Progress in integrated widely tunable edge-emitting 1.55 μm laser diodes

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Abstract: We present the progress obtained in recent years on widely tunable edge-emitting lasers at 1.55μm. We focus on electronically tunable lasers, which can switch the wavelength in tens of nanoseconds and thus offer great potential for new networking concepts such as optical packet/burst switching, label switching, bandwidth on demand, ...

1. Introduction

Wide tunable laser diodes are more and more being considered as the transmitters of choice for a range of optical communication networks. Many different widely tunable laser concepts have been presented and investigated in the past [1], but in recent years research has been directed towards the performance optimisation of only a handful remaining concepts of tunable laser diodes. In this paper we present the progress that has been made on two of the widely tunable laser diodes that were investigated in the (already finished) European project IST-NEWTON: the Modulated Grating Y-branch laser diode and the Widely Tunable Twin-Guide laser diode. Both tunable laser diodes are edge-emitting electronically tunable laser diodes and hence can be used for fast wavelength switching such as might be applied in optical packet or burst switching.

2. Modulated grating Y-branch laser

The Modulated Grating Y-branch laser is a DBR-type laser in which the reflections from two parallel reflectors (with modulated gratings, yielding multi-peak reflection spectra with different peak separation) are combined (via the additive Vernier effect) through a Y-junction [2]. In recent designs, an amplifier (SOA) is integrated with the laser to boost the output power. A schematic top view is shown in Figure 1. The additive Vernier effect gives a better selectivity than the multiplicative one which is e.g. used in the SG-DBR laser. The SOA also allows a power control independent of the wavelength control and the possibility to block the output while tuning. As the MG Y-laser itself requires a reflection on the l.h.s. of the gain section, a broadband reflector is integrated by means of very short, deep grating.

![Schematic of the structure of the MG Y-branch laser diode (l.h.s.) and fiber-coupled power and SMSR over the tuning range (r.h.s.).](image)

Figure 1: Schematic of the structure of the MG Y-branch laser diode (l.h.s.) and fiber-coupled power and SMSR over the tuning range (r.h.s.).

These advanced devices now allow full C-band tuning with a wavelength stabilisation below 2.5 GHz over life and give an output power in the fiber of over 13 dBm for a low power consumption of less than 2.5 W. They are packaged in a mini-butterfly package with wavelength locker and can be used in 300-pin SFFs and in line cards for DWDM metro or long haul networks. The fiber coupled power and the side mode rejection of these packaged devices are shown on the right hand side of Figure 1 for 96 50GHz spaced channels over the C-band.
3. Sampled grating tunable twin-guide laser

The Tunable Twin-Guide laser with Sampled or Superstructure Grating (S)SG-TTG laser) is based on the original TTG laser concept [1], but has two sections with sampled or superstructure gratings for Vernier-effect tuning. This laser is in essence still a DFB laser and hence a phase tuning section is not required. This facilitates a fast device characterisation, which is the main advantage of the (S)SG- TTG laser. A schematic structure of the device is shown in Figure 2. Ideally, there is a phase shift in the middle of the device and the facets are AR-coated such that a single mode DFB laser is obtained.

Figure 2: Schematic structure of the SG TTG laser diode: (a) side view and (b) cross section.

The reflection from the sampled or superstructure gratings is generally rather weak and very low facet reflectivities are required to avoid degeneracy of the single mode character due to facet reflections. Good AR-coatings have been combined with window structures to provide a reflectivity below 10−2. It has also been found out that the phase shift is not really necessary and in practice no significant differences were found between devices with and without phase shift [3].

Figure 3: Wavelength map of a typical SG-TTG laser (lhs) and SMRS and output power vs. wavelength (rhs).

Recent devices achieve tuning ranges of over 40 nm with high side mode suppression of over 35 dB and large output power of 10 mW and more. Figure 3 illustrates the wavelength tuning characteristics of a typical SG-TTG laser. The tuning currents were both swept in a non-linear way up to 45 mA and then converted to the wavelength shift of the reflector. The right hand side shows side mode suppression and output power over the tuning range. From RIN measurements it was concluded that a maximum modulation bandwidth of over 10 GHz should be possible for the current designs (which have a device length of 1200 μm). The above results however are achieved for non-optimised device designs and there is potential for still further improvements of the performance.

4. Conclusion

We have reported the latest developments on two widely tunable lasers: MG Y-laser and the SG-TTG laser. Significant performance improvements have been achieved in recent years with both laser diodes.

5. References

WA3. Tunable Laser and External Cavity

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