Equivalent Chirped Bragg Gratings on SOI using Optical Lithography

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Chirped Bragg gratings play an important role in photonics. Figure 1(a) is a schematic of a chirped grating on a waveguide where the local grating period Λ(z) is a function of position *z*. Apodization, i.e. gradually increasing and then decreasing the grating strength along the waveguide, is generally required in chirped grating to reduce the side lobes in the filter reflection spectrum. This is usually accomplished by varying the grating's duty cycle [1]. To make an accurate chirping profile Λ(z) with apodization, high pattern-placement accuracy is required. Chirped gratings are generally made using electron-beam lithography (EBL) [2]. However, EBL lacks long-range spatial-phase coherence due to electrical charging and other influences.

Previously we described the Sampled-Bragg-Grating (SBG) technique to achieve quarter-wave phase-shifted gratings [3]. Here we describe a more complex application of the SBG technique: an apodized chirped grating achieved without the use of EBL. A uniform grating is first produced by interference lithography, which has the required long-range spatial-phase coherence. Then using low-cost optical-contact lithography, the uniform grating is modulated by a quasi-periodic sampling function *S*(*z*), where its local sampling period *P*(*z*) is a function of position *z*, as shown in Fig. 1(b) and Fig. 2(a). The SBG has a multi-channel reflection response, as shown in the inset of Fig. 2(b). If the sampling period *P*(*z*) is chirped, as shown in Fig. 2(a), an equivalent chirp is introduced in the -1st channel, as shown in Fig. 2(b) where a linear group delay is achieved. Therefore, chirping the sampling function *P*(*z*) is equivalent to chirping the grating period Λ(z) in conventional chirped grating. One advantage of this SBG technique is that the sampling period can be much larger than the fundamental grating period Λ_0 ($P(z)/\Lambda_0>100$), making it easier lithographically to fabricate. In other words, the requirement of pattern placement accuracy in SBG is relaxed by more than a factor of 100. Another advantage is that, the apodization in SBG is realized by varying the duty cycle of sampling period *P* (as shown in Fig. 2(a)) instead of grating period Λ, which, once again, is easier to fabricate. Figure 3 shows SEM images of an application of the SBG technique. Fabrication techniques and optical characterization of the equivalent chirped Bragg grating will be reported.

References:

[1] D. Wiesmann, *et al*, IEEE Photon. Technol. Lett. **22**, 6 (2000)
[2] C. Rogers, *et al*, J. Vac. Sci. Technol. B **17**, 6 (1999)
[3] J. Sun, *et al*, in *EIPBN*, Anchorage, AK, 2010; submitted to Optics Lett.

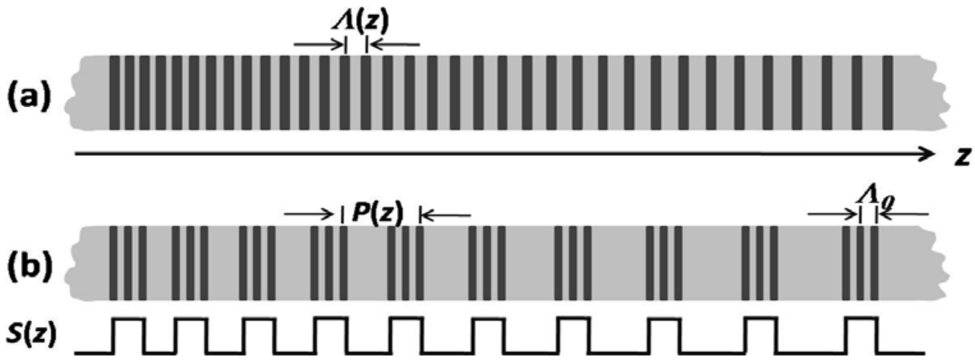
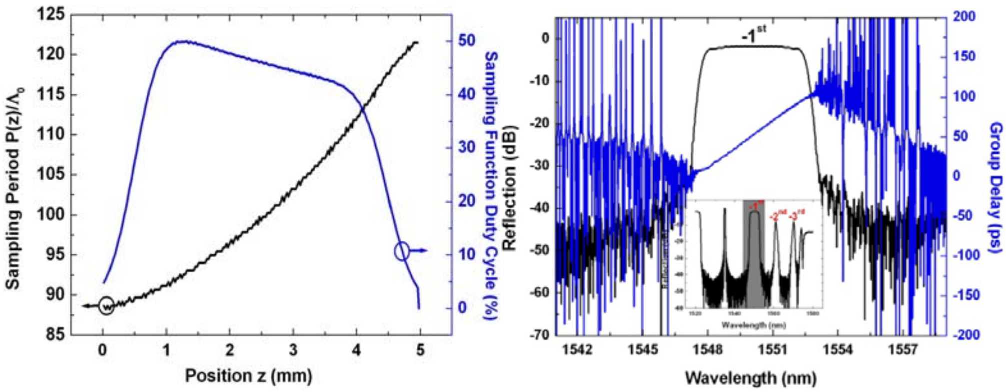


Fig. 1 Schematics of (a) a conventional chirped grating; (b) an equivalent chirped grating using SBG technique



(a) (b)

Fig. 2 (a) Sampling period $P(z)$ and sampling duty cycle as a function of position z in a sampled grating. (b) Simulated reflection and group delay spectrum of the -1st channel of an equivalent chirped grating using SBG technique (inset: the entire reflection spectrum)

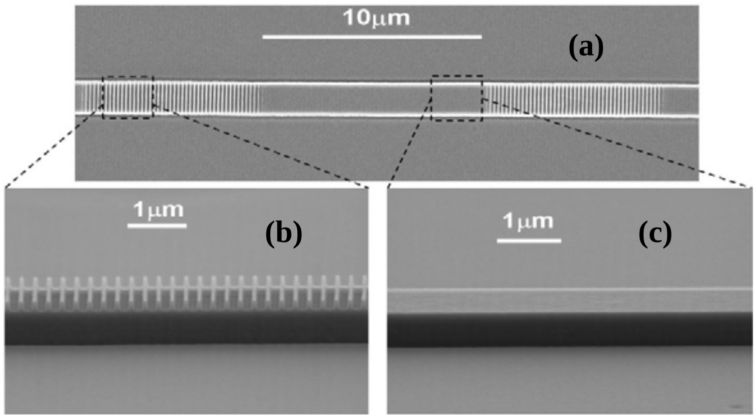


Fig. 3 Scanning-electron micrographs of an application of the SBG technique: (a) top-view of the sampled grating; a zoom-in view of the section where (b) sampling modulation is on, and (c) sampling modulation is off