

Arrayed Waveguide Grating Spectrometer on 2- μm -thick SOI Platform

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Abstract. 32-channel arrayed waveguide grating spectrometer (AWG) at 1800 nm is demonstrated on a 2- μm -thick silicon-on-insulator (SOI) platform. The design and simulation of the device are performed using the beam propagation method (BPM) and we obtain the 3-dB channel width, channel spacing, and extinction ratio of 1.16 nm, 1.56 nm, and 5.17 dB, respectively. The AWG demultiplexer can be applied in the central part of a spectrometer which is replacing in integrated optics a prism or a grating in conventional free-space optics.

1 Introduction

Arrayed waveguide gratings (AWGs) have been implemented in several materials and platforms such as silica, polymers, titanium dioxide, silicon nitride, and strip-loaded slot waveguides [1] - [5]. A silicon-on-insulator (SOI) wafer is however a fascinating platform for AWGs. It regards as a high-index-contrast platform and provides sharp-bend radiuses which lead to even more compact devices. The fabrication procedures are moreover compatible with a complementary metal-oxide-semiconductor (CMOS) technology which allows high-density integration of several photonic devices on a single chip [6]. In addition to the footprint of the device, SOI-based AWGs also offer low insertion losses and crosstalk in near- and mid-infrared [7] - [8]. Micro-scale Si waveguides provide ultra-low loss (~ 0.1 dB/cm), polarization independency, and a wide wavelength range operation from 1.2 to 4.0 μm which is suitable for spectroscopy. This type of waveguide has been introduced to several integrated optical devices, including AWGs [9]. AWGs are demonstrated on a 4- μm -thick SOI rib waveguide with the integration of variable optical attenuators to equalize a multiwavelength source [10] - [11]. A 3- μm -thick SOI is used to design an ultrawide-band AWG which operates from O- to L- band. The device offers very low loss, crosstalk, and polarization-dependent wavelength shift (PDWS) [12]. In this work, we present the design and simulation of an SOI-based AWG demultiplexer at the center wavelength of 1800 nm. The AWG is realized on a 2- μm -thick ridge waveguide which demultiplexes thirty-two wavelengths in a range of $1770 \text{ nm} \leq \lambda \leq 1830 \text{ nm}$.

2 Methodology and Results

We design an AWG on a thick SOI ridge platform which consists of the width (W) = 4 μm and height (H) = 2 μm and the refractive indexes of silicon (Si) and silicon dioxide (SiO_2) at $\lambda_c = 1800 \text{ nm}$ are $n_{\text{Si}} = 3.4597$ and $n_{\text{SiO}_2} =$

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Table 1: Design Parameters

Parameter	Notation	Value
Core effective index	$n_{\text{eff, core}}$	3.46
Cladding effective index	$n_{\text{eff, clad}}$	1.00
Array waveguides number	N	152
Output waveguides number	N_{ch}	32
Diffraction orders	m	58
Output waveguide separation	D	5.80 μm
Array waveguide separation	Λ	4.00 μm
Slab region length	f	3020 μm
Length increment	ΔL	8.87 μm

1.441, respectively. The geometry of the ridge waveguide is shown in Fig. 1a) and due to the high refractive index contrast between Si and SiO_2 , one can observe the strong optical confinement of the fundamental quasi-TE mode inside the waveguide, as illustrated Fig. 1b).

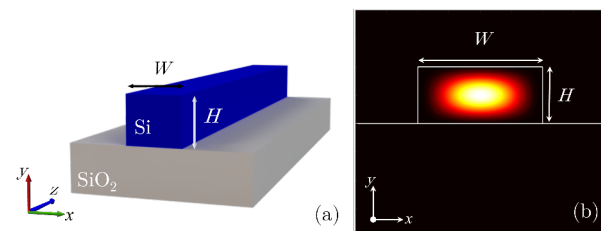


Figure 1: (a) Schematic of a ridge waveguide on silicon-on-insulator platform. (b) The intensity distribution of the fundamental mode in the silicon ridge waveguide ($W = 4 \mu\text{m}$, $H = 2 \mu\text{m}$).

The parameters of the ridge waveguide are utilized to approximate the effective refractive indexes of core ($n_{\text{eff, core}} = 3.45$ and cladding ($n_{\text{eff, cladd}} = 1$ waveguides, and we perform the design and simulation using the beam propagation method (BPM). The optical fields at the range

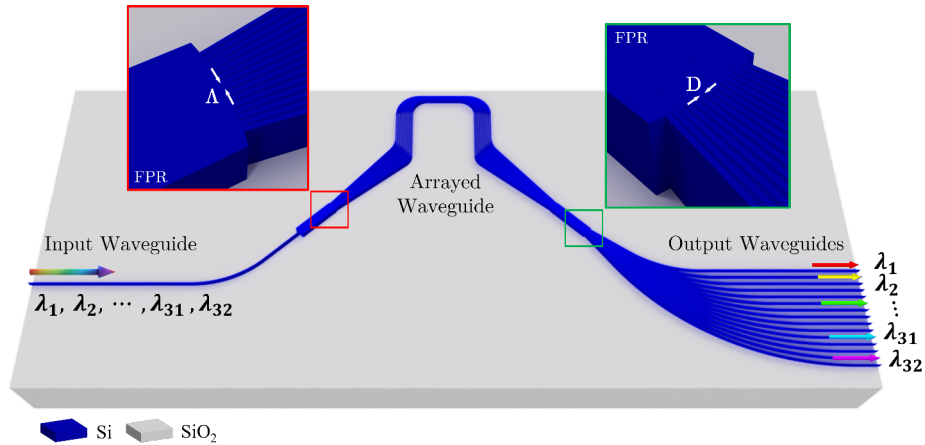


Figure 2: Schematic of the AWG on a thick SOI platform.

of $1770 \text{ nm} \leq \lambda \leq 1830 \text{ nm}$ with the center wavelength of $\lambda_c = 1800 \text{ nm}$ are used as the input wavelengths of the device. Moreover, the additional design parameters which are used to create the AWG structure are listed in table 1. and the geometry is depicted in Fig. 2.

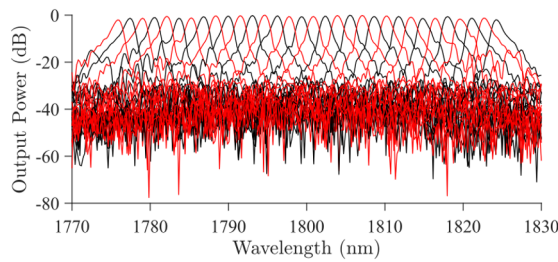


Figure 3: Schematic of the AWG on a thick SOI platform.

Fig. 3 shows the simulation result of the AWG at the range of $1770 \text{ nm} \leq \lambda \leq 1830 \text{ nm}$. We can see that there is thirty-two wavelength which is demultiplexed from the purposed device. The center wavelength is at 1800 nm with the channel spacing $\Delta\lambda = 1.56 \text{ nm}$. The output signals are well-separated which the extinction ratio $ER = 5.17 \text{ dB}$ and the bandwidth $\delta\lambda$ is 1.16 nm which is ideal for an optical spectrometer for sensing applications.

3 Conclusions

We present the design and simulation of an arrayed waveguide grating (AWG) on an SOI ridge waveguide platform with $W = 4 \mu\text{m}$ and $H = 2 \mu\text{m}$. The simulation of AWG is performed using BPM at the range of 1770 nm to 1830 nm and the center wavelength $\lambda_c = 1800 \text{ nm}$. The device demultiplexes thirty-two wavelengths with channel spacing $\Delta\lambda = 1.56 \text{ nm}$, extinction ratio $ER = 5.17 \text{ dB}$, and bandwidth $\delta\lambda = 1.16 \text{ nm}$.

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