GEOMETRY AND CHARACTERIZATION OF LOW INDEX SILICON MICRO RING RESONATORS

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ABSTRACT

An optical ring resonator is indeed a series of waveguides in which a closed loop coupled with some sort of input and output of light is at least one. The consequence of the index difference on dielectric waveguide characteristics such as single-mode process, losses, efficiency of fiber to waveguide coupling, minimum bending radius, hybridity mode, birefringence, polarization effects, repeatability and stability, integration size, realizable circuits, technical constraints and usable materials is indeed very significant for study. The purpose of this article is to analyze the effect of the features of the waveguide with regard to the index correlation and to explore the difficulties. This article assesses the effect of the intensity index on the characteristics of the dielectric waveguide, such as the single-mode device, losses, technical constraints and materials available. This work is an approximation for the design of optical waveguides, so that by lowering the silicon index, we can achieve versatility.

KEYWORDS

Micro-ring resonators, Rsoft CAD, 3D slice, wireframe

1. INTRODUCTION

The features of optical dielectric waveguides and integrated optical circuits are fundamentally connected to the difference between the center and the surrounding media in the refractive index. Furthermore, there are many different types of waves that can be guided, e.g. optical, sonic or electromagnetic, and each type requires a completely similar structure of the waveguide [1]. The geometry of a waveguide is an important factor for it to fulfill its intended function. Throughout the old days, technological constraints such as availability of materials, surface integration, accumulation methodologies, coating mechanisms and such have always been considered predetermined by the index contrast and are limited to the concept of low index contrast, glass-based materials, massive modes and adsorption technologies [2]. As an evolving semiconductor technology for optical telecommunications and optical interconnections [3-5], Silicon Photonics has gained attention in recent decades. The link between a very high index difference and the development of Semiconductor devices that also makes it possible photonic sensors to be designed utilizing electronic processing facilities, could be primarily attributed to it [6]. Reactive silicone waveguide interfaces appear to provide an incredible reduction throughout the size of its waveguide and extremely susceptible wavelength devices [7-9], a key element of which is the ring resonator. Each standard ring resonator consists of an optical wave guide that is looped back on itself, so that when the optical path length of the resonator is precisely a whole wavelength sequence [10], a resonance occurs. The purpose of such an introduction is to explore the emphasis on the index contrast of the waveguide specifications, to investigate the complexities and weaknesses of growing it and to illustrate the benefits of allowing the index contrast as a 'free' variable throughout the design phase of the waveguide [11-12]. While high contrast waveguides are more difficult to detect and also more important, there are no major impediments to their use [13].

The object of this study is to analyze the effect of the characteristics of the waveguide with regard to the contrast difference and to address the difficulties of fabricating rings. The article is presented into several major parts covering the role of index contrast in integrated optics, dielectric waveguide than on contrast properties, widely available methods and technology, and a conclusion is drawn on a new form of waveguide with a multilayer arrangement that aims to provide versatility to the engineers and designers.

2. DESIGN GEOMETRY

Low index contrast techniques, notably glass-on-silicon with $\Delta n = 0.01$, can be made completely established, resulting in waveguides differentiated by very high efficiencies (below 0.05 dB/cm), wide pattern range (that couples with very high performance standard optical fibers), low birefringence and, most significantly, a high degree of repeatability, reliability and stability from an industrial point of view. A special material mixture of Core/ Cladding (1.46/1.45 nm) is considered to achieve a mild differentiation of refractive records and re-enactments of the pattern are carried out via BeamPROP.

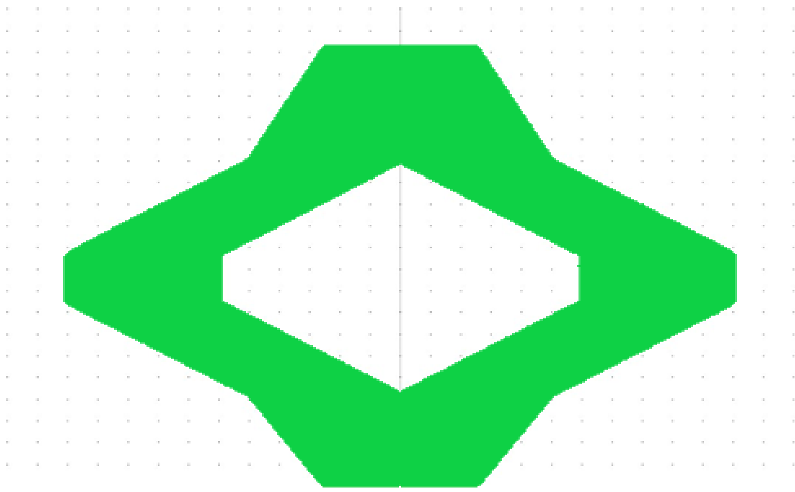


Figure 1: Design of a single ring resonator waveguide.

Figure-1 shows the design of a single ring resonator waveguide. When light of the resonant wavelength is passed through the loop from input waveguide, it builds up in the intensity over multiple round-trips due to constructive interference and is output to the output bus waveguide which serves as a detector waveguide. Because only a select few wavelengths will be at resonance within the loop, the optical ring resonator functions as a filter. For single ring resonator two Y-branch waveguides are needed to couple with each other that forms a ring structure.

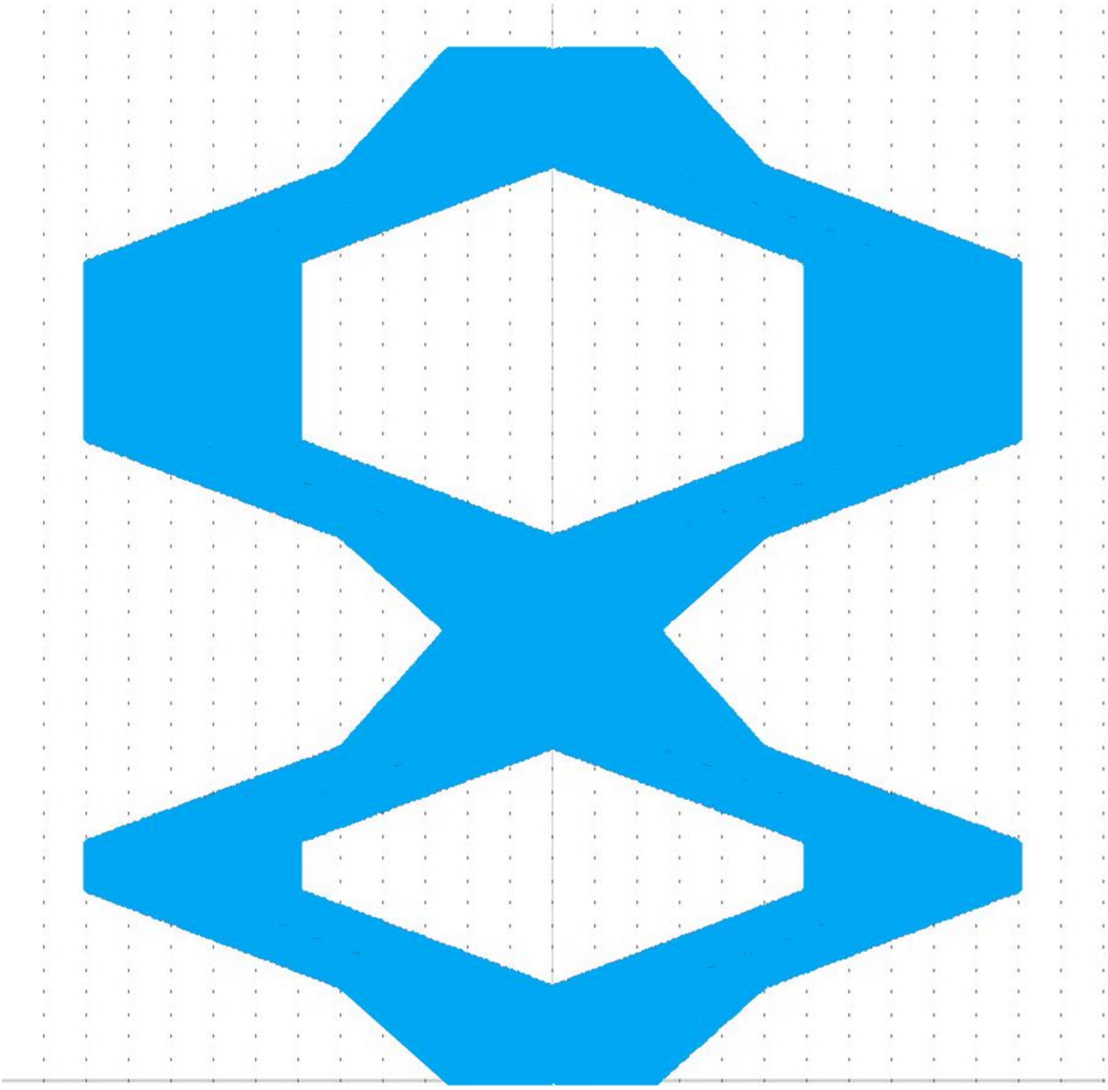


Figure 2: Design of a double ring resonator waveguide.

The configurations of the two -ring waveguide resonator are seen in Figure 2. In the systemically coupled setup, each ring resonator is coupled to each other and a signal to be collected from the interface port to the drop port can move in series over each resonator. With this serial power transmission, all resonators at an increasing wavelength need to be precisely resonant. The resulting resonant path configuration in the system's geometry is physically determined by the separations between the ring resonators. Both waveguide resonators are combined with the input and drop port in the perpendicular-coupled setup. Rather, the resonators are indirectly connected by the optical path lengths along the input and output waveguides which interconnect them. Such sizes define resonant layer design specifications.

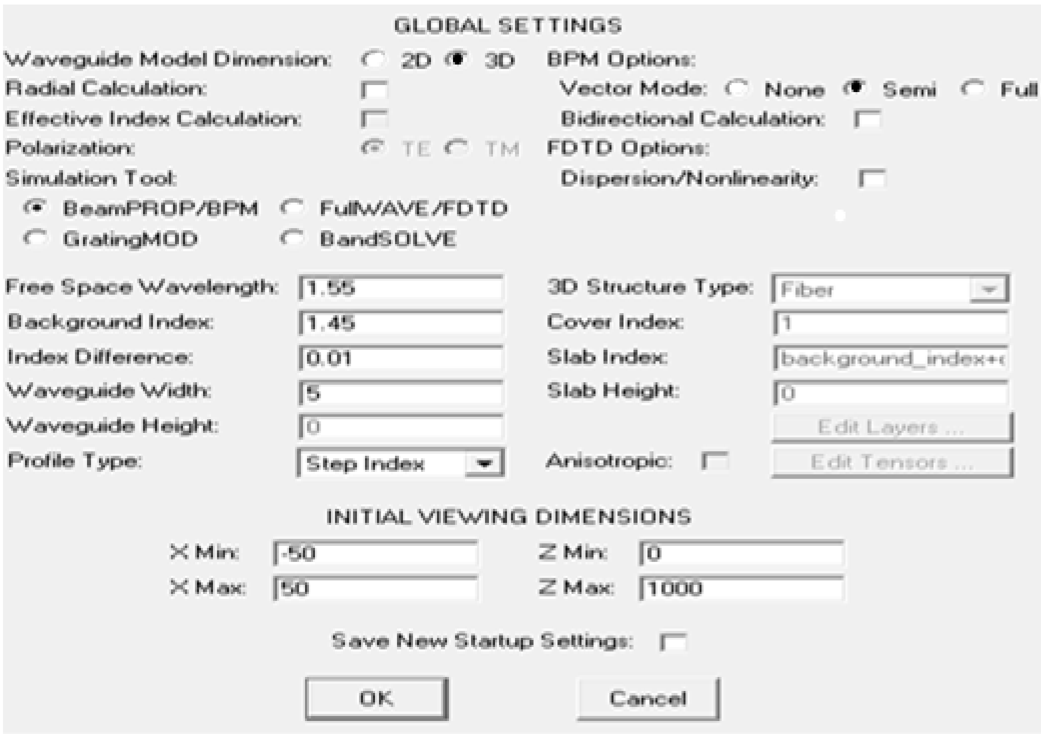
3. Characterization on Simulation Results

It was emphasized that the option of index comparison plays a key role in deciding the characteristics of the waveguides. Nevertheless, the material option available is constrained by design, and while many products have been studied over the years, only a few technical platforms have been tested. The properties of different geometries of Low Index Silicon Waveguides can be calculated following the simulation. We initially performed simulations for single rings in separate simulation modes and later adapted them for double rings. In fiber mode, for execution, the waveguide is called the ideal waveguide.

Table 1: Parameters used for computation

Parameter	***Description***	***Value***
Waveguide model dimension	Design for both 2D and 3D simulations	2D and 3D
Waveguide Width	Width (µm) of a component	5
Free Space Wavelength	Wavelength (µm) setting for the simulation	1.55
Background Index	Real refractive index of the background material	1.45
Index Difference	Contrast difference between a component and the background material	0.01

Table 2: Simulation parameter selection



Micro-Ring Resonator with Single Ring:

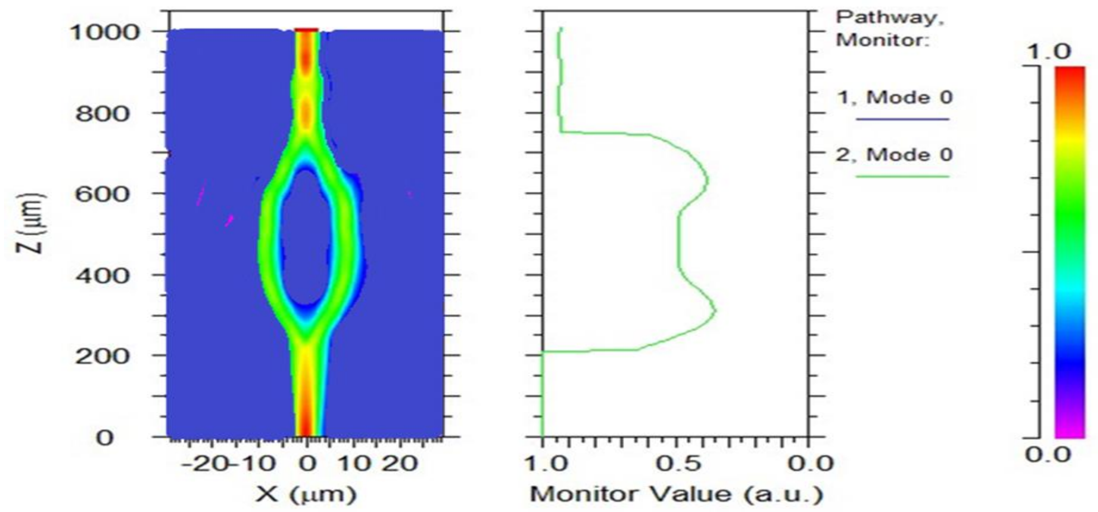


Figure 3: Result of Micro-ring resonator with single ring in Slab Mode.

The discussion based on earlier sections indicates that the refractive index profile greatly affects the key propagation features of optical waveguides and is a fundamental parameter of the design. Figure3 shows the simulation result of Micro-ring resonator with single ring in Slab Mode. We conducted the simulation with a very low contrast difference for a single ring waveguide. It is found from the simulation results that almost 91 percent of the input power is reflected at the output.

Micro-Ring Resonator with Two Rings:

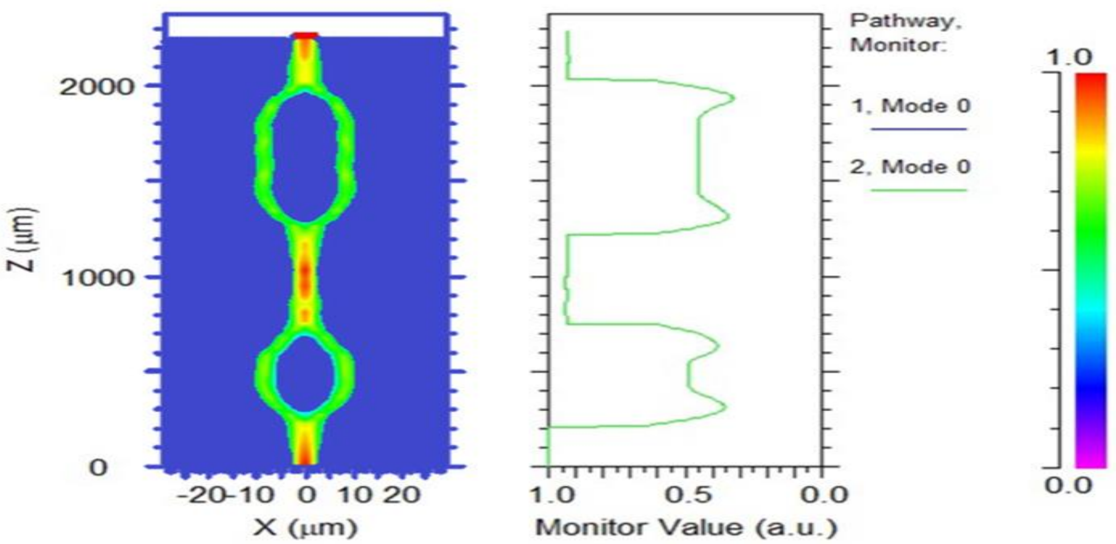


Figure 4: Simulation Effects of a double ring micro-ring resonator in Slab Mode.

The micro-ring resonator simulation outcome of two loops is reflected in Figure 4. The simulation of the double ring waveguide is performed with a very low index profile. We found that in slab mode, the power output is approximately 89 percent of its input power.

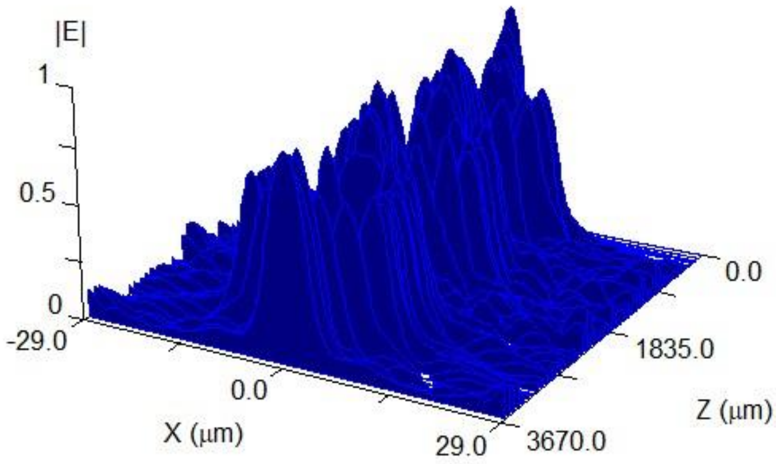


Figure 5: Double Micro-Ring resonator result in 3D slices view.

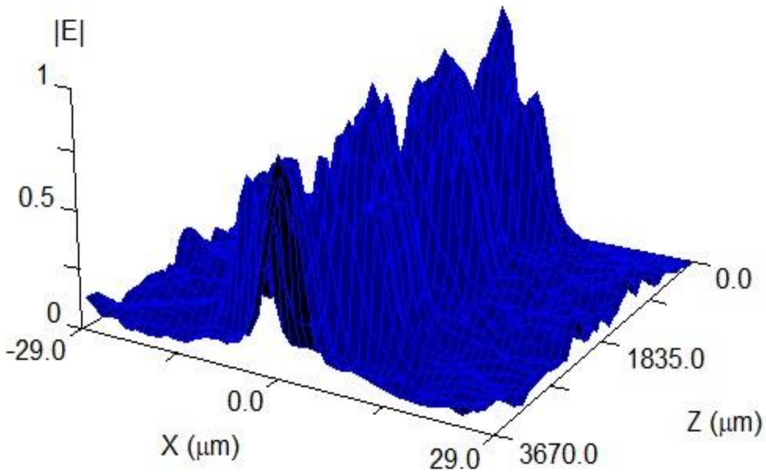


Figure 6: Result of Micro-ring resonator with three rings in wireframe.

The system's stability is illustrated by 3D slice view and Wireframe view, respectively included in Figures 5 and 6. In Figure 5 the field amplitude as a function of x and z is displayed as a 3D representation as a series of slices (at different z) and the field amplitude as a function of x and z as a 3D wire frame graph shown in Figure 6. It is found from the combined study of both statistics that the reliability of the system is noteworthy.

4. CONCLUSIONS

Intending to see all the index contrast as a relevant factor in the design of a dielectric waveguide, it is seen that if, on the one hand, increasing the contrast brings tremendous versatility to the design and optimization of integrated optical waveguides, and if, on the other hand, it is required for a large integration scale and the utilization of such essential functions such as ring resonators. The action of optical micro-ring resonators when acting as refractive index sensors was analyzed in detail in this work. The analysis reveals that in the low refractive index difference waveguide, the sensitivity reliance on the propagation of guided modes in optical waveguide sensors is lower than in silica on silicon waveguides, however it allows design engineers to be flexible. In this article we reproduce a specific material combination in order to achieve a fair refractive record differentiation, and design re-enactments are performed via BeamPROP. The 3D slice view and the Wireframe view demonstrate the architecture's performance and it is noticed that the device's stability from the combined analysis of both figures is exceptional. Our designed photonic waveguides will be substituted of electronic transistors because of slow and decaying electron characteristics.

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