THz Repetition Frequency Mode-Locked Laser Using Novel Sampled Gratings

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Conventional sampled grating distributed-Bragg-gratings (C-SGDBRs) are widely used in tunable DBR lasers [1], and more recently have been used to precisely control the wavelength spacing in arrays of DBR lasers for use in WDM systems [2], and as the reflectors in THz repetition frequency (F_r) semiconductor mode locked lasers (SMLLs) [3]. However, the effective coupling coefficient, κ, of a C-SGDBR (Fig. 1(a)) is necessarily reduced substantially from that of a uniform grating because much of the sampled grating period has no grating. Here, for the first time, we apply a combination of π-phase shifted gratings, previously demonstrated in fiber lasers [4], with the C-SGDBR technique to THz repetition frequency SMLLs. Using a single electron beam lithography (EBL) step we have demonstrated a 620 GHz side-wall SGDBR MLL with an increased effective κ.

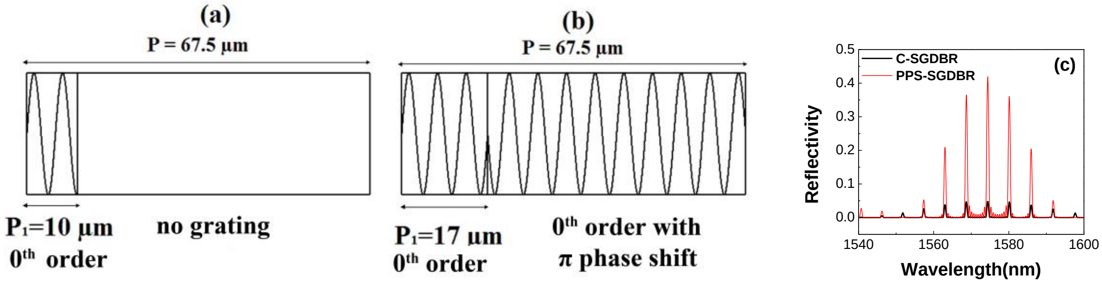

Fig. 1. Grating structures of (a) C-SGDBR (b) PPS-SGDBR and (c) simulated reflectivity of the two SGDBRs, *P* is the sampling period.

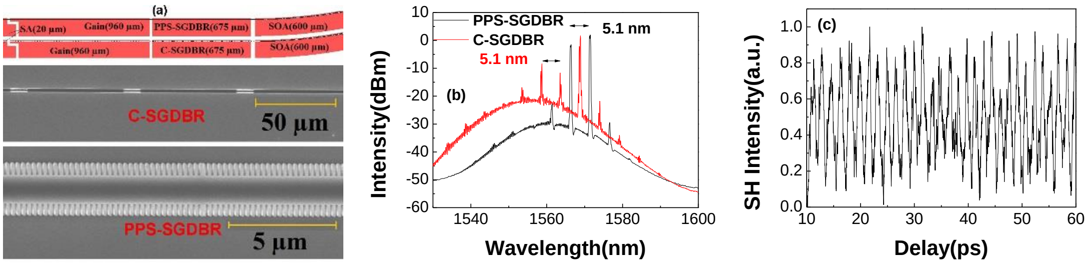

Fig. 2. (a) Device structures based on C-SGDBR and PPS-SGDBR and their SEM pictures, (b) the optical spectrum measured at V_{SA}=-3 V, I_{Gain}=144 mA, I_{DBR}=10 mA, I_{SOA}=150 mA and (c) measured autocorrelation trace for PPS-SGDBR.

Figure 1 illustrates a C-SGDBR and a π-phase shifted SGDBR (PPS-SGDBR). When the duty cycle of the PPS-SGDBR is chosen to be P_1/P=0.25, the different order peaks in the reflection spectrum are most uniform. The effective κ of the PPS-SBG is expected to be more than three times ((67.5-2×17)/10=3.35) that of a C-SGDBR and nearly 1/2 (((67.5-2×17)/67.5=0.4963) that of a uniform grating. Transfer matrix simulations of the reflectivity of the two kinds of SGDBR, calculated confirm this analysis (Fig. 1(c)).

We have fabricated THz repetition frequency MLLs monolithically integrated with semiconductor optical amplifiers based on these gratings (Fig. 2(a)). The 0th order gratings have a period of 246 nm, sampling period P=67.5 µm, and the grating burst P_1=10 µm and 17 µm for the C-SGDBR and PPS-SGDBR respectively. The epitaxial structure and fabrication processes are similar to those described in [3]. Figure 2(b) shows the corresponding lasing spectra under operating conditions indicated in the caption. In our devices, the uniform grating κ≈23.2 cm^{-1}, lower than the designed value of 80 cm^{-1} because of the reactive-ion etch lag effect. However, the effective κ of the PPS-SBG is significantly larger than that of the C-SGDBR, giving a clearer and sharper reflection comb with a wavelength spacing of 5.1 nm. The measured autocorrelation trace of the PPS-based devices is shown in Fig. 2(c). The average period of the pulse train was 1.6 ps, corresponding to an F_r of 620 GHz, and the pulse width was 0.67 ps, assuming a sech^2 pulse shape. The fabrication of the devices is straightforward using conventional EBL and requires no regrowth.

References

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