

852-nm distributed-feedback diode lasers for atomic clocks and laser cooling

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Abstract: We report on narrow linewidth DFB RW lasers emitting at the caesium D₂ resonance wavelength. The devices operate in a single lateral and longitudinal mode up to 250 mW optical power with a spectral linewidth below 1 MHz.

Wavelength-stabilized diode lasers emitting at the caesium D₂ resonance wavelength are of particular interest for applications in atomic clocks and Doppler laser cooling. Although wavelength stabilization can be achieved with gratings in an external cavity configuration, the complex tuning mechanism is necessarily expensive and sensitive to acoustic, thermal, and vibrational perturbations. A monolithic device that offers comparable or even superior properties to an external-cavity system is a distributed-feedback (DFB) laser, where a Bragg grating is integrated into the active semiconductor cavity. DFB lasers are reliable, mechanically stable, and can operate mode-hop free over a large tuning range.

We have developed AlGaAs-based DFB lasers with Al-free grating layers embedded in the p-cladding layer [1]. By varying the grating period and the composition of the active layer, any desired emission wavelength can be obtained with otherwise similar laser structures. Here, we report on 1.5-mm long 852-nm emitting DFB lasers having a 2- μ m ridge-waveguide and their applicability for caesium clocks.

Fig. 1 shows the light-current characteristics measured in continuous-wave (CW) operation at different temperatures of the heat sink. The threshold current is 32 mA and the slope efficiency 0.76 W/A. The optical spectrum depicted in the inset of Fig. 1 reveals single-longitudinal mode emission near 852 nm with a side-mode suppression ratio of 50 dB. The spectral linewidth is limited by the optical spectrum analyser (10 pm). Measurements performed with a heterodyne beatnote technique yielded linewidths below 1 MHz for $P > 20$ mW. The tuning of the wavelength can be achieved by either changing the temperature or the operating current. Fig. 2 shows the light-current characteristics measured upon transmission through a caesium vapour cell. The absorption at the D₂ caesium resonance wavelength leads to a modulation of the detected power with a modulation larger than 15%. At a heat sink temperature of 20°C, the caesium resonance wavelength is reached at a current of 332.0 mA corresponding to an optical power P of 240 mW. An increase of the temperature to 30°C leads to a decrease of the matching current to 190.4 mA (130 mW).

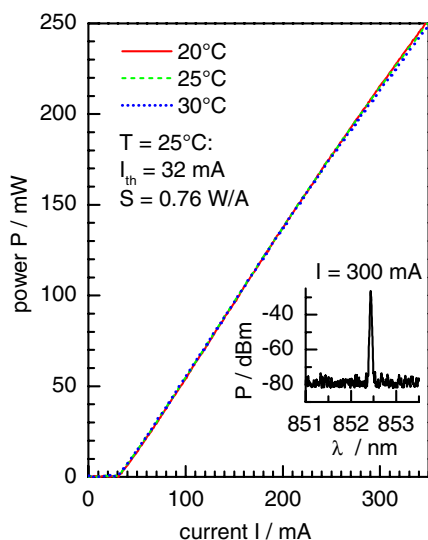


Fig. 1: CW light-current characteristics of a 852-nm DFB laser for different heat sink temperatures. Inset: Optical spectrum recorded at $T = 25^\circ\text{C}$. Cavity length $L = 1.5$ mm.

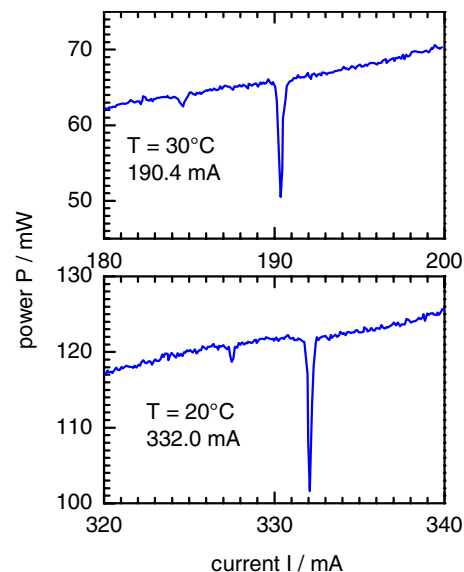


Fig. 2: CW light-current characteristics of a 852-nm DFB laser measured after the passage of the emitted radiation through a caesium vapour cell for different temperatures of the laser heat sink

[1] H. Wenzel et al., "High-power ridge-waveguide distributed-feedback lasers emitting a 860nm," Electronics Lett. 38, pp. 5576-1677 (2002)