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DFB Laser Arrays with Precise Channel Separation and High Coupling Coefficient

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Distributed feedback (DFB) semiconductor laser arrays operating at precisely controlled wavelengths are important components for wavelength division multiplexing networks. Recently, precise wavelength control has been realized by the reconstruction-equivalent-chirp (REC) technique based on sampled Bragg gratings (SBGs) [1]. However, the effective coupling coefficient, κ, of a sampled grating is necessarily reduced substantially from that of a uniform grating, compromising the single longitudinal mode (SLM) performance of DFB lasers. To overcome this, designs of SBGs with phase shifted grating sections have been proposed and demonstrated in fibre lasers. In these structures, the (not required) zeroth-order mode is suppressed while the index modulation experienced by the nonzeroth-order channels is enhanced, the $\pm 1^{st}$ order channels being of particular interest [2]. Here, for the first time, we apply a combination of π-phase shifted gratings with the REC technique to DFB diode lasers. Using a single electron beam lithography (EBL) step we have demonstrated an increased effective coupling coefficient κ and have fabricated an eight-channel laser array with a spacing of 100 GHz (~0.8 nm @1550 nm). For the same channel spacing using conventional 0^{th} order gratings (Fig. 1(a)), a resolution of about 0.125 nm would be required, which is beyond the typical resolution limit of 0.5 nm of EBL machines.

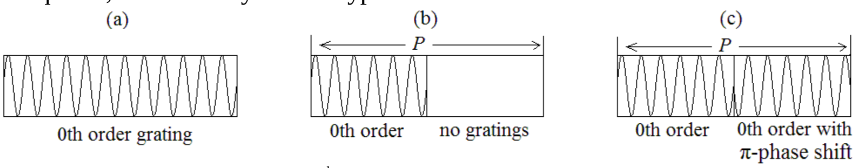

Fig. 1 Grating structures of (a) uniform 0^{th} order grating (b) C-SBG (c) PPS-SBG, *P* is the sampling period

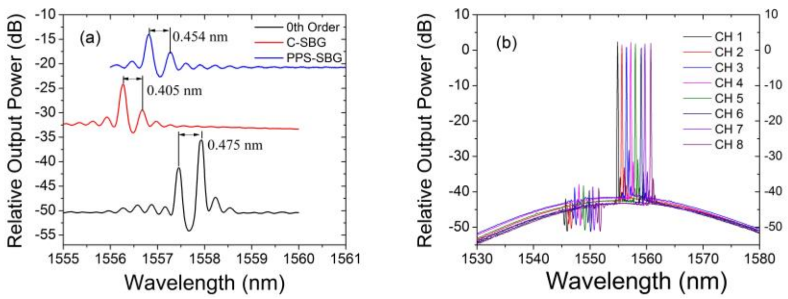

Fig. 2. (a) The optical spectrum below threshold @ 50 mA (b) The optical spectra of the laser array @ 100 mA

The DFB lasers are based on ridge waveguides with sidewall gratings written by EBL [3], with 1.2 mm cavity lengths. Figure 1(a) shows a uniform 0^{th} order grating, Fig. 1(b) shows a conventional SBG (C-SBG), and Fig. 1(c) illustrates a π-phase shifted SBG (PPS-SBG). To obtain the largest κ, the duty cycle of the C-SBG was chosen to be 0.5. Thus, when we choose $\pm 1^{st}$ order channels as the working channels, the effective κ of the PPS-SBG is expected to be 2× as large as that of a C-SBG and 2/π that of a uniform grating [2]. Figure 2(a) shows the spectrum below threshold for the three structures of Fig.1; the stop bands can be clearly seen. For uniform 0^{th} order gratings with a period of 243 nm, the stop band width is 0.475 nm, the largest of the three structures. For the SBG structures, the grating and sampling periods are 260 nm and 3.712 μm respectively. The stop band width of the C-SBG is 0.405 nm and that of the PPS-SBG is 0.454 nm. Since the stop band width is related to the effective index modulation, the effective κ of the PPS-SBG is significantly larger than that of the C-SBG, but, as expected, still below that of the uniform grating. Using this technique, we fabricated an eight-wavelength laser array whose lasing spectra are shown in Fig. 2(b). The channel spacing is designed to be 100 GHz. By linear fitting, the average wavelength spacing is 0.837 nm with a residual of 0.059 nm. The fabrication of the lasers is straightforward using conventional EBL and requires no regrowth.

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