High-Q Distributed-Bragg-Grating Laser Cavities

E.H. Bernhardi*, H.A.G.M. van Wolferen, K. Wörhoff, R.M. de Ridder, and M. Pollnau

Integrated Optical Microsystems Group, MESA+ Institute for Nanotechnology, University of Twente,
P.O. Box 217, 7500 AE Enschede, The Netherlands
* Corresponding author: e.h.bernhardi@ewi.utwente.nl

Abstract

Applying Bragg gratings in Al_2O_3 channel waveguides, we demonstrate distributed Bragg reflectors with Q-factors of 1.02×10^6. An integrated Al_2O_3:Yb^{3+} waveguide laser with 67% slope efficiency and 47 mW output power is achieved with such cavities.

1. Introduction

The ability to integrate Bragg grating structures with optical waveguides provides the opportunity to realize a variety of compact monolithic optical devices, such as distributed feedback (DFB) lasers [1], and distributed Bragg reflector (DBR) lasers. In this work, we report passive DBR cavities with record-high Q-factor and laser operation of actively doped DBR cavities with record-high slope efficiency.

2. High-Q distributed Bragg grating cavities

Undoped and Yb-doped Al_2O_3 layers were deposited on thermally oxidized silicon wafers by reactive co-sputtering [2], and microstructured channel waveguides were fabricated by standard photolithography and subsequent chlorine-based reactive ion etching [3]. After depositing a SiO_2 upper cladding by plasma-enhanced chemical vapor deposition, Bragg gratings were patterned into a photoresist by laser inteference lithography and etched into the waveguide cladding [4]. Transverse and longitudinal cross-sections of the resulting structure are shown in Fig. 1. Since the grating is located in the cladding, the spatial overlap between the guided mode and the grating is only ~0.15% [4].

Transmission measurement performed on passive uniform Bragg gratings resulted in high reflectivities, exceeding 99% (Fig. 2a). DBR cavities formed by two such Bragg gratings generate a resonance within the reflection band (Fig. 2b), resulting in a record-high Q-factor of 1.02×10^6 (Fig. 2c).

3. Highly efficient distributed Bragg grating laser

Applying such monolithic distributed Bragg reflector cavities to actively Yb-doped Al_2O_3 channel waveguides produces highly efficient laser emission. The DBR cavity was formed by two 3.75-mm-long integrated Bragg reflectors on either side of a 2.5-mm-long grating-free waveguide region, to form a total DBR cavity length of 1 cm (Fig. 3a). The device was optically pumped with a 976-nm laser diode. Single-longitudinal-mode and single-polarization operation was demonstrated at a wavelength of 1021.2 nm. The measured linewidth was limited by the 0.1-nm resolution of the optical spectrum analyzer. Continuous-wave output powers of up to 47 mW and a launched pump power threshold of 10 mW resulted in a slope efficiency of 67%.

Acknowledgement

Funding was provided by the Smartmix Memphis programme of the Dutch Ministry of Economic Affairs.

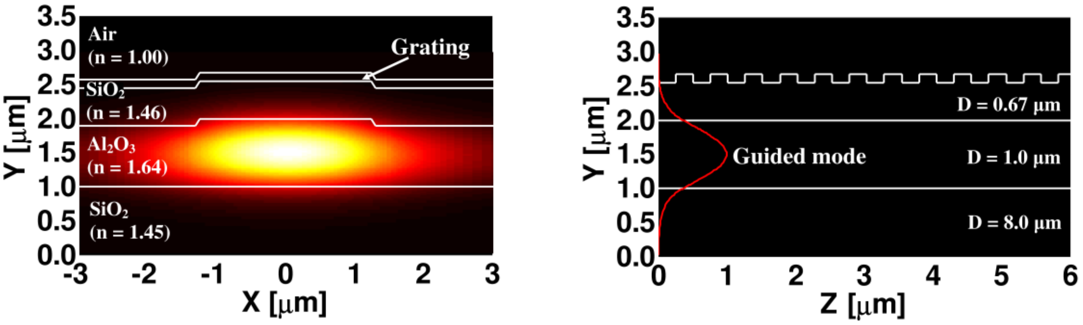

Figure 1. (a) Transverse cross-sectional view of the waveguide structure showing the calculated mode profile; (b) axial cross-sectional view of the waveguide structure showing the thickness *D* of each layer [4].

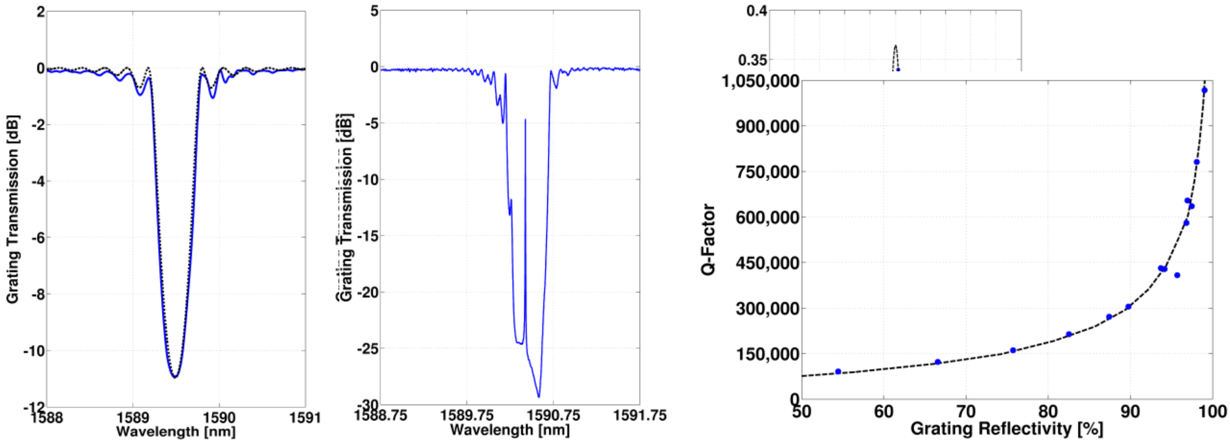

Figure 2. (a) Measured (solid line) and calculated (dashed line) grating transmission spectrum of a 3-mm-long uniform Bragg grating for TE polarization; (b) measured transmission spectrum for a DBR cavity with 4.75-mm-long Bragg reflectors for TE polarization; (c) measured (points) and calculated (dashed line) Q-factors [4].

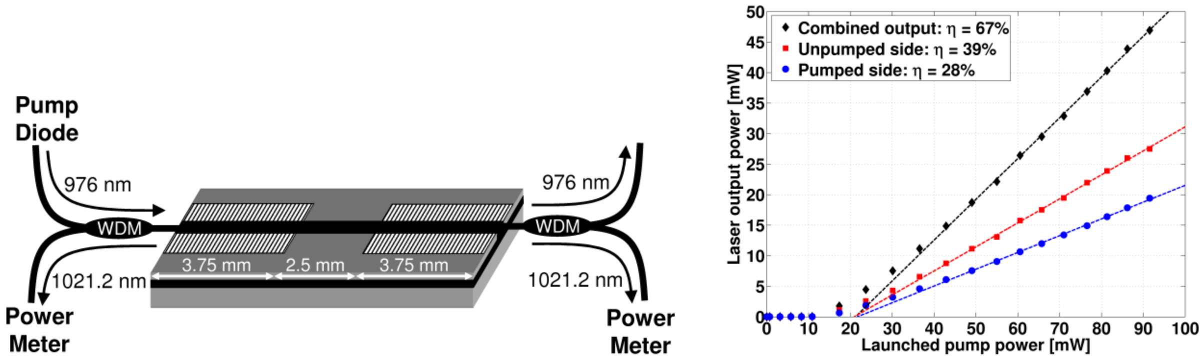

Figure 3. (a) Experimental setup for characterizing the performance of the Al_2O_3:Yb^{3+} DBR waveguide laser; (b) measured power characteristics of the Al_2O_3:Yb^{3+} DBR waveguide laser [5].

References

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