Resonant Grating Based Fabry-Perot Cavity in AlGaAs/GaAs

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***Abstract* — We present a lithographically tunable, resonant subwavelength grating based Fabry-Perot cavity structure for mutliwavelength array devices. Theoretical and experimental performance of the cavity is discussed.**

I. Introduction

Multiwavelength array devices are a key component for short reach optical interconnections. High spatial frequency structures have been proposed for a variety of applications [1]. Recently Mateus et al. have designed and fabricated a broadband reflector based on a Subwavelength Grating (SWG) in Silion-on-Insulator (SOI) [2]. An SWG reflector (SWGR) with a high (>99.9%) reflectance would be an attractive choice for a top mirror in a Vertical Cavity Surface Emitting Laser (VCSEL) [3], allowing for lithographic control of the lasing wavelength and thus monolithically integrated multiwavelength laser arrays. Recently, we proposed a high reflectance SWGR to be used as the top reflector of an active device in AlGaAs/GaAs [4], operating at 850nm, using a suspended grating structure. In this article, we describe the modeling (section 2), fabrication (section 3) and finally optical measurements (section 4) of a SWGR Fabry-Perot cavity fabricated using an oxidized AlGaAs layer as the low index material.

II. Reflector and Cavity Design

We have optimized the design of the structure where a subwavelength grating of period Λ, duty factor α and thickness t_G is located above a low index material of thickness t_{LOW} and a thick substrate, shown in the upper part of Fig. 1.

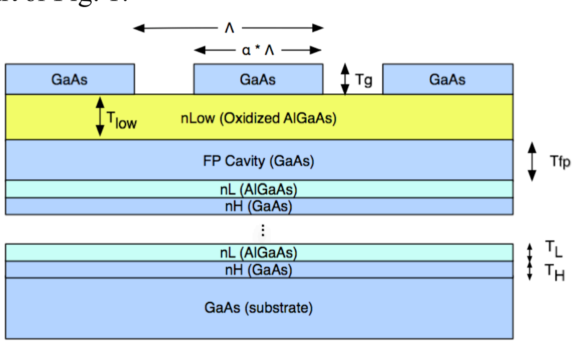

Fig. 1. SWGR Design.

For both the grating and substrate, we chose GaAs as the material and we chose oxidized AlGaAs as the low index material. The design is optimized using Rigorous Coupled Wave Analysis (RCWA). The SWGR reflection for various grating duty factors is shown in Fig. 2. The optimization results in an SWGR (Λ = 384nm, α = 0.68, t_G = 157nm, t_{LOW} = 480nm) that is lithographically defined (by adjusting period and duty) for a reflection R > 99.99% over a wavelength range of more than 200nm. The performance of finite SWGR is confirmed with FDTD.

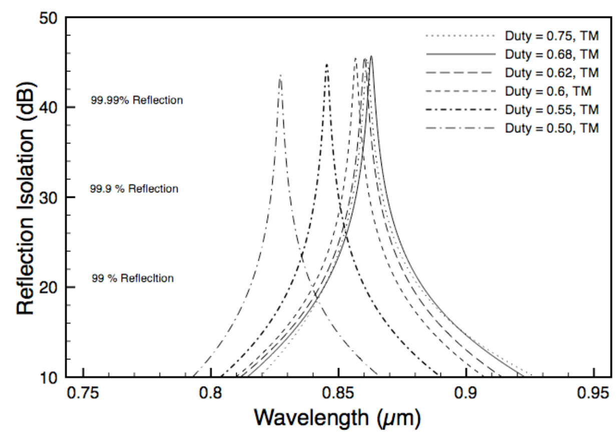

Fig. 2. SWG duty factor impact on reflection.

A 30-pair DBR mirror is combined with the SWGR to form a Fabry-Perot (FP) cavity (Fig. 1). Simulations show that the cavity reflection peak can be adjusted by more than 30nm around 860nm. A high Q (>10^4) can be achieved lithographically over a 30nm range around 860nm, as shown in Fig. 3.

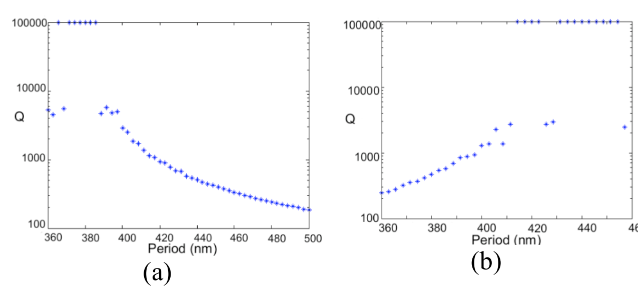

Fig. 3. SWG based Cavity Q behavior for different operating wavelength: a) 844nm and b) 875nm.

III. Fabrication

Devices were fabricated on a wafer with a 160nm thick GaAs top layer, a 480nm thick $Al_{0.90}Ga_{0.10}As$ layer followed by a 30 period distributed Bragg reflector consisting of alternating layers of 70nm thick $Al_{0.9}Ga_{0.1}As$ and 60.3nm $Al_{0.12}Ga_{0.88}As$, on a GaAs substrate. The gratings were patterned using electron-beam lithography. After development, the sample was etched in an electron cyclotron etcher in BCl_3 plasma at 10W RF power. A 10 second 1:25 BOE:DI H_2O dip was then performed on the sample to remove any particulates which might have been deposited during dry etching. Wet oxidation was then conducted at 440 °C for one hour [6]. Fig. 4 shows the fabricated gratings. The achieved grating period was 384nm and duty cycles ranged from 0.38 to 0.73.

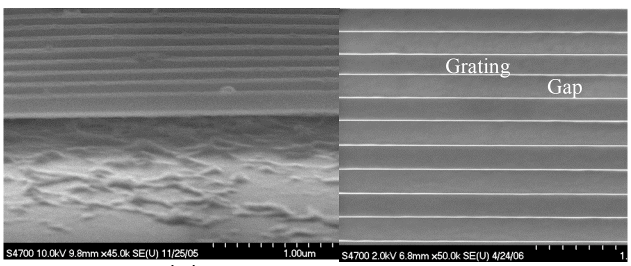

Fig. 4. Fabricated SWG structure a) side view of suspended grating, b) top view of oxide grating.

IV. Results and Discussion

Reflectivity measurements of the sample were conducted using a halogen light source and a fiber-based reflectivity measurement apparatus. Reflectivity for a SWGR cavity with a duty cycle of 0.47 is shown for 0° and 90° polarizations in Fig. 5.

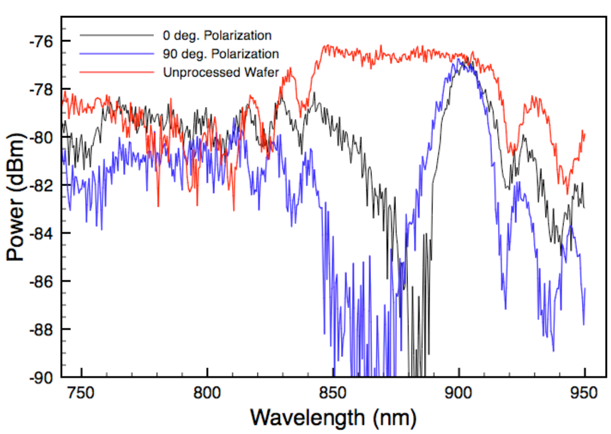

Fig. 5. Measured reflectivity spectrum of SWG based FP cavity.

The notch in the spectrum occurs at a wavelength of 882nm. The 3dB bandwidth of the reflectivity spectrum obtained for 90° polarized light was 23nm, while that for 0° polarized light was 13nm. Preliminary Q measurements results are low (<100), however work is being done which is aimed at increasing the quality factor by improving the fabrication uniformity, with the goal of fabricating SWGR-based VCSELs.

V. Conclusion

We have presented the design for a very high reflectance (99.99%) lithographically adjustable (200nm) SWGR used as the top mirror of a lithographically adjustable Fabry-Perot cavity. The structure can be used to fabricate monolithically integrated multiwavelength arrays of devices at 850nm. Modeling predicts a lithographically adjustable range of more than 30nm for the cavity. SWGR and SWGR-based cavity structures have been successfully fabricated. The impact of the duty factor and polarization on the cavity peak wavelength shift has been observed.

Acknowledgements

This work was supported by NSERC and by the Canadian Institute for Photonic Innovation (CIPI). The authors would also like to acknowledge the Western Canada Research Grid computation facilities and Lumerical FDTD.

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