Optical Generation of Millimeter-waves using Monolithic Sideband Injection Locking of A Two-section DFB Laser

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Abstract: A novel optical millimeter-wave generation using sideband injection locking is demonstrated using monolithic two-section DFB lasers. The tunable millimeter-wave is generated by adjusting the RF-modulation frequency and bias currents.

Summary

The optical generation of millimeter-wave has been demonstrated and attracted much attention because of its flexibility and applicability in broadband mobile communication systems and optical beam forming [1, 2]. Specifically, sideband injection locking technique using master and slave laser is promising for generating millimeter-wave since it is simple to implement and gives high tunability. However the experimental setups used to achieve sideband injection locking often require two or more light sources –a master laser and a slave laser, or a master laser and two slave lasers [2, 3]. Recently, we reported modulation bandwidth enhancement of monolithic injection-locked DFB lasers with two sections [4]. In this paper, we extended our research to millimeter-wave generation using the two-section DFB laser and, for the first time, experimentally demonstrated optical generation of millimeter-wave using monolithic sideband injection locking of a two-section DFB laser without any external optical element.

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. The device is etched to form a metallization ridge 3-4 μm wide and silicon nitride is used as a passivation layer. The top metal contact is split into two sections with equal spilt ratio between sections. A 0.5 μm etch is then done between the laser sections and an electrical isolation larger than 1 KΩ is achieved. Because of the distributed feedback nature of the device, individual sections of the fabricated two-section DFB laser can lase on its own in the current bias range of the master and slave section. To investigate the lasing wavelength dependence on bias current in each section, the slave laser section is biased at fixed current and master laser section is biased at various current. An isolated external cavity laser is used as an absolute frequency to observe the frequency tuning characteristics of the master and slave section. In Fig. 2, slave laser is biased at 45.2 mA and master laser is bias at 58.1 mA. The relative frequency of the master section and slave section is –17.6 GHz and 7.6 GHz, respectively. The beating of the master and slave modes generates RF product at 25.2 GHz. By changing current bias on the master section, frequency difference between two sections is varied as shown in Fig. 3.

Using this phenomenon, the two wavelengths from the master and slave laser section can be used as a source for generating millimeter-wave signals as shown in Fig 4. Fig. 5(a) shows a beating at ~ 36 GHz between master and slave wavelength without RF modulation of slave section. The beat signal appears noisy because each section operates independently from each other with random phase. To generate a pure 36 GHz microwave signal with high power, the slave laser section is modulated with a 12 GHz RF signal. The third sideband of the modulated slave laser is locked to the master laser. This establishes phase coherence between the primary mode of the master and slave laser. The beating of these two modes generates a high fidelity 36 GHz signal as shown in Fig. 5(b).

In conclusion, we have demonstrated a method for optical generation of millimeter-wave using a single chip laser. By adjusting bias currents on each section and RF modulation frequency, we can have an environmentally robust and simple sideband injection locking system.

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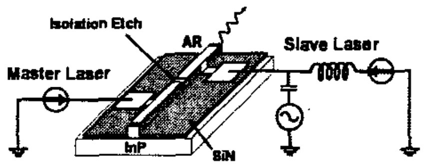

Fig. 1. Two-section DFB laser used for millimeter-wave generation by sideband injection locking

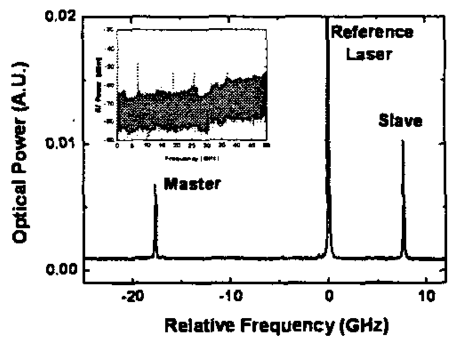

Fig. 2. Measured optical spectrum and RF power

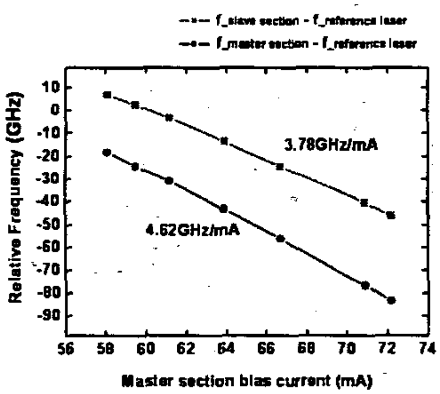

Fig. 3. Measured current tuning characteristics

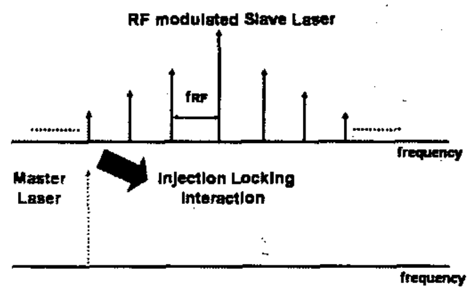

Fig. 4. Sideband injection locking

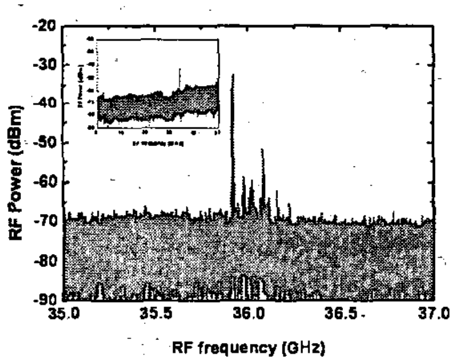

Fig. 5(a). Detected RF spectrum without RF modulation

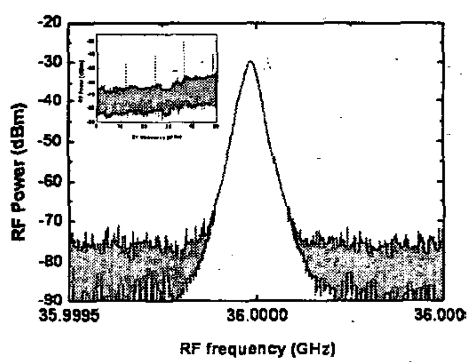

Fig. 5(b). Detected RF spectrum of generated millimeter-wave under RF modulation of 12 GHz on the slave section.

Acknowledgement

This material is based upon work supported by the US DARPA/Army Research Lab under Contract No. DAAD17-01-C-0077.

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