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MICROSTRIP ANTENNA PARAMETERS IMPROVEMENT USING EBG STRUCTURE

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ABSTRACT

A novel mushroom like electromagnetic band gap (EBG) structure for antenna improvement is presented in this paper. The idea proposed in this paper is etching several properly shapes in the metal surface of the mushroom-like compact EBG cell to introduce stop band in electromagnetic band gap structur. This band gap is represented by LC equivalent circuits, from which the resonant frequencies can be estimated. The effectiveness of the EBG as a surface wave suppresser is demonstrated using numerical simulations CST microwave studio. Two port method is used to analysis the band gap properties of the proposed structure.[1] Micro strip antenna surrounded by double layer of EBG structure presented in this paper which enhance return loss and bandwidth of conventional micro strip antenna

KEYWORDS: Electromagnetic Band Gap Structure, Surface Wave, Band Gap Property, Micro Strip Antenna

INTRODUCTION

EBG structures are periodical cell composed of metallic or dielectric elements. Unique feature of EBG structures is to create the forbidden band of frequencies in which surface waves cannot propagate. Surface wave propagation is a serious problem in microstrip antennas. Surface waves reduce antenna efficiency and gain, limit bandwidth, increase end-fire radiation, increase cross-polarization levels, and limit the applicable frequency range of microstrip antennas [2]. When the antenna operates in the frequency band of this prohibition, it will improve significantly enhanced features, such as increasing the antenna return loss and bandwidth, the back, gain etc.

An antenna that is placed on a high-permittivity dielectric substrate may couple power into substrate modes. As substrate modes do not contribute to the primary radiation pattern, these modes are a loss mechanism. EBG structure can offer a real solution to this problem.

Utilized in patch-antenna configurations as substrates, EBG structure suppress both substrate modes and surface waves that would otherwise be excited in the substrate by the radiating element. Suppression or reduction of surface waves improves antenna efficiency and reduces the sidelobe level that is caused by the diffraction of surface waves at the edges of the antenna substrate [3]. Surface-wave diffraction plays a major role when thick substrates are used to increase the bandwidth of the antenna. Power losses due to surface waves can be as high as 60% of the radiated power when thick substrates with high dielectric constant value are used.

There have been many proposed EBG structures with applications in wide band. Overall, there are two types of EBG is very widely used today is mushroom-type EBG [3] and uni-planar EBG [4]. Mushroom like EBG structure is proposed in this paper This model mainly use metal plates with grounding bias.

By etching alternative symmetric square slots on the patch of the structure, it has created the equivalent elements LC resonant circuit. As shown in figure 1. They behave as a network of parallel LC resonant circuits, which act as a two-dimensional electric filter to block the flow of currents along the sheet [3].

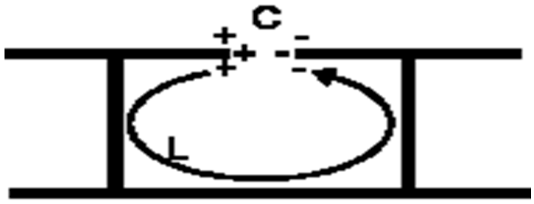

Figure 1: Origin of the Equivalent Circuit Elements

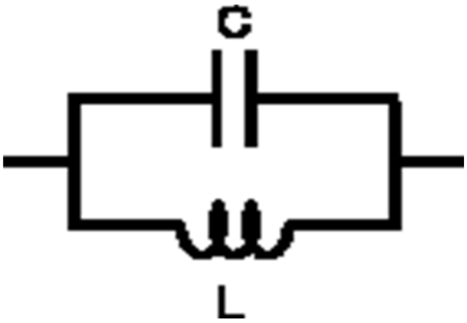

Figure 2: Equivalent Circuit Model for the EBG Surface

EBG DESIGN

The basic design of EBG structure is shown in figure 1, known as mushroom like EBG structure. EBG structure has frequency range where the surface impedance is very high. The equivalent LC circuit acts as a two-dimensional electric filter in this range of frequency to block the flow of the surface waves The mushroom-like electromagnetic band gap (EBG) structure printed on the one side of the FR4 lossy substrate and the ground plane is located on the other side of the substrate with bias ground. The proposed design of mushroom-like electromagnetic band gap structure is constructed in alternative square shape with symmetric slot as shown in figure 3 and figure 4. Dimension of proposed structure in presented in Table1.

Table 1: Dimensions of Layer

Layer	Ground	Substrate	Cylinder	Slots
Material	PEC	FR-4 (lossy)	PEC	vacuum
Dimension (mm)	7.5×7.5	7.5×7.5	h=1.676 r=.1	As show in figure 3

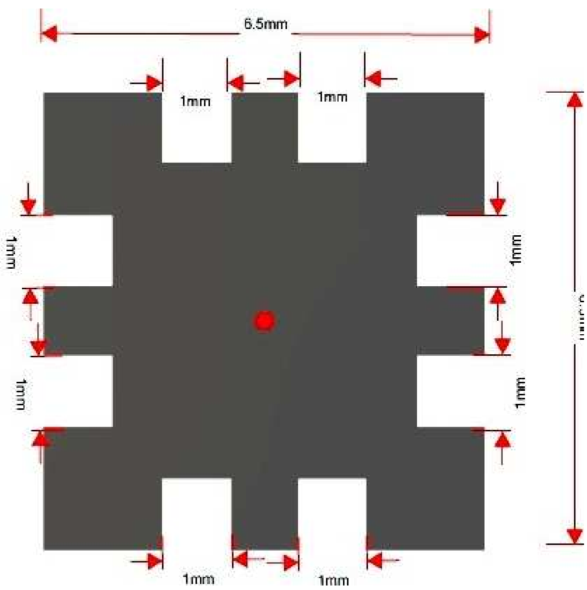

Figure 3: Front View of EBG Unit Cell

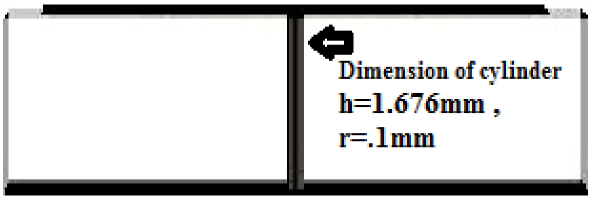

Figure 4: Side View of EBG Unit Cell

BAND GAP ANALYSIS

The frequency band gap of EBGs is directly related to the geometrical parameters and material parameters of the host medium. The band gap is specified by magnitude of transmission coefficient (S21) using full wave simulator CST MWS, which describes the propagation characteristics of an EBG structure. Performance of 2×4 EBG array has been investigated by two port method [1] as shown in figure 5. Band gap of 2×4 EBG array is simulated by introducing port on each side of EBG array. Proposed array exhibit two band gap region as shown in figure 6. First band gap region (BG1) spread over the frequency range 0 – 4 GHz and second band gap region spread over the frequency range 7.2 - 11.2 GHz. Due to above characteristics proposed array is also referred as dual band EBG array.

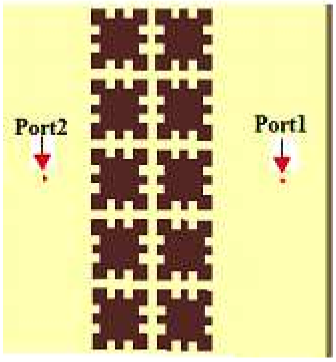

Figure 5: Band Gap Measurement Set up

Figure 6: Band Gap Result of 2×4 EBG Array

MICROSTRIP ANTENNA WITH EBG SUBSTRATE

Conventional Rectangular Micro Strip Patch Antenna is designed on FR-4 (lossy) substrate. The parameter specifications of rectangular microstrip patch antenna are mentioned in table 2.

Table 2: Dimension of Microstrip Patch Antenna (mm)

Length (L)	Width (W)	Cut Width	Cut Depth	Path Length	Width of Feed
35.4	45.6	5	8.6	28.8	2.4

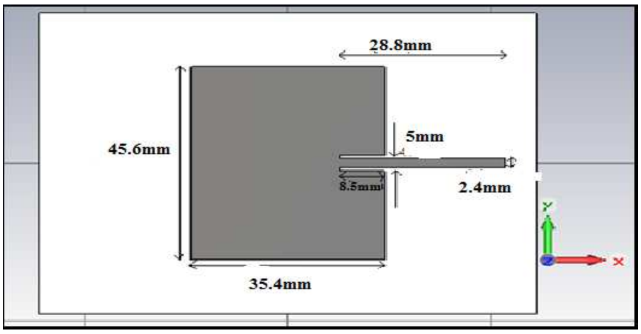

Figure 7: Conventional Micro Strip Antenna at 2GHz

According to the theory [5] Surface wave exist in Convensinal microstrip antenna. To reduce surface wave, convesinal microstrip antenna is surround by dual layer of EBG structre as shown in figure 8.

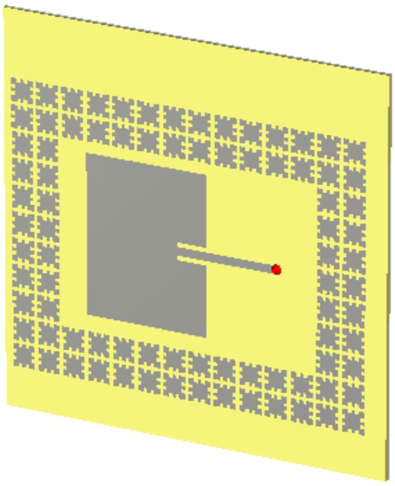

Figure 8: Microstrip Antenna with EBG Structure at 2GHz

RESULTS

Conventional micro strip antenna with PEC ground plane and FR4 substrate has been simulated on CST MWS. Return loss and Bandwidth of conventional rectangular micro strip patch antenna is shown in figure 9. According to this figure 9, return loss and bandwidth are -14dB & 35MHz respectively.

To enhance the characteristics of conventional micro strip antenna, it is surrounding by dual layer of EBG structure as shown in figure 8 and simulated . EBG layer provide improvement in return loss and bandwidth as shown in figure 9. According to result, return loss reached at -25dB and bandwidth reached at 45MHz.

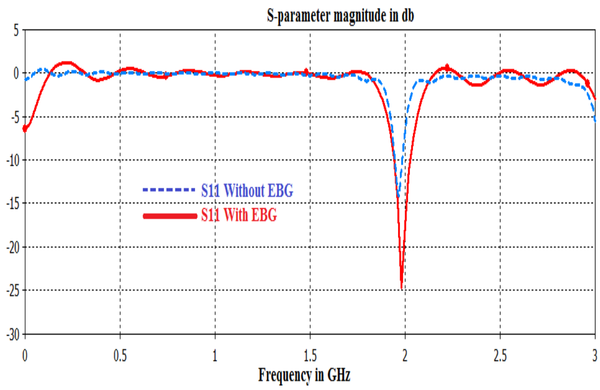

Figure 9: Comparison of Transmission Coefficient

CONCLUSIONS

A mushroom like EBG structure for antenna improvement has been analysis in this paper. Band gap has been achieved by changing the different shapes of top layer of proposed structure in order to create suitable LC resonance condition. The band stop properties of the structure has been investigated by using CST Microwave Studio. Band gap is investigated by two port method. EBG structure applied on convensitinal rectangular microstrip antenna, (which improve the -10db return loss and increase of 10MHz bandwidth). These enhancement occurs due to reduction of surface wave in substrate region.

REFERENCES

1. John Sandora "*Isolation Improvement with Electromagnetic Band Gap Surfaces*" Lincoln Laboratory Journal, Vol. 19, No. 1,pp.51-61, 2012,
2. F. Yang, Y. Rahmat-Samii, *"Microstrip Antennas integrated with electromagnetic band-gap structure: a low mutual coupling design for array application,"* IEEE Trans. Antennas and Propagation, Vol. 51, pp. 2936-2946, Oct. 2003.
3. Sievenpiper, D., L. J. Zhang, R. F. J. Broas, N. G Alexopolous, E. Yablonovitch, *"High- impedance electromagnetic surface with a forbidden frequency band,"* IEEE Trans. Microwave Theory Tech., Vol. 47, No. 11, pp. 2059-2074, Nov. 1999.
4. Yang, F. R., K. P. Ma, Y. X. Qian, and T. Itoh, *"A uniplanar compact photonic-bandgap (UC-PBG) structure and its applications for microwave circuit,"* IEEE Trans. Microwave Theory Tech., Vol. 47, No. 8,, Aug. 1999.
5. Dan Sievenpiper, L.Zhang, F. J. Broas, N.G. Alexopolous, E.Yablonovitch *"High Impedance Electromagnetic Surfaces with a Forbidden FrequencyBand"* IEEE Trans. on Microwave Theory and Technology, Vol.47, No.11, Nov. 1999, pp. 2059-2074.
6. Dalia M.N. Elsheakh, Hala A. Elsadek and Esmat A. Abdallah Chapter 16 "*Antenna Designs with Electromagnetic Band Gap Structures"* Tech Publication 2nd Edition.
7. Fan, M. Y., R. Hu, Z. H. Feng, X. X. Zhang, and Q. Hao, *"Advance in 2D-EBG research,"* Journal of Infrared Millimeter Waves, Vol. 22, No. 2, 2003.pp. 883-887