

Uncooled laser operation over 32, 1 nm spaced, channels

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Abstract: Simple quadratic trends were used to stabilise uncooled widely tuneable lasers over 32, 1 nm spaced, channels. Wavelength accuracy of 0.1 nm was maintained over a temperature range from 15 °C to 40 °C.

Key words: tuneable laser; optical communications, wavelength control, cooling.

In a more and more cost driven telecommunications industry the cooling system for the lasers is a prime target as shown by the strong growth in coarse wavelength division multiplex (CWDM) [1-2] network standards [3-4]. This technology uses uncooled lasers, widely spaced channels (20 nm) and simple filters. Thus the cost of WDM networks with modest channel number is greatly reduced. The success of CWDM has started a growing interest in uncooled lasers for closer channel spacings [5-6] using programmed control loops monitoring the laser wavelength and the temperature.

This paper describes a system which using measurements of the temperature only stabilises the output wavelength with an error <0.1 nm. The lasers used were widely tuneable super-structure grating distributed Bragg reflector (SSG-DBR) lasers and sampled grating DBR (SG-DBR) lasers to allow demonstration of the stabilisation technique over 32 channels (1531-1562 nm) when the temperature was varied from 15 °C to 40 °C.

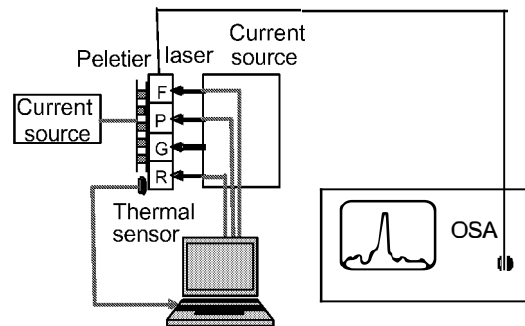


Fig. 1: Experimental system

Figure 1 shows the experimental system used for the stabilisation experiment. For this experiment we used four section tuneable lasers (SG-DBR and SSG-DBR). The laser gain section current was fixed at 90 mA. The three other sections (the front, rear and phase sections) were driven by a multiple channel GPIB controlled current source. This current source and the thermal sensor embedded in the packaged laser was connected to a computer containing the stabilisation programme. In order to change the laser temperature over a large range the Peltier cooler in the packaged laser was connected to a separate current source, allowing independent control of the laser temperature.

Wavelength monitoring was carried out using an optical spectrum analyser with a resolution of 0.06 nm. The programme was used to lock the laser to a particular wavelength and the temperature was then varied using the Peltier cooler during test.

The Control loop used a computer to read the temperature from the thermal sensor and set the front, rear and phase currents for the desired wavelength. The currents were changed using quadratic trends which were given by the general tuneability mapping of the lasers and a fixed trend for the phase section for all the different channels.

Figures 2a and 2b show the tuneability mapping of both SG and SSG-DBR lasers at 25 °C. Note that when the temperature changes the general areas on the maps between large mode jumps (between super-modes of the gratings) do not change, but the wavelengths increase within these areas at a measured rate of 0.13 nm/°C. This allows trends for the rear current and the front current as a function of the laser temperature to be extracted for a given wavelength such as those shown as an example for an SG-DBR laser at 1537 nm in Figures 2c and 2d. However, for large temperature change, the Fabry-Perot cavity length changes in such a way that though the output wavelength will not change the laser will hop from one Fabry-Perot mode to the next approximately every 4 °C to 5 °C. As this effect is the same for all the different wavelengths the trend was the same and is shown in Figure 2e.

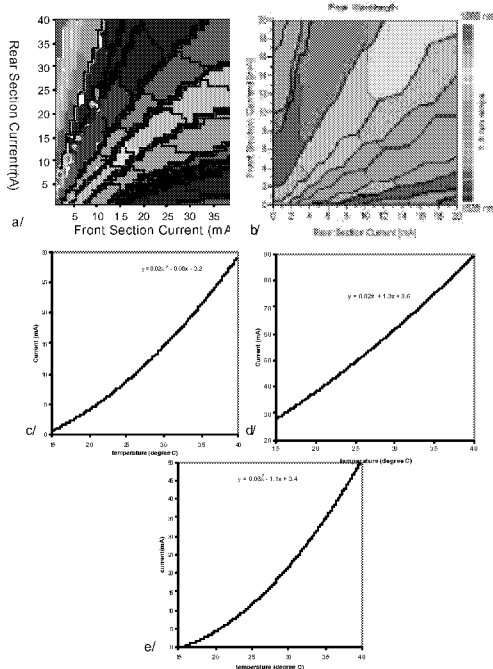


Fig. 2: Tuneability map for a: SG DBR laser, b: SSG DBR laser. Quadratic trends for c: front current at 1537 nm, d: rear current, e: phase current.

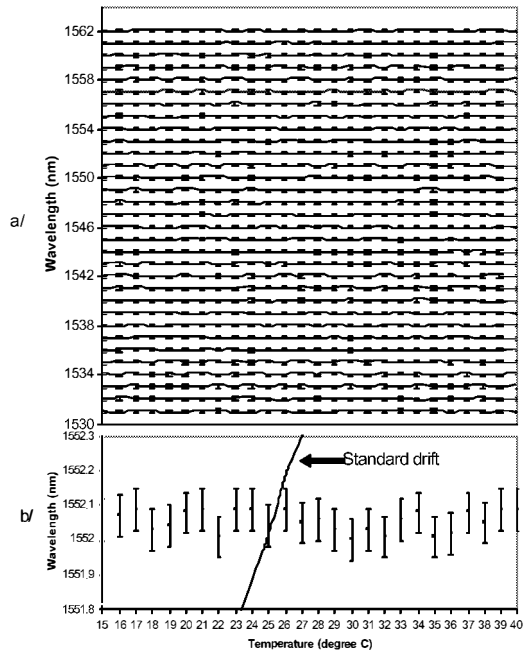


Fig. 3: a/ 32 Channels (1531 to 1562 nm) controlled from 15 to 40 °C. b/ detail of channel 22 (1552 nm) compared with standard drift (0.13 nm/°C for this laser)

The stabilization programme was tested for 32 different channels spaced by 1 nm from 1531 nm to 1562 nm Figure 3a/ shows that all channels remained stable from 15 °C to 40 °C. Figure 3b/ shows an example wavelength result (1552 nm) compared to the measured standard drift of 0.13 nm/°C. This demonstrates that the laser wavelength did not drift more than 0.1 nm over the full temperature range when the temperature was changed at a rate of 1 °C/s. The drift could be reduced further if the temperature changes were slower as the drift was mainly due to the slow response of the computer-current source GPIB link. When the loop was tested over a smaller temperature range at a lower rate of temperature change, we indeed observed drift as low as 0.05 nm.

Note also that, as the temperature was ramped continuously, it was possible to confirm for all channels that there were no Fabry-Perot mode jumps across the temperature range.

The range of temperature used was set by operating limits for the tuneable lasers used which were not designed for uncooled operation.

Finally the technique is applicable to both SG-DBR and SSG-DBR lasers, since just the trends need to be adapted for each laser and in both cases a quadratic trend is a good enough approximation for the variations of each current as a function of temperature.

The uncooled operation of widely tuneable SG-DBR and SSG-DBR lasers, using a programmable control loop has been demonstrated for 32, 1 nm spaced, channels from 15 °C to 40 °C. For each of these channels the wavelength drift was measured to be less than 0.1 nm over the temperature range compared with the 0.13 nm/°C standard drift measured for these lasers.

We believe that further work using these lasers in a transmission system will illustrate the value of uncooled widely tuneable lasers in a WDM network.

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