80 GHz beatnote generation in a single tapered distributed feedback hybrid III-V / silicon laser

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A 80 GHz beatnote is reported from a III-V on silicon distributed feedback laser having a large quality factor. These results pave the way for all-optical microwave generation using compact and energy efficient semiconductor devices.
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1. Introduction

Microwave photonics continue to gain a significant amount of attention from different communities in particular for applications in broadband wireless networks, sensor networks, radars, communications, among others. The major functions of microwave photonics systems include photonic generation, processing, control and distribution of microwave signals. Here, we concentrate on all-optical microwave generation from a compact and energy efficient semiconductor device. The device under study consists in a high-Q Silicon cavity made of a tapered distributed feedback (DFB) shallow grating, as in [1] which is monolithically hybridized to III-V active section. The detail of the technology is given elsewhere in [2]. These devices have been shown to operate with much reduced phase noise (spectral linewidth < 20 kHz) owing to the reduced spontaneous emission in the mode [3].

2. Results

The laser is biased with electric probes while a fiber is used to extract the output from one of the two grating couplers at the two edges of the silicon waveguide. A Peltier module is used to stabilize the temperature at 20°C. The tapered DFB cavity design is shown in fig. 1(a). The increase of the width of the patterns forming the distributed Bragg grating induces a frequency shift of the edge of the transmission stop band, leading to a confining potential where a single mode is allowed to have a large Q factor. However, an additional weakly confined mode (with much lower Q) exists at a lower optical frequency. As the laser diode current is increased, this additional mode initiates lasing simultaneously with the fundamental, as shown in fig. 1(b). When the current is further increased, two additional narrow peaks appear, a clear signature of four-wave-mixing (FWM), hence indicating coherent interaction between modes. The radio-frequency (RF) beatnote is then extracted with a fast photodetector (Finisar 70 GHz) straight after the laser output, and analyzed with an ESA (Rhode and Schwartz) equipped with a mixer module for down conversion. The beatnote is detected as the current is above 80 mA, consistently with the optical spectra, and its frequency increases nonlinearly with the bias current, as shown in fig 1(c). For I > 90 mA, the RF linewidth fitted with a Voigt profile narrows down to about 500 kHz, but remains however quite unstable due to technical noise. It is important to stress that that the laser diode operates under free running and that no stabilization technique is being used.

3. Conclusions

Using a III-V on silicon DFB laser with a high-Q factor, a microwave beatnote is reported owing to FWM effect. These results are meaningful for all-optical microwave generation from compact and energy efficient semiconductor devices.

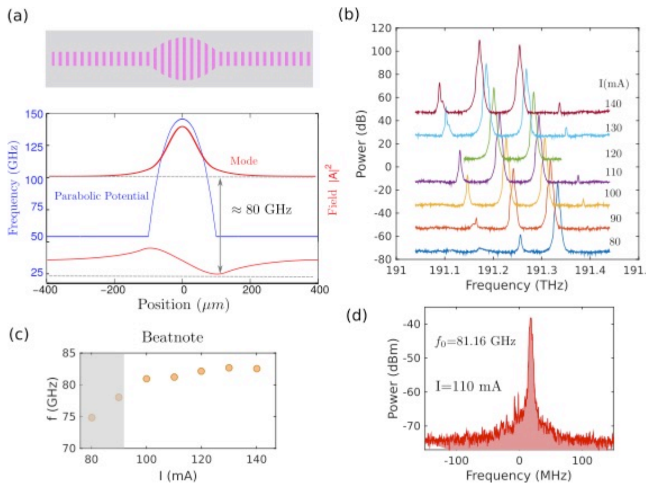

Fig. 1 (a) The tapered DFB cavity; (b) Optical spectra at different bias current conditions; (c) Measured beatnote as a function of the bias current; (d) RF linewidth above 90 mA.

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