Wideband filter using meta material at THz frequency

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Abstract

Wideband filtering application using ceramic meta material is reported in this work. Reflective properties of both SNG and DNG, glass and ceramic materials are presented. Simulation results for both structures predict the wide reflected band is found at Terahertz frequency pertaining to above structures. Also non linear variation of "width of the reflected band" is found with varying the thickness of meta material structure.

Keywords:*DNG,SNG,Reflected bandwidth*

INTRODUCTION

The word "meta" is originated from Greek word, which means "beyond". More specifically, we can say, metabehavior means abnormal properties of the material which is not found in normal material. Cogitating above concept, different types of applications using electromagnetic devices can be realized. As far as application of electromagnetic devices is concerned; the efficiency of devices depends on the nature and configuration materials. Now-a-days researcher are dealing with positive electromagnetic material, where device size usually more than wavelength of electromagnetic waves. Those positive materials show normal behavior with respect to different applications. However, researchers deal with new sorts of materials, where size of the device is quite significant and assumes to be much smaller than the wavelength of electromagnetic materials. These materials are called negative material. This is also named as metamaterial, which shows abnormal behavior with respect to applications. Though professor Vesclago pointed out the concept of the metamaterial in the year 1960, no substantial work have been carried out with respect to real applications due to the constraint of feasible fabrication[1-2].

Although different work related to the metamaterial are being carried out throughout the globe now a days, research in this field stands with infant stage owing to manufacture hinderers. As far as different type of application using metamaterial is concerned, antenna, absorber, superlense, cloaking device, seismic protection, sound filter and optical filter etc. found in literature [3-4]. Though above works are realizing different interesting applications we, in this work deal with five layers of positive and negative material, which shows properties at THz frequency. This paper is organized as follows; section 2 discusses the structure of metamaterial waveguide where as the resultant and discussion is presented in section 3. Finally conclusions are landed in section 4.

STRUCTURE ANALYSIS

The proposed five layer structure in figure 1 gives high reflected band width is made of positive and negative materials in an alternative manner. The figure 1 represents the alternate layer of glass or mica materials, where electromagnetic wave having frequency around THz range incident on the structure then electromagnetic wave reflected at particular range of frequencies is called as reflected band. We in this paper discuss the variation of reflected band with varying the thickness of each layer.

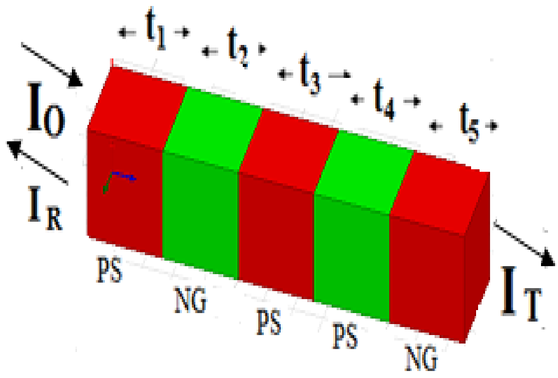

Fig1:*Five layer Matamaterial structure*

Though such structure is not new with respect to different applications [5-22] related to photonics and metamaterials but the five layer structure of ceramic material is a new-fangled application in the field of filter.

RESULTS AND DISCUSSION

The simulation is made to obtain the reflected band with the help of finite difference time domain technique [23] pertaining to different frequencies, where the range of frequency varies up to 80 THz. We have chosen mica and glass for 100% reflected band here. Using above technique, simulation is made for both SNG and DNG of mica structure. The results for the same are shown in figure 2 and 3.

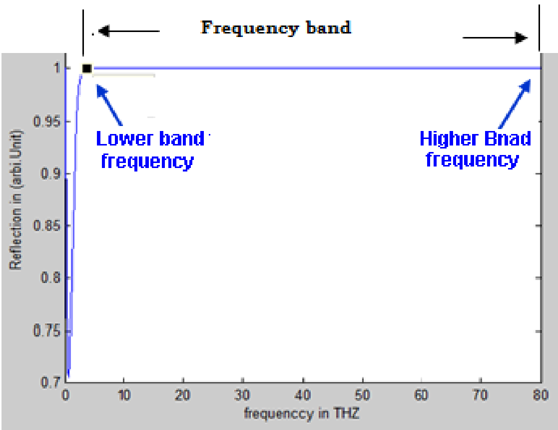

***Fig2:**Reflected band result for Mica SNG structure with respect to THz frequency.*

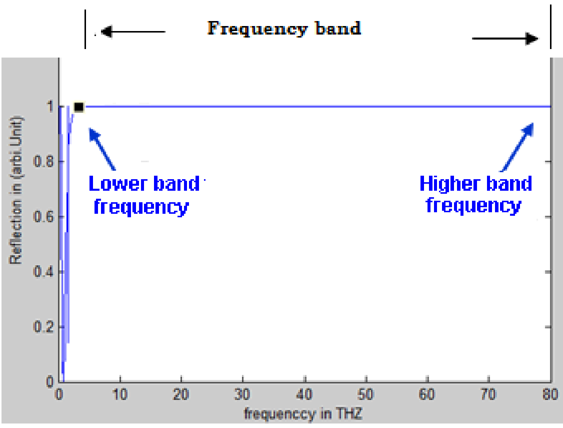

***Fig 3:**Reflected band result for Mica DNG structure with respect to THz frequency*

Figure 2,3 shows the reflection (Arbi unit) and frequency (THz) is taken along y and x axis respectively. Also lower band, higher band and bandwidth frequencies are shown by mentioning arrow marks. From above figure, It is observed that reflection is one (100%) corresponding to certain range of frequencies. So, it is seen that lower frequency is 3.819 THz and higher frequency is 79.91 THz. After finding this frequency we computed bandwidth with taking difference between higher bands to lower band, resulting 76.091 THz. Using similar technique, we calculated lower band, higher band and bandwidth of DNG Mica. From Fig. 3 it is seen that lower band, higher band and band width are 3.2 THz, 79.91 THz and 76.71 THz, respectively. Apart from these results we, also made simulation for same structure with respect to thickness (0.5 nm, 1.5 nm, 2.5 nm, 3.5 nm, 4.5 nm, 5 nm, 15 nm, 25 nm, 35 nm, 45 nm) of above SNG and DNG grating structures. From these results we computed the lower band frequency, higher frequency and frequency band of all grating structures. Using these results a graph is plotted for SNG Mica grating and DNG Mica grating, which is shown in Fig. 4 and 5

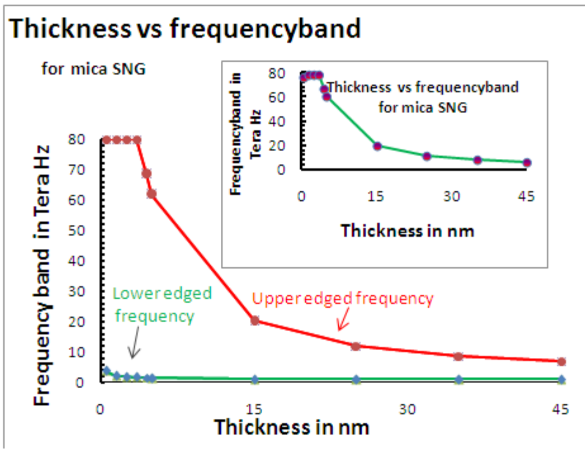

***Fig 4:**Result for lower reflected band, Higher reflected band and reflected bandwidth SNG Mica grating structure*

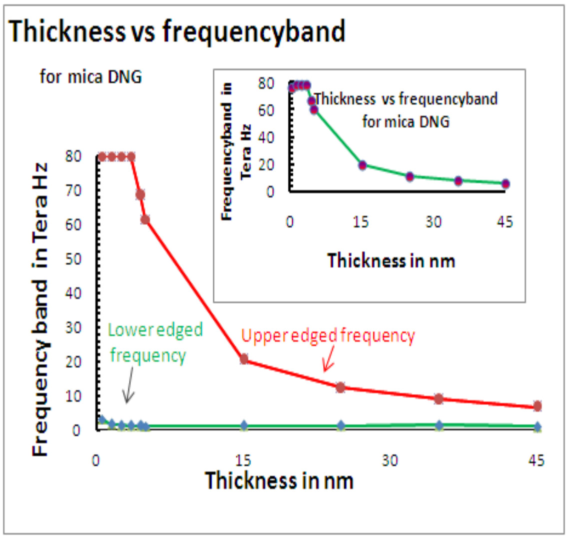

Fig 5:Result for lower reflected band, Higher reflected band and bandwidth DNG Mica grating structure.

Fig. 4 and 5 represents the variation of lower frequency, higher frequency and frequency band width for SNG and DNG Mica grating structure, respectively. From these figures, it is seen that lower and higher frequency band in THz is taken along vertical axis, where thickness of grating in nm is taken along x-axis. Aside this, the inset figure in this graphs are represented as variation of reflected bandwidth with respect to same thickness. As far as result is concerned, it is observed from Fig. 4 that lower band frequency decreases from 3.819 THz to 1 THz and higher frequency band decreases from 79.91 THz to 8.56 THz with respect to thickness of grating which varies from 0.5 nm to 45 nm. Apart from this from inset graph, it is found that frequency band decreases from 76.091 THz to 5.89 THz with respect to same thickness. Again from figure 5, is seen that lower band frequency decreases from 3.02 THz to 1.02 THz and higher frequency band decreases from 79.91 THz to 6.6 THz with respect to thickness of grating which varies from 0.5 nm to 45 nm. Apart from this from inset graph, it is found that frequency band decreases from 76.71 THz to 5.58 THz with respect to same thickness.

We also deal with similar types of computation for reflectance of other grating structure glass. The same result is suitable placed in form of graph in figure 6,7.

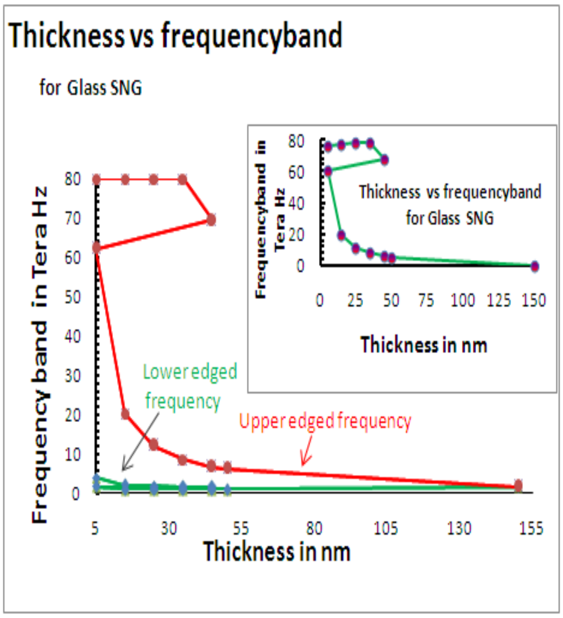

Fig 6:Result for lower reflected band, Higher reflected band and bandwidth DNG Mica grating structure.

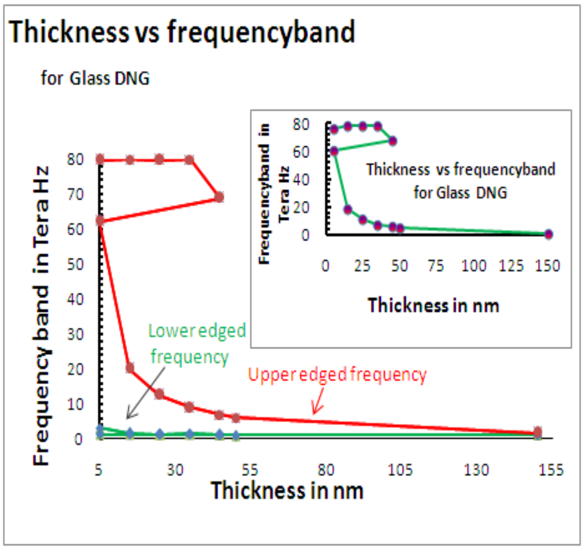

Fig 7:*Result for lower reflected band, Higher reflected band and bandwidth DNG Glass grating structure.*

Fig. 6 and 7 represents the variation of lower frequency, higher frequency and frequency band width for SNG and DNG glass grating structure, respectively. From these figures, it is seen that lower and higher frequency band in THz is taken along vertical axis, where thickness of grating in nm is taken along x-axis. Aside this, the inset figure in this graphs are represented as variation of reflected bandwidth with respect to same thickness. As far as result is concerned, it is observed from Fig. 6 that lower band frequency decreases from 3.992 THz to 1.59 THz and higher frequency band decreases from 79.91 THz to 1.59 THz with respect to thickness of grating which varies from 0.5 nm to 150 nm. Apart from this from inset graph, it is found that frequency band decreases from 76.091 THz to 1.59 THz with respect to same thickness. Again from figure 7, is seen that lower band frequency decreases from 3.24 THz to 1.03 THz and higher frequency band decreases from 79.72 THz to1.59 THz with respect to thickness of grating which varies from 0.5 nm to 150 nm. Apart from this from inset graph, it is found that frequency band decreases from 76.48 THz to 0.56 THz with respect to same thickness.

Though we have mentioned the lower and higher value of reflected band with frequencies for 5 layer structures, it is observed that the variation is nonlinear for both SNG and DNG structures of mica as well as glass materials. The reason for such variation is due to internal properties of both waveguide structures.

CONCLUSION

In this paper, the reflected properties of mica and glass materials are discussed. Lower, higher and width of the reflected band is computed using finite difference time domain method. Simulation result shows that nonlinear variation of lower band, higher band and band width are realized for both SNG and DNG structures.

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