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Optimization of Reluctance at 1310 Nm in SOI Grating Structure for Planar Light Wave Circuits

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ABSTRACT

Now days the top layer silicon is made inform of grating structure for the sake of Planner light wave circuits. The grating structure is consists of alternate layers of two materials, for an example alternate layers of silicon carbide and silicon monoxide. When light incidents on SOI waveguide light propagates through the grating. The efficiency of SOI waveguide depends on the grating structure, which is placed on the top of the insulator. In this research, we discusses about silicon grating SOI Structure. Mathematical analysis is described and simulation results with discussions are made for Si-SiC SOI grating structure.

Keywords: SOI, Si-SiC, CMOS

Introduction

Most common basic channel waveguide structures in silicon photonics, a field that is experiencing a dramatic increase in interest due to emerging application areas and several high profile successes in device and technology development, is grating structure on Silicon-On-Insulator (SOI) waveguides. Silicon photonics based on Silicon-On-Insulator (SOI) photonic waveguides is a promising technology for integrated photonics due to unique properties of the ultra-high index contrast silicon waveguide systems, and due to the use of advanced microelectronics manufacturing technologies.[1,2,3] The high index contrast of silicon grating structure allows for sharp waveguide bends with radii of just a few microns.[4] The footprint of silicon waveguide devices is therefore strongly reduced compared to classical bulk silicon substrate.[5] Now days, photonic crystals made from Silicon-On-Insulator (SOI) wafers are promising because we can make use of commercially available high-quality wafers and mature Si nano-fabrication technology.[6] In fact, the SOI-PC slab fabrication process is almost completely compatible with the conventional semiconductor device fabrication process.[7] When we are applying grating structure on silicon on insulator, we must deal with the efficiency of the same structure. The efficiency of grating structure depends on the optimization of reflectance and transmittance of the said structure.[8] This optimization is directly depends on the structure parameters. Keeping these views, one has to choose a grating parameters in such way that it will give minimum reflectance or maximum transmittance. These parameters are length of grating, grating periods, refractive indices and thickness of alternate layers of grating structure. Apart from this, the wavelength at which signal carries plays vital role for the sake of Planer light wave circuits. We know that wavelength 1310 nm is suitable for the same.

This chapter is organized as follows: section II, gives introductory concept of silicon *a* silicon grating SOI structure Results and analysis are presented in III.

Si- Si Grating SOI Structure

Now days silicon on insulator plays vital role in the field of photonic integrated circuits. A lot of optical functions are being carried out using silicon on insulator technology.[9]As far as fabrications are concerned, SOI yields low cost and more compatible.[10] SOI plays a vital role in the recent explosion of one dimensional photonic crystal structure.[11] Silicones large refractive index differences give big challenge to realize different types of optical structure.[12] The SOI structure can be used as waveguide in planar light wave circuits. To achieve high efficiency of PLC, one has to increase the efficiency of silicon on insulator waveguide. 1D grating SOI structure is used to obtain high efficiency. Recently, a high efficiency of grating structure is designed, which gives maximum throughput efficiency.[13] Basically an ordinary waveguide suffers to use in SOI due to different reasons, for example loss due to reflection at interface. This loss cannot be ignored, particularly in optoelectronic devices.[14] Here a grating structure is proposed to overcome this problem. The merit of using such structure is that the absorption loss is zero at the wavelength of 1310 nm.[15] Apart from this reflectance plays vital role for optimizing the efficiency of grating structure. The structure which gives high efficiency of 1D grating is schematically depicted in Figure 1.

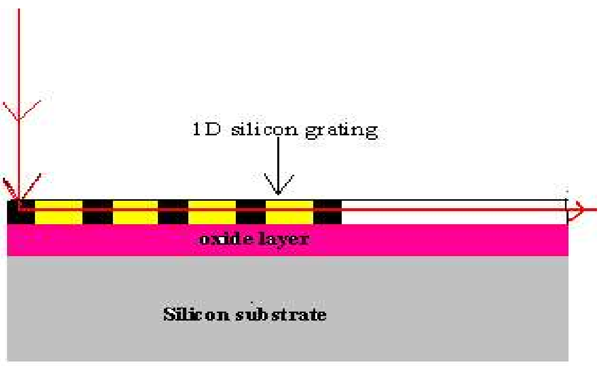

Figure 1.1D grating SOI structure

In Figure 1, a silicon epitaxial grating layer is grown on oxide layer, which is placed on silicon substrate. In this paper we propose a siliconsilicon grating structure. Though a number of papers have appeared in literature relating to absorption loss in SOI waveguides,[16,17] but to best of our knowledge, a very few papers deal with the reflection loss.[18] Moreover for the first time we have considered both absorption and reflectance loss at wavelength 1310nm because 1310nm as this wavelength is suitable for optical communication.

Here we considered a 1D grating structure by repeating silicon and *a* silicon and optimized its efficiency with respect to absorption and transmission loss using plane wave expansion method. A suitable configuration that can be used in optical interconnect is then investigated.

Result and Discussion

To achieve high efficiency of silicon grating structure, we opted zero absorption (absorption coefficient is zero) materials i.e. silicon-*a* silicon 1D grating. To find out minimum reflectance with respect to wavelength, we have carried out the simulation using plane wave expansion method for the variation of reflectance with respect to wavelength. The plane wave expansion method is thoroughly closer in chapter 3, section 3.3 In this case, we have carried out simulations using grating parameters such as refractive indices and thickness of grating layers.

Firstly, we have made simulation, choosing refractive index of silicon (n_1 = 3.449) and *a*-silicon (n_2 = 3.55) and thickness of silicon (t_1) 1µm, where as thikness of a-silicon (t_2) varies from 1µm to 10µm.

Simulation Result and Analysis for Thickness 1*µ*m of Silicon

For making simulation of grating SOI structure (Figure 1), we have used different input parameters of grating SOI structure, which is shown in Table 1.

Table 1.Various input parameters for simulations

Refractive index of silicon (n_1)	Refractive silicon (n_2)	Thickness of silicon in µm (t_1)	Thickness silicon µm (t2)
3.449	3.55	1	1
			2
			3
			4
			5
			6
			7
			8
			9
			10

Using data from Table 1, simulations are made for silicon-*a* silicon D grating using plane wave expansion method to find out wavelength for which minimum reflectance occurs. The simulation graphs for silicon-*a* silicon 1D grating structure having silicon thikness of 1µm and a silicon thikness from 1µm to 10µm is shown in Figure 2, 3, 4, 5, 6, 7, 8, 9, 10.

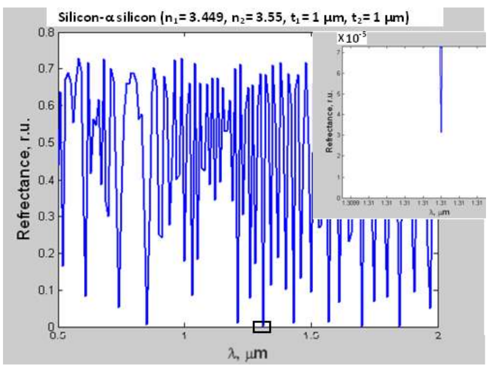

Figure 2.Silicon-*a* silicon (n_1 = 3.449, n_2 = 3.55, t_1 = 1 *µ*m, t_2 = 1*µ*m)

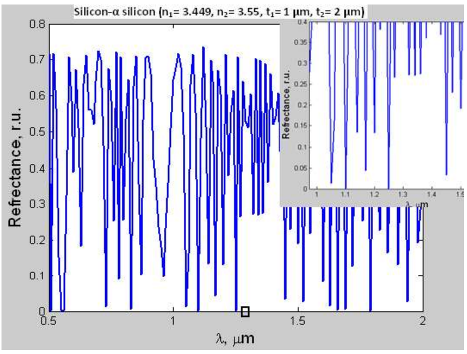

Figure 3.Silicon-*a* silicon (n_1 = 3.449, n_2 = 3.55, t_1 = 1μm, t_2 = 2μm)

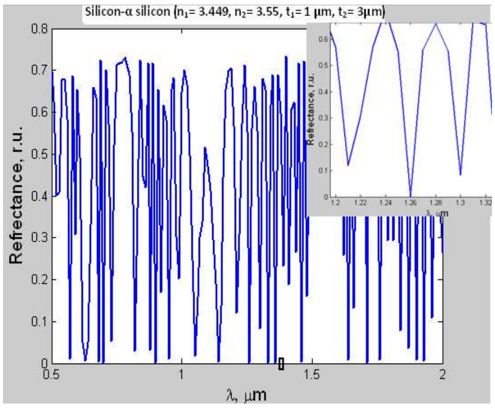

Figure 4.Silicon-*a* silicon (n_1 = 3.449, n_2 = 3.55, t_1 = 1μm, t_2 = 3μm)

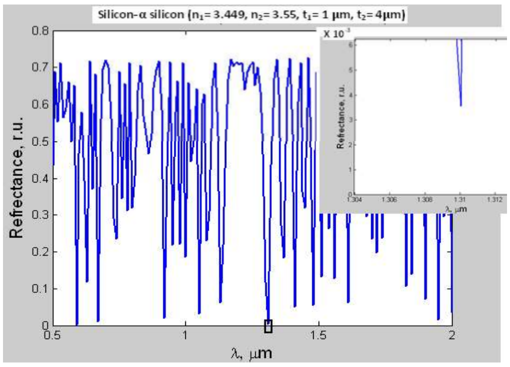

Figure 5.Silicon-*a* silicon (n_1 = 3.449, n_2 = 3.55, t_1 = 1μm, t_2 = 4μm)

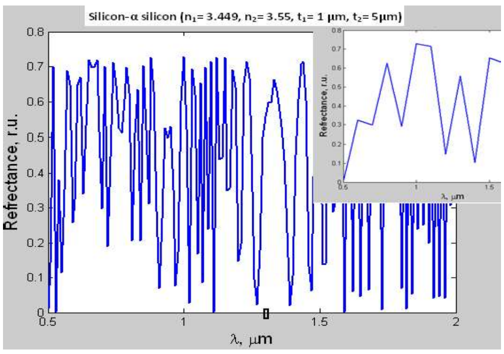

Figure 6.Silicon-*a* silicon (n_1 = 3.449, n_2 = 3.55, t_1 = 1μm, t_2 = 5μm)

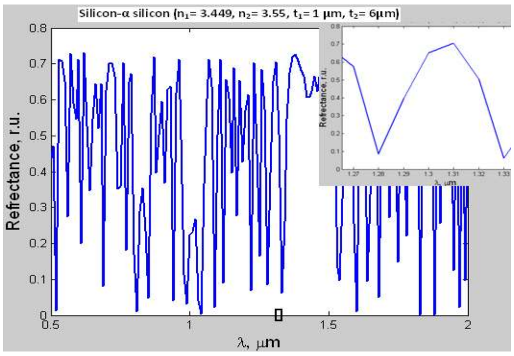

Figure 7.Silicon-*a* silicon (n_1 = 3.449, n_2 = 3.55, t_1 = 1μm, t_2 = 6μm)

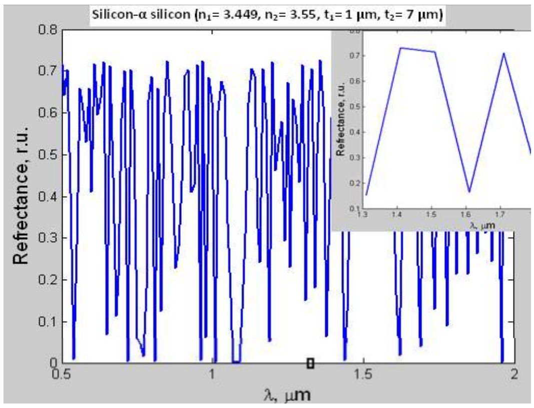

Figure 8.Silicon-*a* silicon (n_1 = 3.449, n_2 = 3.55, t_1 = 1μm, t_2 = 7μm)

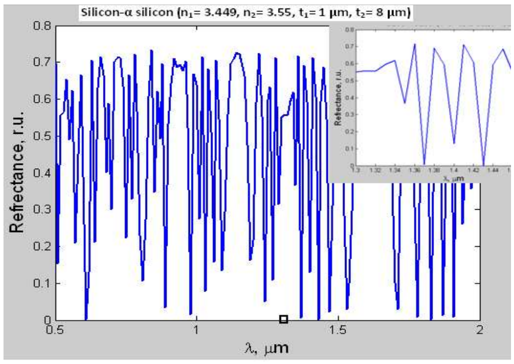

Figure 9.Silicon-*a* silicon (n_1 = 3.449, n_2 = 3.55, t_1 = 1μm, t_2 = 8μm)

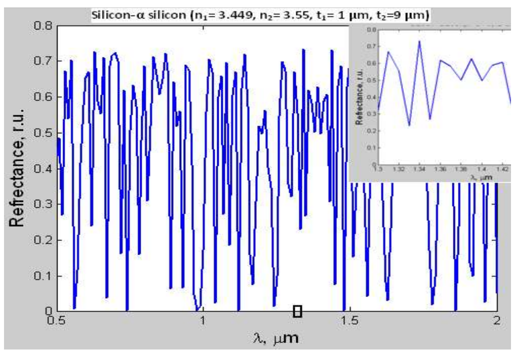

Figure 10.Silicon-*a* silicon (n_1 = 3.449, n_2 = 3.55, t_1 = 1μm, t_2 = 9μm)

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The above Figures (from 2 to11) represent the graphical representation between wavelength in um along horizontal axis and reflrctance in r.u in vertical axis. Since we are eagered to calculate the reflectance at the wavelength 1310 nm, we intentionally put a box mark at each figures in wavelength axis for indicating 1310 nm wavelength. Then the values of the reflectance is obtained from each corresponding figures. To obtain so, a magnified portion corresponding 1310 nm wavelength is inserted in each simulation graph. The values of reflectance corresponding different thickness of a-silicon are shown in Table 2.

Table 2.Reflectance corresponding different thickness of *a*-silicon

Refractive index of silicon (n_1)	Refractive indexn silicon (n_2)	Thickn ess of silicon in µm 1	Thickn ess of silicon 2	Reflectance in r.u
3.449	3.55	1	1	$3.14\times10^{-}$
			2	0.55
			3	0.42
			4	$3.57\times10^{-}$
			5	0.19
			6	0.69
			7	0.32
			8	0.57
			9	0.625
			10	0.55

Using data from Table 2, a graph is plotted between thiknessof *a* silicon along x-axis and reflectance along y-axis, which is shown in Figure 11.

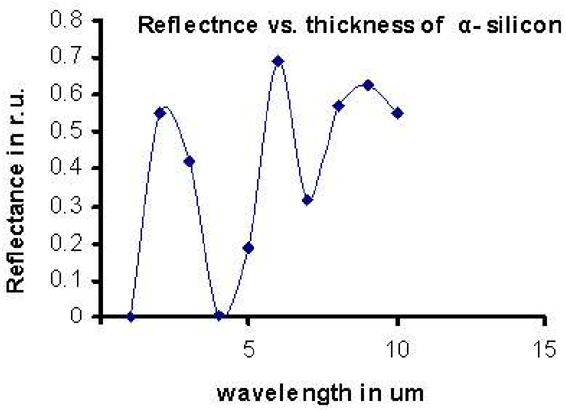

Figure 11.Variation of reflectance with respect to the thikness of *a* silicon

From the above graph, it is seen that reflectance of the grating SOI structure are different from different combinations of thickness of siliconand a silicon. It is also found those reflectance's are almost zero (3.14×10-5) for 1-1 µm and (3.57×10-3) for 1-4 µm. Beside these combinations, reflectance are found reasonable high values in all combinations.

Table 3.Transmittance corresponding different thikness of *a*-silicon

Refractive index of silicon (n_1)	Refractive index silicon (n_2)	Thickn ess of silicon in µm (t_1)	Thickn silicon µm (t2)	Reflectance in r.u
3.449	3.55	1	1	0.9999
			2	0.2025
			3	0.3364
			4	0.993
			5	0.6561
			6	0.0961
			7	0.4624
			8	0.1849
			9	0.1406
			10	0.2025

Using data from table 3, a graph is plotted between thiknessof *a* silicon along x-axis and transmittance along y-axis, which is shown in Figure 12.

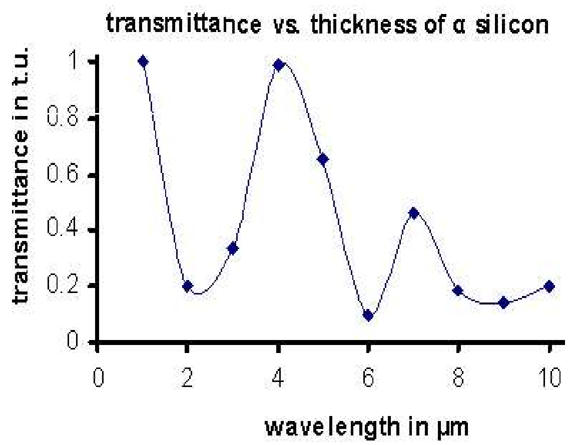

Figure 12.Variation of transmittance with reso=pect to the thikness of *a* silicon

From this above graph, it is clearly indicated that maximum transmittance of the grating SOI structure are found 0.9999 for 1-1µm and found 0.993 for 1-4µm combinations of silicon-*a* silicon layers. These combination of SOI structure are suitable for planar light wave circuits at the wavelength 1310 nm.

Conclusion

From this above graph , it is clearly indicated that maximum transmittance of the grating SOI structure are found 0.9954 for 4-1 µm and 0.9841 for 7-1µm and 0.996 for 10-1 µm combinations of silicon-*a* silicon layers. These combinations are suitable for SOI graty structure at the wavelength 1310 nm, for planner light wave circuits.

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