ICOCN 2021

A simple optical frequency comb generator based on the monolithic integrated dual-tone semiconductor laser subject to the gain-switching effect

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Abstract:

A simple photonic approach to generating the wideband optical frequency comb (OFC) based on the monolithic integrated dual-tone semiconductor laser (MI-DTSL) subject to the gain-switching effect is proposed and experimentally demonstrated in this work. The impressive hotspots focus on that different from the traditional single-section laser, the MI-DTSL naturally owns dual-wavelength state attributing to the two DFB laser sections integrated on one chip. Thus, when the MI-DTSL is injected with large RF signal, all optical wavelengths in the integrated cavity would be simultaneously modulated and go into the gain-switching effect, leading to the generation of the wideband OFC compared to one single-section laser attributing to the wavelengths of the dual lights are not distant. In addition, as a result of high integration of the MI-DTSL, the system would be rather low-cost, flexible and convenient. In the experiment, one discernible OFC with a bandwidth of 115 GHz and a comb line of 23 within 10-dB amplitude variation is obtained and it is the twice than that by using the gain-switching single-section laser, largely suggesting this method huge effectiveness.

Principle:

- One is the gain-switching effect of the semiconductor laser which is widely utilized for the generation of the discernible OFCs.
- The other principle is the undamped period-one (P1) oscillation, which can generate the dual-tone oscillating state.

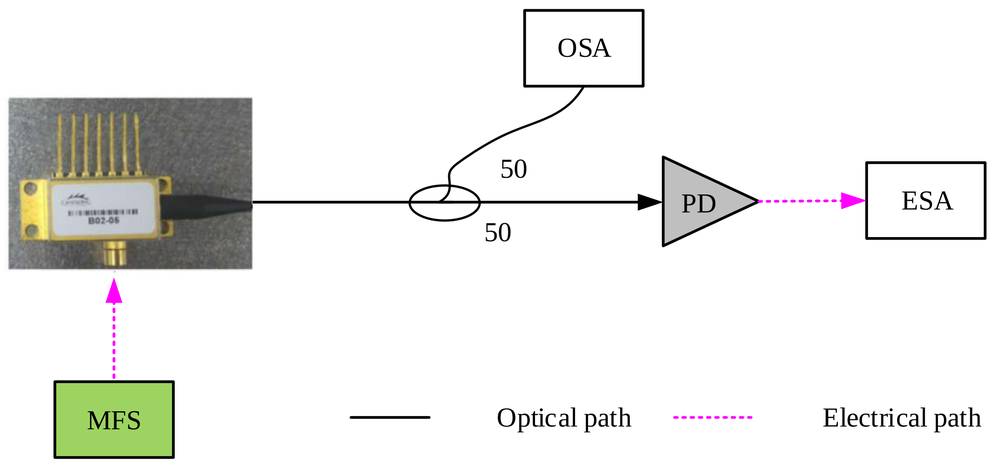
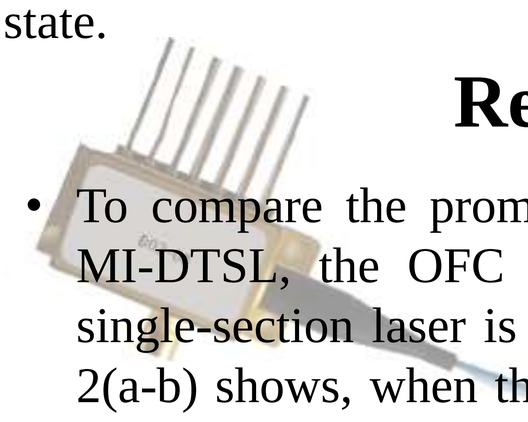


Fig. 1. The experimental setup of the optical frequency comb generation based on the gain-switched integrated laser.

Results:



- To compare the prominent of the gain-switching MI-DTSL, the OFC generation by utilizing the single-section laser is also tested here. As the fig. 2(a-b) shows, when the single light is large-signal modulated with the frequency fixed at 5 GHz, one discernible OFC with a 60-GHz bandwidth, 13 comb lines is generated under the gain-switching effect. Subsequently, the single-section laser is replaced by the MI-DTSL. As the fig. 2(c) depicts, the original optical signal includes two main oscillating lights. When the integrated laser is modulated with the similar external microwave signal, the generated OFC can be observed as the fig. 2(d) shows. It can be seen that the bandwidth and the comb number are separately 115 GHz and 24 within 10 dB power variation, suggesting a great improvement compared to that in fig. 2(b).

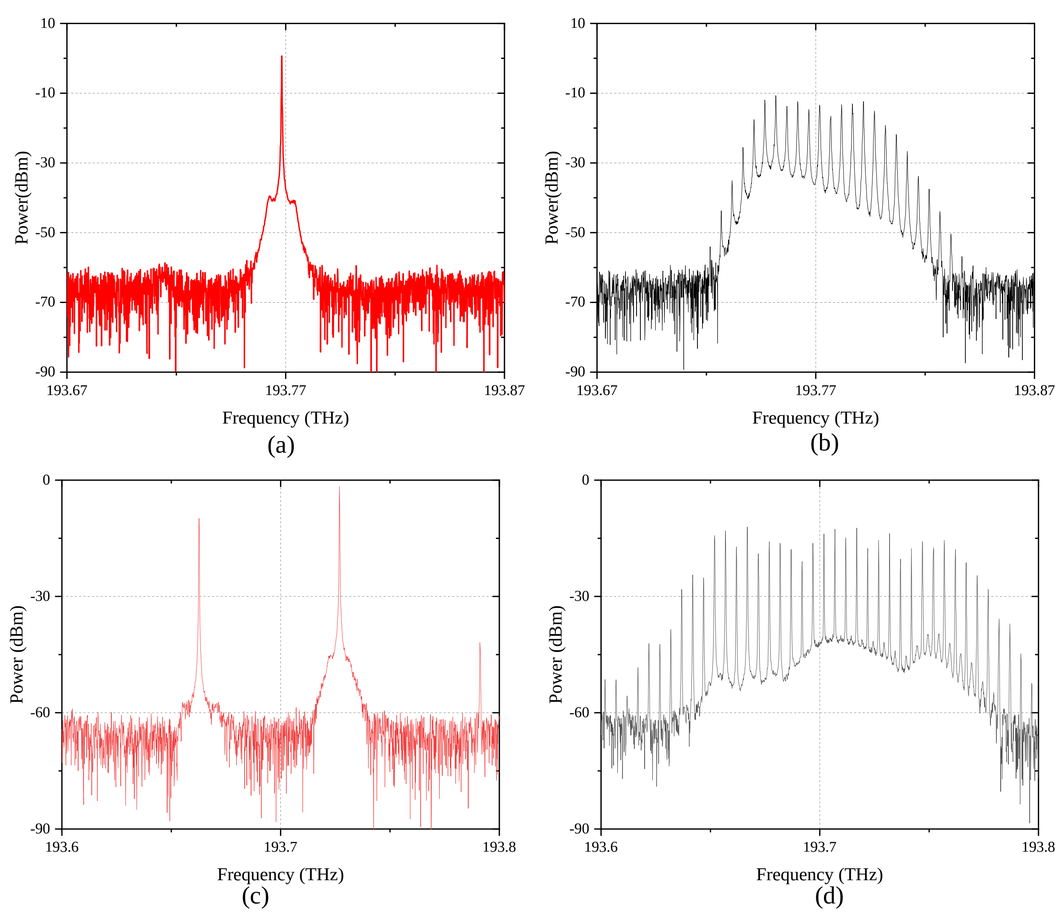


Fig. 2. (a-b) The comparison of the optical spectrum separately under the free-running state and the gain-switching state with the single-wavelength laser and the two-wavelength integrated laser.

- The tunability of the OFC generator can be also guaranteed just by tuning the modulation frequency as well as the spacing of the dual optical modes. As the fig. 3(a-b) shows, different OFCs with the diverse comb spacings including 2.862 GHz, 4.862 GHz can be got. The beating signals after the photodetector are also evaluated to verify the application of the generated OFC in the generation of the multi-carrier signal as the fig. 3(c) shows.

Fig. 3. (a-b) Different OFCs with the diverse comb spacings including 2.862 GHz, 4.862 GHz, (c) the generation of the multi-carrier signal under the gain-switching state.

Conclusion:

In this paper, we have proposed and experimentally demonstrated a novel and cost-effective approach to generating the wideband OFC based on the gain-switching integrated dual-tone semiconductor laser. By injecting with large-amplitude signal, the dual main oscillating wavelengths would be simultaneously modulated and enter into the gain-switching state and thus a wideband OFC can be realized conveniently. In the current proof-of-concept experiment, one superior OFC with a bandwidth of 115 GHz, and a comb line of 24 within 10-dB amplitude variation is generated by using this proposed OFC generator, confirming the effectiveness of this scheme.