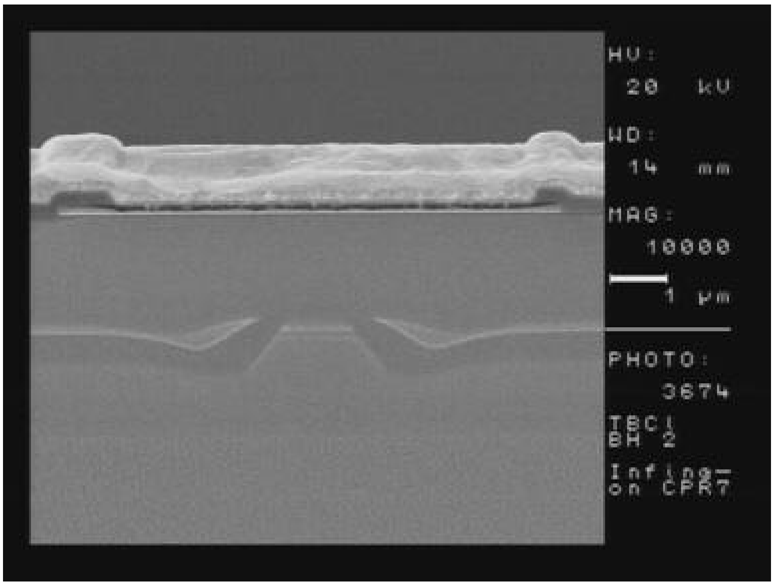

Fig.1: SEM cross section view of overgrown BH laser structure with p-/n- blocking layers

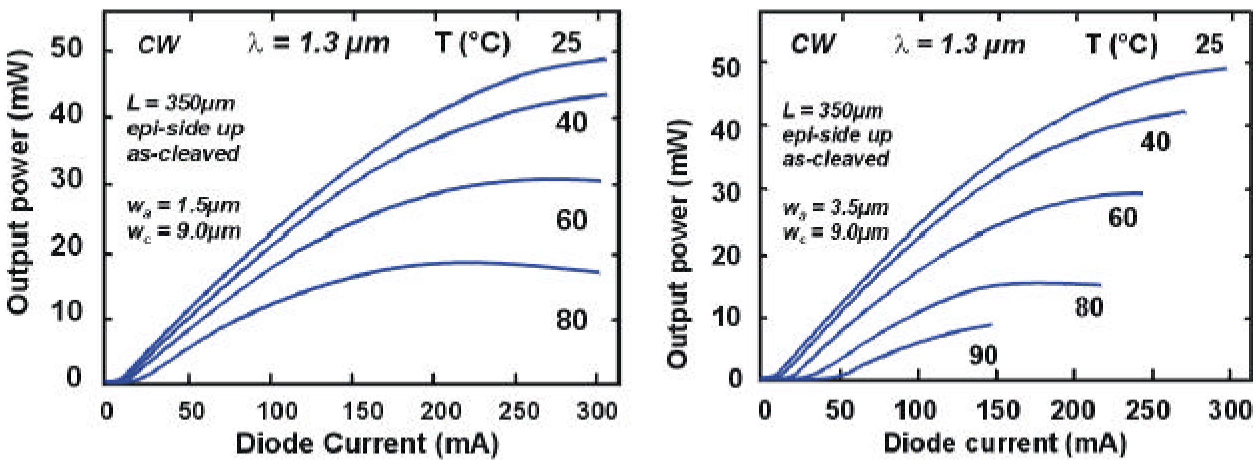

Fig.2: P-I characteristics for active stripe widths w_a = 1.5 mm (left) and 3.5 mm (right). W_c denominates the width of the p contact, L the cavity length.

T	**25 °C**	**25 °C**	**80 °C**
w_a	***1.5 mm***	***3.5 mm***	***1.5 mm***
I_{th}	6.8 mA	10.6 mA	18.7 mA
η	0.25 W/A	0.29 W/A	0.17 W/A
T_o	58 K	55 K	

Table 1: Device results of 1.3mm BH lasers, cavity length 350 mm (as cleaved), operation temperature T, active stripe width w_a, threshold current I_{th}, slope efficiency h, characteristic temperature T_o.