Demonstration of Monolithic Optical Injection Locking Using a Two Section DFB Laser

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Abstract: A simplified monolithic optical injection locking system using a two section DFB laser is demonstrated. The operating wavelength of the two sections is current tuned to achieve optical injection locking; when locked the modulation bandwidth is increased from 10GHz to 23 GHz.

OCIS codes: (000.0000) General

Summary

Strong optical injection locking has been demonstrated to improve the modulation bandwidth and linearity of semiconductor distributed feedback (DFB) lasers [1, 2]. The experimental setups used to achieve this locked state often require a tunable external cavity laser (ECL) or a well matched DFB laser such that current and temperature tuning can be used to achieve locking. Since the operating wavelength of the master laser and the slave laser must be carefully controlled and polarization must be carefully matched, injection locked lasers have been limited to laboratory use. In a typical system the master laser is also isolated from the slave laser using optical isolators, typical isolation is on the order of 30-40dB with an insertion loss of 1-3 dB. The isolator loss and optical coupling efficiency limits the maximum injection ratio. For very high injection ratios (close to 1) the master laser output power will need to be much higher than that of the slave. Often an optical amplifier is used to boost the master laser power to achieve high injection ratios.

To overcome these issues, we demonstrate an optical injection locking system using a two section DFB laser as shown in Fig. 1. The DFB laser is designed with a very strong grating such that the κL product is approximately 3 to 4 for a device length of 750 μm. A ridge 3 μm high is etched and silicon nitride is used as a passivation layer. The top metal contact is split into two sections of nearly equal lengths. After etching the p++ layer between the two sections, over 1 KΩ of electrical isolation is achieved. An anti-reflection (AR) coating with a reflectivity of less than 0.1% is deposited on one facet to minimize the Fabry Perot modes of the cavity.

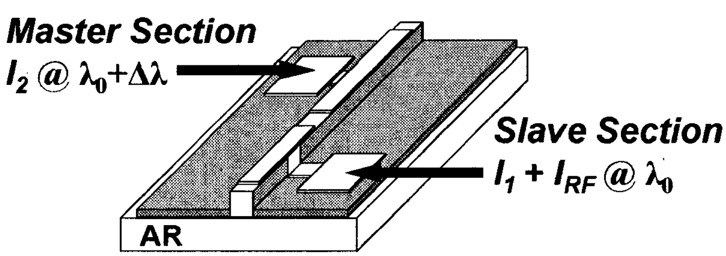

Figure 1. Two section DFB laser used for optical injection locking.

Due to the distributed feedback nature of the device, individual sections of the laser can lase on its own. The optical spectrum of each section with the other section turned off is shown in Fig. 2(a). The optical spectrum of the section furthest away from the output facet is attenuated by the unbiased section closest to the output facet; however nearly equal output power is achieved by measuring the output at the other facet. The operating wavelength of the two devices can be matched by current tuning. Since the two lasers are not isolated the locking range is very complex since both lasers will try to force the other to operate at its own wavelength [3]. When tuned very close to the locking range two discrete modes can be resolved (master and slave), along with an optical modulation component shown in Fig. 2(b). The beating of different modes generates a very sharp spike in the modulation response.

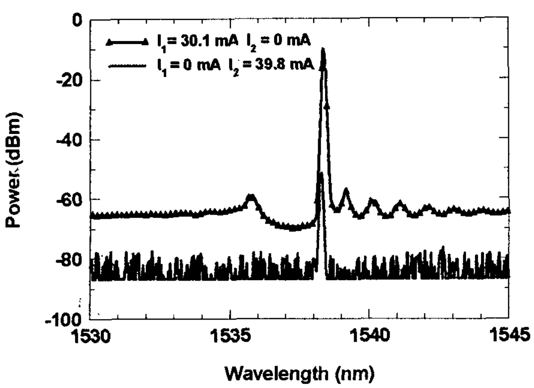

Figure 2(a).

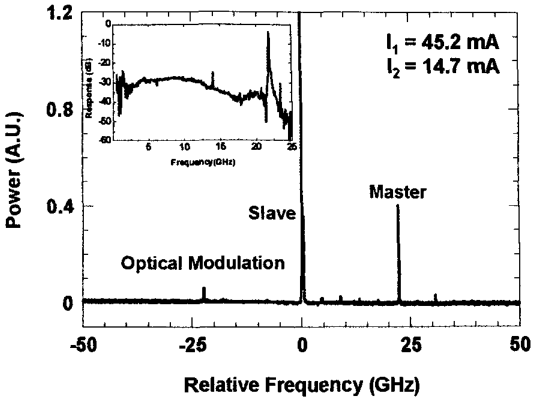

Figure 2(b).

Figure 2(a): Optical spectrum of each individual section with the other turned off. Figure 2(b): Optical spectrum when both sections are tuned closer to each other and modulation response near the locking edge.

When optical injection locking is achieved, the modulation response of the laser shows a resonance peak of approximately 21 GHz, and the measured optical spectrum indicates a single operating wavelength as shown in Fig. 3. The resonance peak is very broad compared to that of the unlocked state and is not due to optical modulation. The modulation responses for a single section bias and for an unlocked state (with large frequency detuning) are shown for comparison. The measured relaxation frequency is consistent with that obtained by using an ECL as a master laser and a single section DFB. Optical pumping outside the locking range does not improve modulation response.

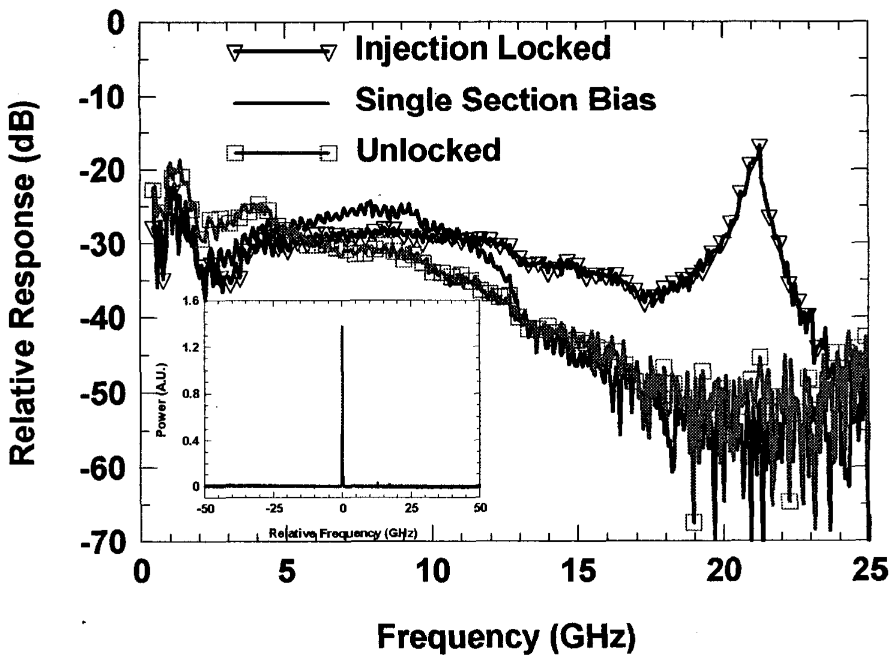

Figure 3. Measured modulation response of the laser when injection locked, free-running, and unlocked. Single mode optical spectrum when injection locked.

In conclusion we have demonstrated a method for optical injection locking using a single chip laser. By splitting the DFB into two sections we can have an environmentally robust optical injection locking system.

References:

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