Novel Sampled Grating Design for High Precision, Multiple Wavelength DFB Laser Arrays

Song TANG[1], Lianping HOU[1], Iain EDDIE[2], Xiangfei CHEN[3], John H. MARSH[1*]
[1]University of Glasgow, School of Engineering, Glasgow, G12 8QQ, U.K.
[2]CST Global Ltd., 4 Stanley Blvd, Blantyre, Glasgow, G72 0BN U.K.
[3]Nanjing University, College of Engineering and Applied Sciences, Nanjing, 210093, China
*john.marsh@glasgow.ac.uk

Distributed feedback (DFB) semiconductor laser arrays are important components for wavelength division multiplexing networks. Recently, the reconstruction-equivalent-chirp (REC) technique, based on sampled Bragg gratings (SBGs), has been applied to DFB laser arrays to give precise wavelength control [1]. Rather than operating at the 0^{th}-order reflection of the Bragg grating, the lasers make use of either the $+1^{st}$- or -1^{st}-order reflections. However, the effective coupling coefficient, κ, of a sampled grating is reduced substantially from that of a uniform grating, because of the reduced duty cycle of the grating and because the effective index modulation seen by $\pm1^{st}$-order reflections is only $1/\pi$ times that of the 0^{th}-order reflection. 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) 0^{th}-order mode is suppressed while the index modulation experienced by reflection orders is enhanced [2]. Here we have designed gratings using the REC technique with π-phase shifted gratings for DFB diode lasers.

The device layout, fabricated devices and a fabricated grating are shown in Fig. 1. Three different gratings were studied: a uniform 0^{th}-order grating, a conventional SBG (C-SBG), and a π-phase shifted SBG (PPS-SBG) shown in Figures 2(a), (b), (c) respectively. The largest κ for a C-SBG is obtained with a duty cycle of 0.5, which reduces the effective κ of the $\pm1^{st}$-order reflections by a factor of π relative to that of the 0^{th}-order refection from a uniform grating [2]. The effective κ of the $\pm1^{st}$-order reflections from the PPS-SBG should therefore be $2/\pi$ times that of a uniform grating.

For the uniform 0^{th}-order gratings, the period was 243 nm; for the SBG structures, the grating and sampling periods were 260 nm and 3.712 μm respectively. Figure 3(a) shows the spectrum just below threshold for the three structures of Fig.2; the stop bands can be clearly seen and their widths are listed in Table 1. Also shown in Table 1 are the stop band widths, calculated using a simple transfer matrix approach, for uniform passive waveguides for three different values of κ (Fig. 3(b)). Stop bands of active structures are significantly smaller than for passive waveguides because of the effect of the laser gain. In order to relate the measurements on active devices with the modelling results for passive waveguides, we have calculated the ratio of the stop bands for active and passive structures and shown it is almost constant (0.6 ± 0.03). Based on this simple approach, we conclude the effective coupling coefficients are approximately in the expected ratios of 1 : 1/π : 2/π for uniform : C-SBG : PPS-SBG.

We have also fabricated an eight-wavelength laser array using PPS-SBG whose lasing spectra are shown in Fig. 3(c). 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.

Table 1. Properties of modelled and measured gratings

Grating type	C-SBG	PPS-SBG	Uniform
Measured stop band / nm	0.405	0.454	0.475
Uniform grating equivalent κ / cm^{-1}	7.4	14.8	23.2
Uniform grating passive stop band / nm	0.645	0.719	0.835
Ratio of {measured/passive stop band}	0.63	0.63	0.57

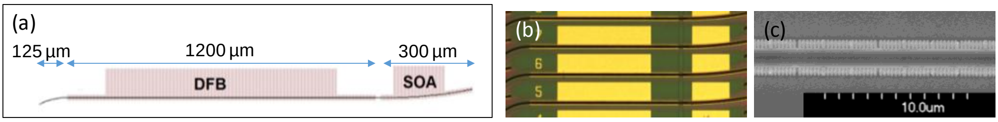

Fig. 1. (a) Device schematic, (b) micrograph of fabricated device, and (c) π-phase shifted sampled Bragg grating (PPS-SBG) in DFB section.

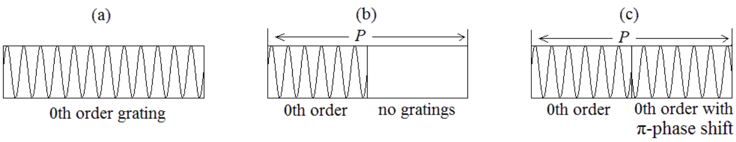

Fig. 2. Grating structures of (a) uniform 0th order grating (b) conventional sampled Bragg grating (C-SBG) (c) π-phase-shifted SBG (PPS-SBG). *P* is the sampling period.

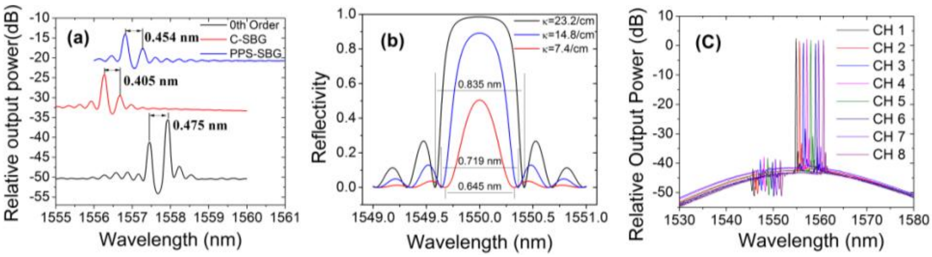

Fig. 3. (a) Spectra of lasers just below threshold (50 mA) with uniform 0th order grating, C-SBG, and PPS-SBG, (b) calculated stop bands of passive laser waveguides, and (c) optical spectra of the laser array.

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