In Fig. 4, we plot the duration of the stable pulses for different pumping levels in the gain and absorbing sections. The pulse durations become smaller as the pumping in the gain section increases and the pumping in the absorbing section decreases. The pulse duration may be smaller than 100 fs. In Fig. 5, we plot the durations of stable pulses for different recovery times in the absorbing section and for a fixed recovery time in the gain section. We note that stable pulses are created even when T_{1a} is as short as 1 ps. The pulses become shorter as the recovery time in the absorbing section increases. We note that the Maxwell-Bloch equations solved in this work do not consider the saturable nonlinearity and group velocity dispersion that the pulse will experience while traveling in the cavity. However, these effects were extensively studied for SIT modelocked pulses in QCLs in [24]. It was found that stable modelocked pulses evolve over a broad parameter regime in the presence of nonlinearity and group velocity dispersion. In addition, the nonlinearity-induced changes are mostly canceled by the anomalous dispersion of typical QCLs and the stable pulse durations are not significantly changed.

In Fig. 6, we plot the pulse intensity evolution at the laser output with fixed pump parameters, but when the lengths of the gain and absorbing sections vary. We note that stable pulses are created in all cases. However, the pulse intensity increases and the pulse duration decreases as the length of the gain section increases and the length of the absorbing section decreases.

4. Conclusion

We have proposed that stable ultra-short pulses can be created from a quantum cascade structure if the cavity is processed into two sections so that one section works as a gain medium and the other works as a resonant absorbing medium. This approach will allow one to control the pumping and bias-dependent parameters of the gain and absorbing periods separately, which should make it easier to construct a device than when gain and absorbing periods are interleaved. We have shown that in the proposed two-section QCL the saturable resonant absorbing section can suppress the growth of the continuous waves and the spatial hole-burning. Stable ultra-short pulses on the order of $\sim$100 fs are created when the pumping in the gain section is enough to overcome the losses in the cavity and the facets and the pumping in the absorbing section is less than the value that absorbs the light completely. The duration of the pulse can be varied by controlling the pumping parameters in the two sections.

#211285 - $15.00 USD Received 1 May 2014; revised 6 Jun 2014; accepted 9 Jun 2014; published 18 Jun 2014