Characterization of a Novel Three-Section Tunable Slotted Fabry-Perot Laser

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Abstract: A novel three-section tunable slotted Fabry Perot laser has been examined. Characterizations of the linewidth, SMSR and RIN indicate that this type of laser may be a suitable source for dynamic networks employing advanced optical modulation formats.

OCIS codes: (250.5960) Semiconductor lasers; (060.1660) Coherent communication

1. Introduction

Widely tunable lasers have become a key component in optical networks not only for inventory and sparing, but also for realizing the dynamic reconfiguration of the network [1]. Monolithic tunable lasers using current control have gained enormous interest because of the wide tunability (>50 nm), high side-mode suppression ratio (SMSR>30 dB) and high output power (>10 dBm). Various types of monolithic laser diodes have been proposed, including DBR-type structures, interferometric structures, codirectionally coupled structures and combination of the techniques above [2]. Moreover, a shorter switching time comparing with the mechanical controlled and thermal controlled devices make the current controlled monolithic tunable laser suitable for optical packet switching and optical burst switching networks.

Recently a new type of monolithic tunable laser fabricated by etching perturbing slots into the laser ridge has been presented and demonstrated by researchers [3]. These lasers have a single growth fabrication process and only use standard lithography, which significantly reduces the cost and complexity of fabrication while increasing the yield. This type of laser structure, known as the slotted Fabry Perot (SFP) laser, offers wide (discrete) tunability, high SMSR and sub nanosecond switching [4]. Like the single mode devices based on a similar structure [5], this type of tunable SFP laser is shown here to also exhibit narrow linewidth.

Tunable laser linewidth is becoming more important as systems begin to employ advanced optical modulation formats in which information is carried in the phase (or phase changes) of the optical carrier. Systems that use advanced optical modulation formats offer high receiver sensitivity, good tolerance to major nonlinear effects in high-speed transmissions and good tolerance to coherent crosstalk [6]. They are, however, more sensitive to the phase noise of the optical carrier than intensity modulated systems. Hence, low linewidth sources are critical, especially at lower bit rates and higher orders of phase modulation [7] and it is now necessary to include the linewidth into the calibration of a tunable laser source as well as the SMSR and output power [8].

In this paper, a novel three-section tunable SFP laser is described and characterized. Discrete tuning over 25 channels of the ITU 100 GHz DWDM grid is demonstrated. The averaged relative intensity noise (RIN) within the 200MHz to 14GHz frequency range is examined and found to be lower than -135dB/Hz in the worst measured case. The SMSR of all the channels is greater than 30 dB, while the linewidth is below 800 kHz, significantly lower than other monolithic tunable lasers. The lineshape of the laser has also been examined and is found, like DBR-type lasers to have a Voigt lineshape (a combination of Lorentzian and Gaussian). This kind of lineshape indicates the SFP laser exhibits enhanced low frequency noise due to electrical noise in the tuning currents [9, 10]. The low linewidth of the SFP laser, combined with its low cost fabrication and wide tunability means that it may find application in dynamic phase modulated systems and particularly in the DWDM access network [11].

2. Device

The device consisted of a ridge waveguide semiconductor laser, separated into 3 active sections by two single slots etched into the waveguide. The wafer material is a standard 5 QW off-the-shelf laser structure from a global wafer supplier (IQE), with no regrowth steps. The slots are formed in the same etch step as the laser ridge, and do not go through the active region. However, the depth is sufficient to perturb the mode and cause a reflection at the slot position. Unlike Vernier tuning or SG-DBR type lasers, there are no slots or perturbations within any of the sections to act as gratings. However, as each section is of slightly different length the reflections from the slots between the sections cause interference effects at slightly different spacing. By varying the drive current to each section, the gain and index of each section of the laser could be controlled such that single mode lasing was achieved in any of 25 modes. The device was mounted in a standard 14 pin butterfly package with integrated TEC, and an 11 μm radius lens ended fibre was aligned and welded into position.

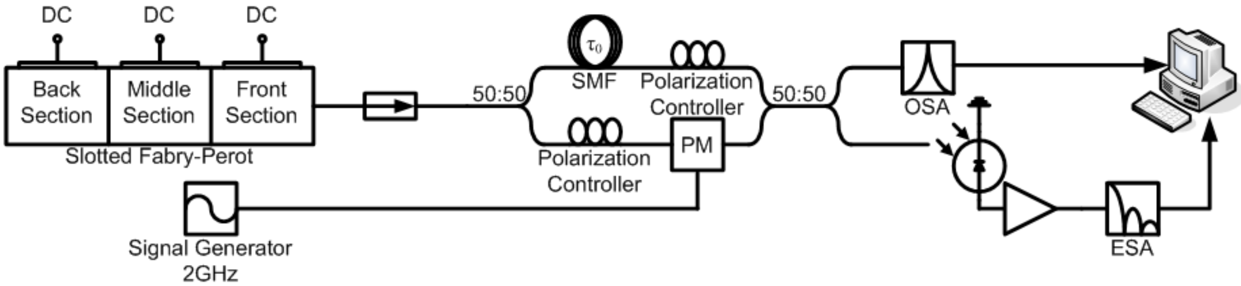

Fig. 1 Diagram of experimental setup

3. Device Characterization

The linewidth characterization setup is shown in Fig. 1. The delayed self-heterodyne method [12] is used to measure the linewidth of the SFP laser which was optically isolated to prevent optical feedback into the cavity. The fiber delay of a 12 km single mode fiber (SMF) is approximately 60 μs, which corresponds to a resolution of 17 kHz for the linewidth measurement. The Optical Spectrum Analyzer (OSA) and Electrical Spectrum Analyzer (ESA) were used to record the optical spectrum and lineshape of different channels respectively. RIN measurements were taken using an 11GHz photoreceiver with an integrated transimpedance amplifier (TIA). The output of the photoreceiver was split using a bias-tee with the DC component measured using a digital multimeter and the AC component is measured using the ESA.

25 channels of the ITU 100 GHz grid were found by applying tuning currents between 0 and 60 mA to each section of the SFP laser. The superimposed tuning spectra are shown in Fig. 2 (a). A power variation of 5 dB between different channels can be found due to the active characteristic of the three tuning sections. Both the carrier density and the photon density are changed according to the changes of currents. The RIN spectra of the laser at five different channels are shown in Fig 2 (b). The averaged RIN within 200 MHz to 14 GHz frequency range was below -135 dB/Hz for the five measured channels. The output power of each of these channels is given in the legend of Fig. 2 (b) and as expected the higher power channels exhibit lower RIN. The lineshape of the channel at 191.4 THz is shown in Fig. 3 (a). The measured curves were fitted with Lorentzian, Gaussian and Voigt functions respectively (see the fitting curves in Fig. 3 (a)). We found that the lineshape of the SFP laser is closer to the Voigt function than the expected pure Lorentzian function. This change in shape is caused by the conversion of electrical noise in the tuning currents to low frequency optical phase noise and has previously been observed in the passive tuning devices i.e. DBR-type lasers [9, 10]. The linewidth, calculated from the 20 dB spectral width averaged over 50 sweeps is shown in Fig. 3 (b), along with the SMSR. The values of linewidth are less than 800 kHz for all

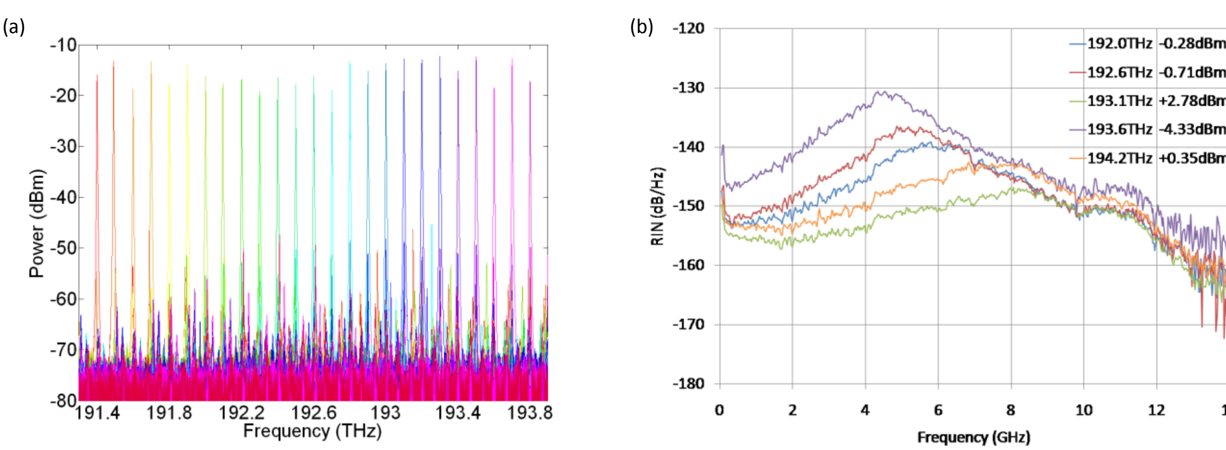

Fig. 2 (a) Optical spectrum at different ITU channels. (b) The RIN of five ITU channels with different fiber launch powers. Data is averaged over 20 sweeps.

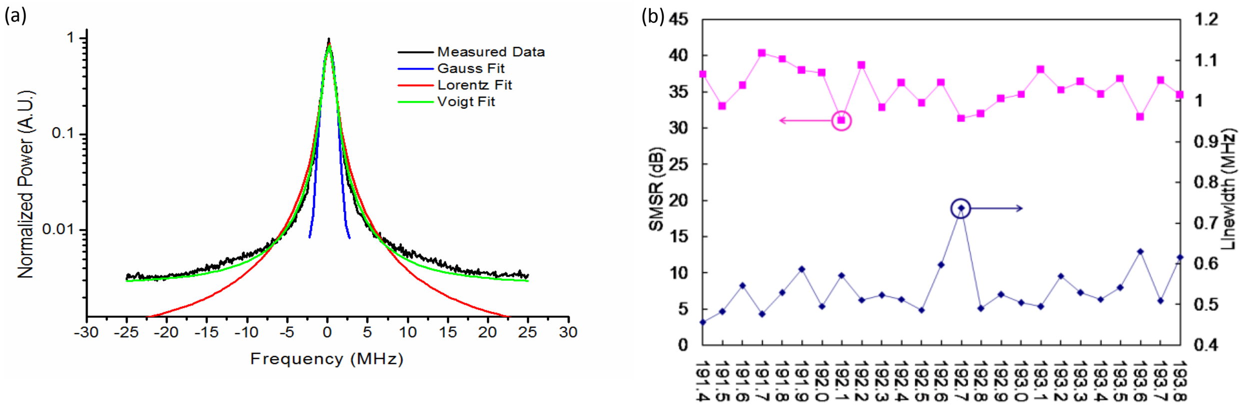

Fig. 3 (a) Lineshape of the SFP laser with Lorentzian (red line), Gaussian (blue line) and Voigt (green line) fitting. (b) Linewidth and SMSR.

channels, and the SMSR of each channel is above 30 dB.

4. Conclusion

This paper presents characterization results for a packaged three contact tunable SFP laser. Characterization of the laser has shown that the linewidth of the laser is less than 800 kHz and the SMSR is above 30 dB for all 25 available channels of 100 GHz ITU grid. The Voigt lineshape of the laser indicates that like passive tuning DBR lasers, this type of SFP laser is sensitive to the electrical noise from the current source. Of the five channels a maximum averaged RIN of -135 dB/Hz was measured. The low linewidth of the SFP laser, combined with its low cost fabrication and wide tunability mean that it may be suitable for use as a low cost transmitter in a dynamic coherent network, and may prove especially suitable for the access network.

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6. References

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