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Wavelength Tunable DBR lasers for DWDM Network Applications

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1. Introduction

'There is a need for tunability in optical networks', a proposition put forward many times over the last decade. Yet, with the recent downturn in telecommunications markets economical, fully wavelength agile optical systems seem as far away as ever. However, the recent surge of interest in tunable lasers of all kinds has finally seen an acceptance that a move away from systems based on fixed wavelength DFBs is about to happen. Cost control through sparing and inventory reduction may provide the first stepping stone on the way to wavelength agility. Thermally tuned DFBs capable of covering four to eight channels at 50GHz spacing are available, but only when tuning over 6.25nm (sixteen, 50GHz channels) or more is achieved will real economic benefits in inventory management be gained.

To displace the incumbent technology there is a requirement for a closely equivalent output power, side-mode suppression ratio (SMSR), linewidth, and RIN as well as the need for wavelength stability of +/- 2.5GHz over twenty five years of life. The new family of devices will have to have the look and feel of a DFB technology to the user to gain acceptability. Monolithically integrated multi-section DBR lasers are well positioned to take on this role (see [1] for a recent review), but will additionally require a systems interface, in an outer shell, for wavelength selection and control, which are transparent to the user.

Monolithically integrated, InP-based laser diodes will be reviewed in this invited paper, in particular with regard to their applicability to DWDM systems. However, the focus will be on a new device, the digital supermode DBR (DS-DBR) laser [2], which in its class combines several improved features along with a capability for broadband tunability in excess of eighty ITU grid channels at 50GHz.

The first step to tunability through narrowband tuning lasers is well matched to the capabilities of the three-section DBR laser, which was widely developed in the 1980's, particularly in Japan. A thermally enhanced electronic tuning range of up to 17nm, has been reported [3], although an initial specification of 6-8nm all electronic tuning is a more manufacturable target. Three section DBR lasers can give, 70-80mW ex facet powers at zero tuning current, with >40dB SMSR and linewidths 10-15MHz over the tuning range. However, the three-section device is in itself only a stepping stone to a single device, that can cover C- or L-band. For that, broadband tuning over 50nm is required.

2. Device description

The DS-DBR laser is a monolithic, InP-based, DBR laser with essentially four sections as shown schematically in a chip plan view in Fig. 1.

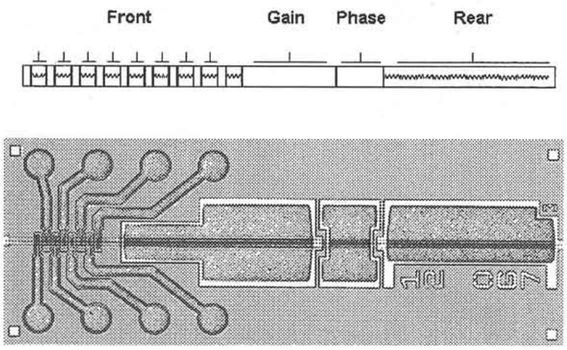

Fig. 1: DS-DBR laser diagram and chip plan view.

Initial results for a widely tunable DS-DBR laser were described in [2]. Here details of an eight front contact device design for full C-band coverage are reported. Surface ridge waveguide devices have been fabricated using conventional InP processing and e-beam written gratings. Devices have been packaged in standard 26-pin butterfly modules, which demonstrate ~50nm tuning range with excellent power, power uniformity and SMSR.

As described in [2] the front section is a multi-grating structure, and the rear section has a phase grating based comb reflector that gives a rectangular wavelength comb reflection response. The selection of one of the rear reflection peaks is achieved by activating the front multi-grating structure. This section consists of a series of gratings at different pitches, addressed by individual contacts. Each grating length is quite short, typically 25μm, and the resulting reflection response is, therefore, broad. The overlap of the adjacent grating reflectors provides the front section with broad and non-selective reflectance when no current is applied.

When a fixed current is applied to one of the front contacts the corresponding grating blue shifts, reinforcing the reflectance of the adjacent reflector. This mechanism is capable of digitally selecting a broad range of wavelengths and operates across the band. Quasi-continuous tuning is then achievable in the selected sub-band by varying the current into the rear grating only.

Despite the apparent increase in complexity, the DS-DBR laser is in effect a composite of many three-section devices activated by the choice of front grating current. Because of this it is, as discussed below, actually rather simpler to control than other broadband tuning lasers in its class.

3. Module results: wavelength tuning

Devices have been fabricated based on an eight-front contact design from which ~50nm tuning range has been achieved as shown in tuning map, Fig. 2. The vertical axis shows the wavelength variation with rear current in the range 0-50mA. The horizontal axis maps the wavelength selection via the front grating currents. One vertical band is plotted for each selection. Settings one to eleven for example map different currents in the overall range 0-15mA on contact pair one and two. Twelve to twenty two maps different current settings on contact pair two and three and so on. The vertical lines indicate the boundaries between the contact pairs selected.

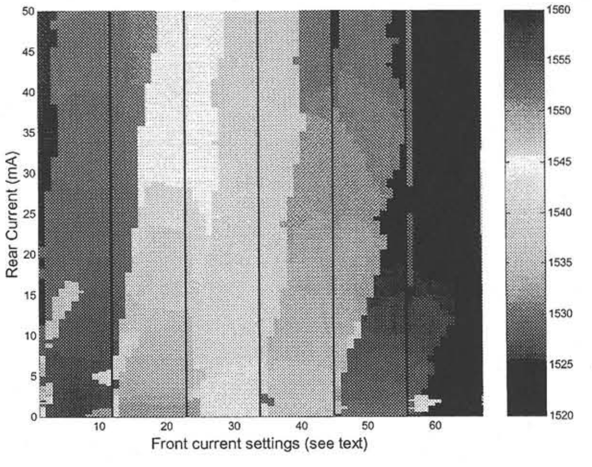

Fig. 2. A wavelength tuning map for a DS-DBR laser.

Individual currents in the range of 0 to 15mA are all that is required to activate the desired supermode, and as shown in Fig. 2, scanning within a sub-band via the rear current is relatively insensitive to this choice. The broad vertical bars show the relative simplicity of the wavelength selection in this device. Hence the overall current necessary to tune the device is far less compared to that needed in other multi-section laser approaches. This results in better thermal-stability when the device is tuned, and offers improved dynamic performance, which could be exploited in wavelength agile systems. Moreover, because only a short front grating section is activated, output losses due to free carrier absorption are minimised and output power change with tuning reduced.

4. Module results: power uniformity and SMSR

Modules were calibrated for 80 channels of the ITU grid, spaced at 50GHz and with an accuracy of 2.5GHz. The associated power variation is plotted in Fig. 3. Output power variation across the channels was contained within 2dB. The SMSR for these calibrated channels is plotted in Fig. 4. It is >40dB for all channels.

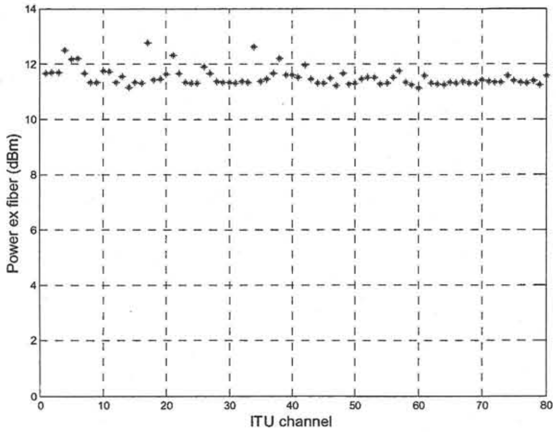

Fig. 3: DS-DBR laser power variation for constant gain section current.

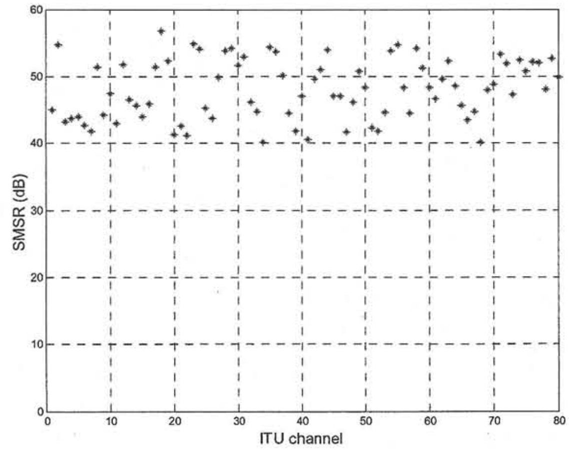

Fig 4. SMSR measured for each channel in Fig. 3.

5. Summary

A novel broadband tunable DS-DBR laser has been described. It has proved to have excellent performance characteristics for DWDM applications.

References

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[3] F. Delorme, IEEE Photon. Technol. Letts **PTL-12** 621 (2000).