First Complex Coupled 1490nm CSDFB Lasers: High Yield, Low Feedback Sensitivity, and uncooled 10Gb/s Modulation

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Abstract *1490nm complex-coupled CSDFB lasers with excellent single mode yield, high optical output power, uncooled 10Gb/s performance and low feedback sensitivity are presented for the first time*

Introduction

1490nm DFB lasers as single wavelength light sources are key components in the central office of fiber based optical access systems. With state-of-the-art DFB lasers it is very challenging to simultaneously fulfil the range of parameters required for such devices in combination with a high yield, i.e. low costs. We have recently introduced the Curved Stripe (CS) DFB laser design [1,2,3] that largely meets the required performance. CSDFB-lasers not only exhibit high yield and stable single mode operation particularly in the low temperature regime but at the same time high slope efficiency and excellent modulation capability. Inherent to the design is a curved and tapered active region resulting in low beam divergence at the front facet. In this paper we present for the first time 1490nm CSDFB lasers with a (gain & index)-coupled grating accomplished by etching the grating partly into the MQW-structure. Compared to the index-coupled CSDFB structure, even superior single mode yield and immunity to optical feedback have been obtained.

Device structure and fabrication

The epitaxial structure and processing of the investigated DFB-lasers is similar to the tapered BH-laser diode published previously [1,2]. The active layer consists of compressively strained InGaAsP quantum wells separated by tensilely strained InGaAsP barriers and embedded in an InGaAsP-waveguide. The DFB-grating is defined by electron beam direct writing and then etched into the p-side waveguide and partly into the MQW-structure using a reactive ion etching process. For the fabrication of the laser structure three MOVPE overgrowth steps are used. Length and width of the laser chips are 400µm and 250µm, respectively.

DC results

Fig. 1 shows the CW optical output power of a 1490nm CSDFB-laser having an antireflection (AR) coated front facet and an as-cleaved back facet.

The devices show low threshold currents of less than 10mA and 25mA and slope efficiency values >0.4W/A and >0.2W/A at 20°C and 90°C, respectively. In order to assess the single mode yield of the CSDFB-lasers we measured the sidemode suppression value of 158 devices taken from different bars across the wafer without any preselection. About 95% of these devices exhibited single mode operation with a side mode suppression ratio >35dB.

The tapering results in a very narrow and symmetrical farfield at the front side facet (16°x19° FWHM), thus allowing for efficient fiber coupling.

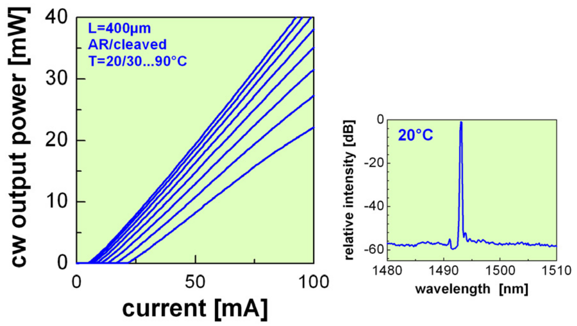

Fig. 1: Optical output power and spectrum of complex-coupled 1490nm CSDFB lasers

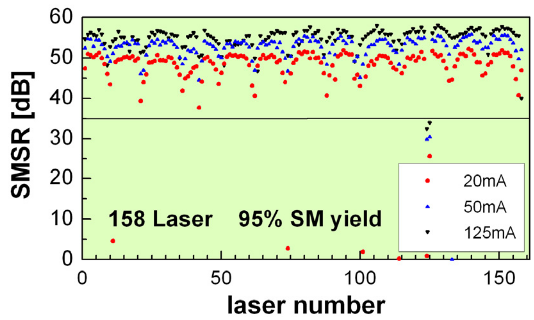

Fig. 2: Single mode yield of 158 complex-coupled CSDFB lasers on several bars (w/o preselection)

Modulation results

For direct modulation the devices were mounted on copper heatsinks. The surface p- and n-contact of the lasers [1] were fed by a microwave probe.

Fig. 3 and 4 show the typical eye diagrams measured at 10Gb/s PRBS direct modulation.

Clear eye openings are obtained. The signal to noise ratio amounts to >8dB and >7.5dB at 20°C and 90°C, respectively, the extinction ratio to 6.5dB and 6.3dB.

BER measurements have also been carried out and no error floor was observed.

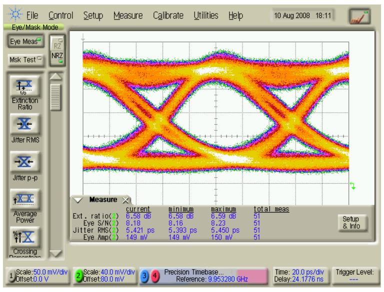

Fig. 3: 10Gb/s modulation at 20°C, I_{bias}=28mA

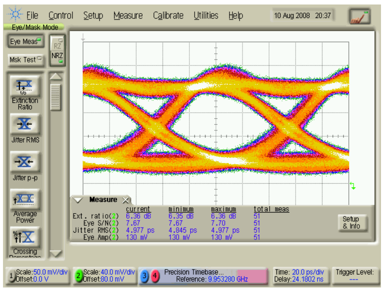

Fig. 4: 10Gb/s modulation at 90°C, I_{bias}=70mA

Feedback sensitivity

As already proved for lasers in the 1550nm wavelength range index-coupled CSDFB-lasers show clearly lower feedback sensitivity than state-of-the-art DFB-lasers [2]. In this paper we investigated whether the complex-coupled CSDFB-lasers show a further improvement to the index-coupled version.

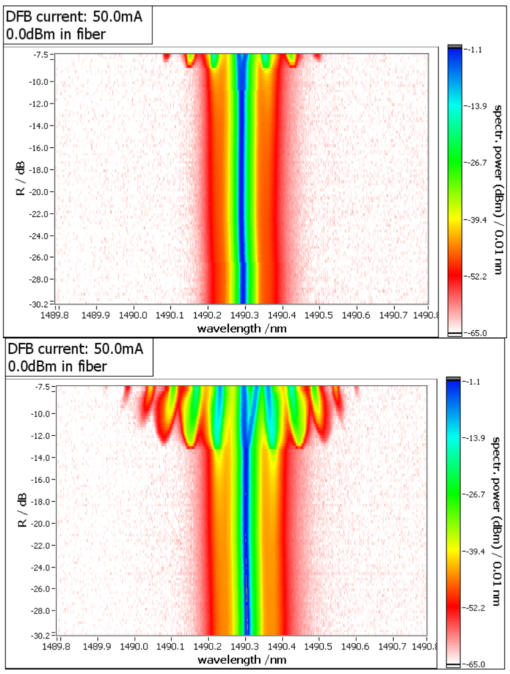

Fig. 5: Spectral behaviour of complex-coupled (top) and index-coupled (bottom)1490nm CSDFB-laser in dependence of the reflected optical power R

We investigated the feedback sensitivity of the optical spectrum in dependence of the reflected optical power. The fibre-coupled optical power was adjusted to 0dBm. The result of these measurements is shown in Fig. 5.

While the complex-coupled CSDFBs turn out to be single mode until about -9dB back reflexion the index-coupled version becomes multi-mode at -13dB. So the complex-coupled CSDFBs are clearly less sensitive to back reflected light. Depending on the application, these complex-coupled CSDFBs have the potential to be used without an additional optical isolator. This is especially important for the integration of lasers to passive waveguides, where no isolator can be inserted.

Reliability

For reliability tests, lasers were mounted on copper heatsinks, burned for 20h, and then operated at 85°C and 100mA, corresponding to about 20mW output power. Periodically the lasers were cooled to 20°C and the output power was measured. The result of these investigations after 1200h ageing duration is

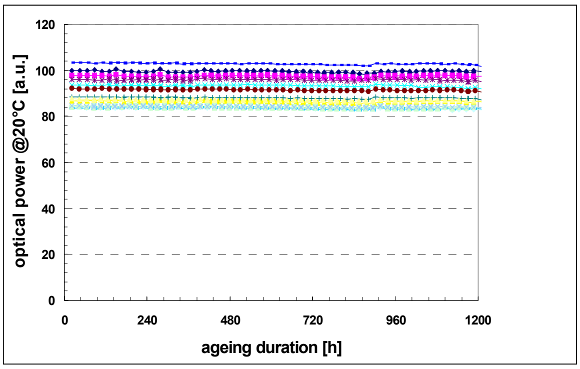

Fig. 6: Optical output power at 20°C in dependence of the ageing duration (13 lasers)

shown in Fig. 6. No degradation was observed.

Conclusions

The presented complex-coupled CSDFB-lasers show high optical output power, narrow optical far field, high single mode yield, uncooled 10Gb/s operation and a reduced feedback sensitivity compared to conventional DFB-lasers. These features make these lasers perfectly suited to be implemented in low-cost transmitter modules.

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References

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