International Journal of Materials Science

E-ISSN: 2707-823X
P-ISSN: 2707-8221
IJMS 2022; 3(1): 09-12
Received: 08-11-2021
Accepted: 11-12-2021

Dr. Rohitash Singh
Department of Physics, Hindu college Moradabad, Uttar Pradesh, India

Corresponding Author:
Dr. Rohitash Singh
Department of Physics, Hindu college Moradabad, Uttar Pradesh, India

Nanophotonic optimization of high efficiency of power in SG-SOI structure of semiconductor grating at 1550 nm

Dr. Rohitash Singh

Abstract
Semiconductor grating SOI structure having nanometer thickness gives high efficiency of power at wavelength 1.55 μm. The simulation is done using plane wave expansion method. It is concluded that suitable combination of semiconductor grating materials gives high optical power.

Keywords: Nanophotonic optimization, semiconductor, SG-SOI structure

Introduction

The Silicon-on-Insulator (SOI) is a perfect medium for short-distance transmission and modulation of light beam [1]. The SOI is a critical platform for integrated optoelectronic circuits since it offers the potential for monolithic integration on a single substrate [2]. The Silicon-on-Insulator leads to very compact photonic integrated circuits (PICs) with densely spaced nano-scale photonic devices [3]. However, silicon's large refractive index also poses a number of challenges such as the ability to realize narrow spectral width Bragg's grating of interest for WDM filters as well as for nonlinear pulse propagation [4, 5].

Basically, an ordinary wave guide 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 [6]. Recently, a grating structure is proposed to overcome this problem [7]. This proposed structure is an embedded in SOI wave guide. As far as literature survey for the grating SOI structure is concerned, different types of grating structures are used for different purposes, for example, silicon grating structure is used for SOI application, polymer grating is used for module chip [8, 9]. But here, the authors have considered semiconductor grating which is placed on SOI structure to obtain high transmitting power. This optical power is computed using plane wave expansion method. The merit of using such structure is that at wavelength 1550 nm, the absorption loss is zero corresponding to suitable grating thickness, which is shown in Table 1. Apart from this, it is also found that the reflectance is almost zero at this wavelength. So, the transmitting power of SG-SOI structure will be nearly equal to 100%.

Structure analysis

Figure 1 represents high efficiency of semiconductor grating SOI structure. From Figure 1, it is seen that one dimensional semiconductor grating layer having a period of 4 is grown on SOI structure. A semiconductor grating structure is a sequential arrangement of different semiconductor materials.

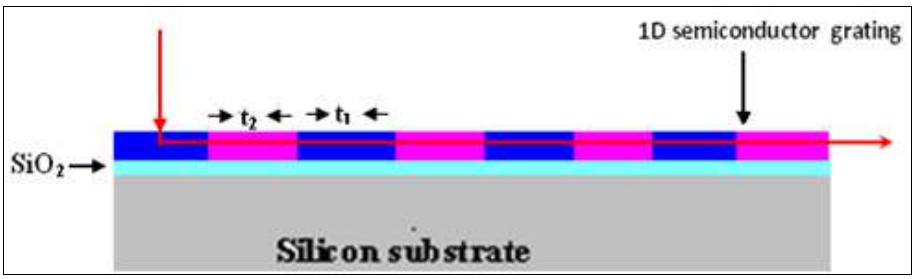

Fig 1: Schematic Diagram of 1D Semiconductor Grating SOI Structure

It is also seen that light having wavelength 1550 nm is incident on grating structure. To receive high optical power from this SOI structure, the authors have chosen proper input grating parameters, such as refractive indices and thickness of odd and even layers. Table 1 shows input parameters of SG-SOI structure. Here, there are five different semiconductor materials such as aluminum phosphide (AlP), gallium phosphide (GaP), aluminum arsenide (AlAs), indium phosphide (InP), and gallium arsenide (GaAs) are chosen. Using these materials, grating structure is realized by arranging any two materials in a sequential manner. So, there are 5C2 (20) numbers of combinations that are feasible for the same. Using these combinations of different materials, simulations are made by using plane wave expansion (PWE) method to obtain optical power corresponding to each combination of grating SOI structure at wavelength 1550 nm.

Simulation results and discussion

Using data from Table 1 and with the help of plane wave expansion method [10], simulations are carried out for optical power of SG-SOI structure.

Table 1: Simulation parameters for optical power

Materials	Refractive indices		Thickness in nm	
	n_1	n_2	t_1	t_2
AlP-GaP	3.13	3.16	99	99
AlP-AlAs	3.13	3.46	97	99
AlP-InP	3.13	3.48	97	99
AlP-GaAs	3.13	3.62	97	98
GaP-AlP	3.16	3.13	98	98
GaP-AlAs	3.16	3.46	97	97
GaP-InP	3.16	3.48	96	99
GaP-GaAs	3.16	3.62	98	95
AlAs-AlP	3.46	3.13	90	91
AlAs-GaP	3.46	3.16	90	91
AlAs-InP	3.46	3.48	89	90
AlAs-GaAs	3.46	3.62	89	89
InP-AlP	3.48	3.13	90	90
InP-GaP	3.48	3.16	90	90
InP-AlAs	3.48	3.46	89	89
Inp-GaAs	3.48	3.62	90	87
GaAs-AlP	3.62	3.13	89	84
GaAs-GaP	3.62	3.16	89	84
GaAs-AlAs	3.62	3.48	90	80
GaAs-InP	3.62	3.46	89	82

The simulation results for AlP-GaP and AlP-AlAs grating structures are shown in Figures 2(a) and 2(b). Other simulations are done but are not shown here.

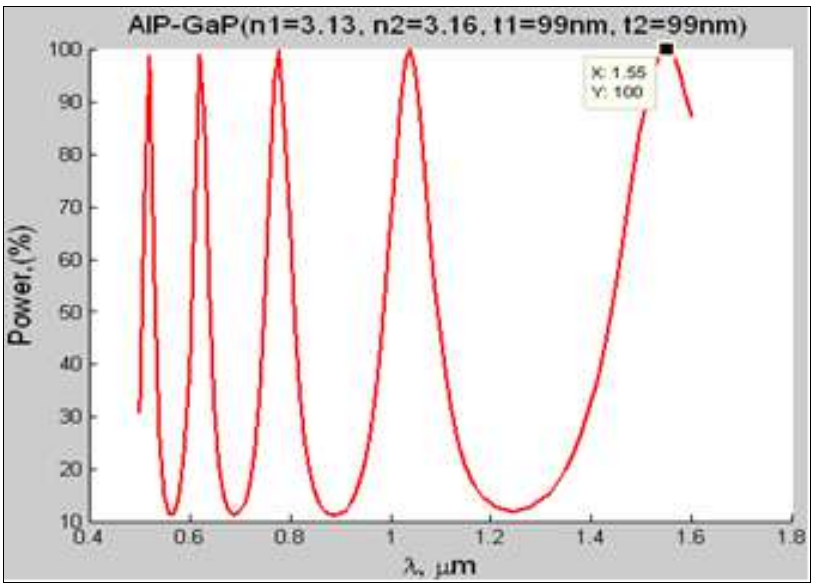

Fig 2(a): Simulated Graph for Power (%) of AlP-GaP Grating SOI Structure.

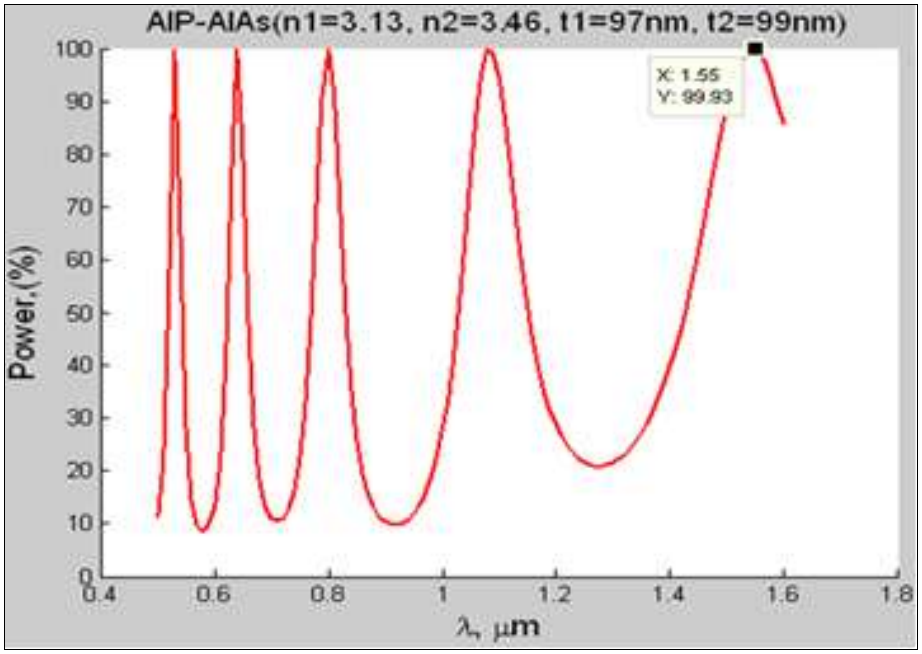

Fig 2(b): Simulated Graph for Power (%) of AlP-AlAs Grating SOI Structure

The top of Figures 2(a) and 2(b) represents the name of materials (AlP-GaP) and AlP-AlAs, refractive indices (n_1, n_2), and thickness of grating layer (t_1, t_2). In these figures, graphical representation is shown between wavelength in µm along horizontal axis and power (efficiency) in percentage along vertical axis. It is seen that power from grating SOI structure varies randomly with respect to wavelength. It is found from the above diagrams that data cursor shows the power is 100% at wavelength 1550 µm (1.55 µm) in case of AlP-GaP and 99.93 in case of AlP-AlAs grating structure. Similarly, using the same technique, the optical power for other semiconductor grating is also obtained. The whole investigations of optical power with respect to different materials are analyzed in Figure 3.

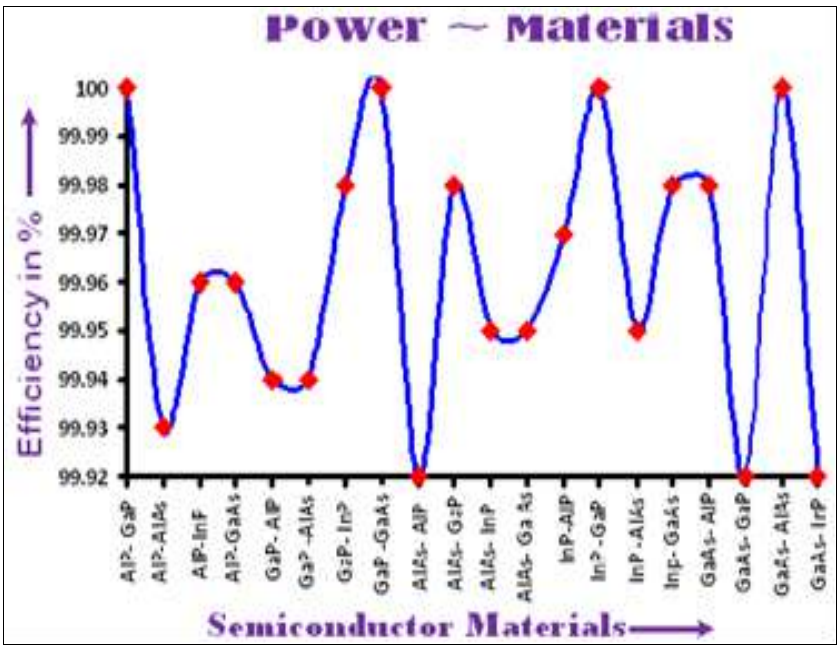

Fig 3: Investigation for Optical Power

From Figure 3, it is seen that the efficiency of power is 100% in case of AlP-GaP, AlAs-AlP, InP-AlP, GaAs-InP grating SOI structure. It is also seen that this efficiency is more than 99.2% in all grating structures.

Conclusions

Semiconductor grating SOI structure having nanometer thickness gives high efficiency of power at wavelength 1.55 µm. The simulation is done using plane wave expansion method. It is concluded that suitable combination of semiconductor grating materials gives high optical power.

References

1. Angulo Barrios C, Almeida VR, Panepucci R, *et al*. Electrooptic Modulation of Silicon-on-Insulator Submicrometer-Size Waveguide Devices; Journal of Lightwave Technology. 2003 Oct;21(10):2332-2339.

2. Shih-Hsiang Hsu. A Simple Optical Interconnection Integrated with Low Birefringence Silicon-on-insulator Waveguide, Lasers and Electro-Optics - Pacific Rim, 2007. Conference on CLEO/Pacific Rim 2007 Aug;26-31:1-2.
3. Lourtioz JM, Benisty H, Berger V, *et al*. Photonic Crystals; Towards Nanoscale Photonic Devices. Translated by Fornel Pierre de. Original French Edition published by Hermes Science, France 2003, 2nd Edn. 2008, P. 514.
4. Eggleton BJ, Slusher RE. Non Linear Photonic Crystals. Springer, New York, 2003.
5. Wang J, Jin Y, Shao J, *et al*. Optimization design of an ultra-broad band, high efficiency, all-dielectric grating. Opt. Lett. 2010;35(2):187-189.
6. Tang CK, Kewell AK, Reed GT, *et al*. Development of a library of low-loss silicon-on-insulator optoelectronic devices. IEE Proc. Optoelectron. 1996;143(5):312-315.
7. Prakash A, Suryavanshi SK, Priyanka Tripathy. Optical interconnects for multiplechip module using polymer embedded waveguide grating. Int. J Mater. Sci. 2010;5:715-722.
8. Palai G, Tripathy SK. Efficient silicon grating for SOI applications. Optik - International Journal for Light and Electron Optics. 2013;124(17):2645-2649.
9. Hornberger JM, Cilio E, Schupbach RM, *et al*. A High-Temperature Multichip Power Module (MCPM) Inverter utilizing Silicon Carbide (SiC) and Silicon on Insulator (SOI). Electronics Power Electronics Specialists Conference. PESC '06. 37th IEEE; 18-22. 2006 June;18-22:1-7.
10. Sukhoivanov I, Guryev IV. Physics and Practical Modeling: Photonic Crystals. Springer, Heidelberg; c2009.