EFFECT OF EBG STRUCTURES ON THE FIELD PATTERN OF PATCH ANTENNAS

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ABSTRACT

The incorporation of number of unit cells in EBG arrangement produces two major side effects on the performance of patch antenna. First one is parasitic loading, this causes multi resonance in antenna hence obtains some enhancement in antenna band width. Second one is cavity effect, this reflects some of energy from EBG toward antenna which results in reducing bandwidth. Present paper, rectangular microstrip patch antenna is surrounded by number of EBG rows is designed; and the results of proposed antenna with a conventional patch antenna is presented comparatively.

KEY WORDS

Patch antenna, SW, EBG structure, gain, and bandwidth

1.INTRODUCTION

The microstrip patch (MSP) antennas have wider applications in live environment because of its several advantages. These MSP antennas also have some drawbacks such as narrow bandwidth; low gain and surface waves excitation[1]. In order to suppress the surface wave propagation, two techniques have been adopted popularly, namely micromachining [2] and the electromagnetic bandgap (EBG) structures [3]. However, the placement of EBG structures surrounding to MSP antenna is effecting it's radiation characteristics.

Present work, the effect on field pattern of MSP antenna by the incorporation of the EBG structures is investigated. The parameters effect and number of EBG elements arranged in row wise surrounding to MSP patch antennas also investigated. The changes in the far-field radiation patterns are discussed.

2.THEORY OF EBG

The parametric study on mushroom-like EBG structure is presented in [4]. It focused on four main parameters that affecting the overall performance of the antenna design. The parameters namely, patch width W, the spacing between mushroom-like EBGs, substrate thickness h and substrate permittivity εr. In this paper, the study is focusing not only on W, s and h as in [4], but also on the spacing between patch element, g and the number of rows of the EBG inserted between the patch elements. The architecture of Mushroom EBG consists of a ground plane, a dielectric substrate, metallic patches and vias arranged like mushrooms. The mushroom EBG structure is producing an inductance due to vias and capacitance due to spacing between the adjacent metal patches hence functions like resonating structure[5].

3.SIMULATION OF PATCH ANTENNA INTEGRATED WITH EBG

The coaxial feed microstrip antenna is designed with following specifications.

Table 1: Microstrip Patch Antenna Specifications

Parameter	**Value**	**Specification**
Dielectric Constant	2.5	
Height of substrate	1.588	mm
Length	8.3	mm
Width	11.34	mm

The microstrip patch antenna with one row of mushroom like EBG structure shown in figure 2. patches located half wavelength (g=15mm) far from antenna radiating edges in E-plane with resonant frequency at 10GHz . The parameters of EBG unit cell are as followes

Table 1: EBG Unit Cell Specifications

Parameter	**Value**	**Specification**
Width (w)	3.5	mm
Gap (g)	1	mm
Radius of via (r)	0.2	mm

Figure3 is shown return loss of antenna with and without EBG structure, and figure4 shown E-plane pattern of these two antennas. As shown in figure 3, as expected, bandwidth of antenna whit one row EBG in E-plane is greater than antenna without EBG about 2%, due to domination of parasitic effects.

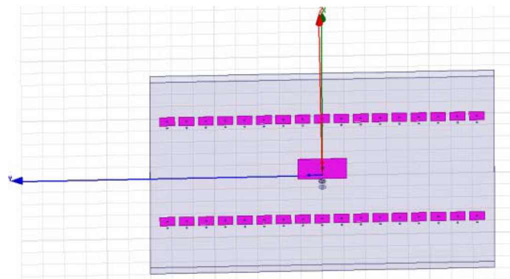

Figure 2**:** Microstrip patch antenna with resonant frequency at 10 GHz

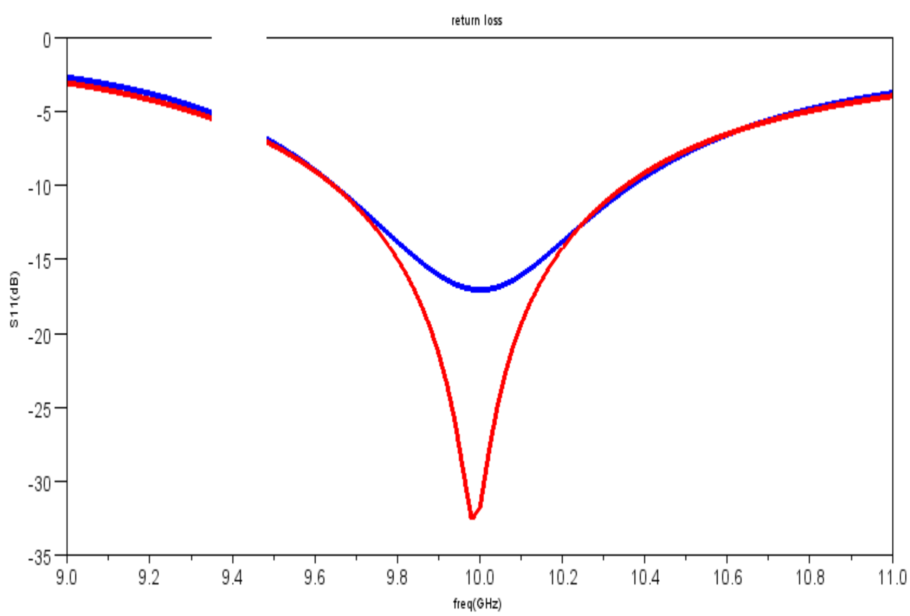

Figure 3**:** Return loss of patch antenna with one row EBG (blue) and without EBG structures (red)

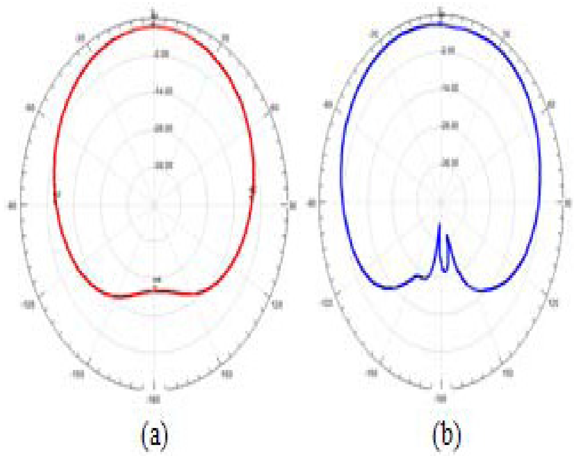

Figure 4**:** E-plane patterns of patch antenna (a) without EBG structures (b) with one row EBG

The reference antenna shows large radiation in the backward direction, and the antenna integrated with one row of conventional mushroom like EBG patches produces a lower backlobe, with less power wasted in the backward direction. Also, surface wave is reduced in EBG antenna. In this part the antenna patch is simulated with increasing the number of EBG rows, figure 5 is shown the antenna patch with 4rows of EBG structures in E-plane. Figure 6 is shown return loss of antenna with different number EBG rows.

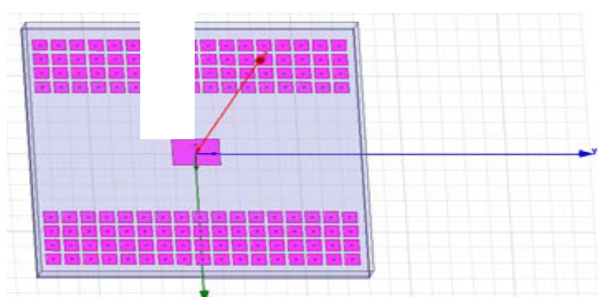

Figure 5**:** Microstrip patch antenna, with 4 EBG rows.

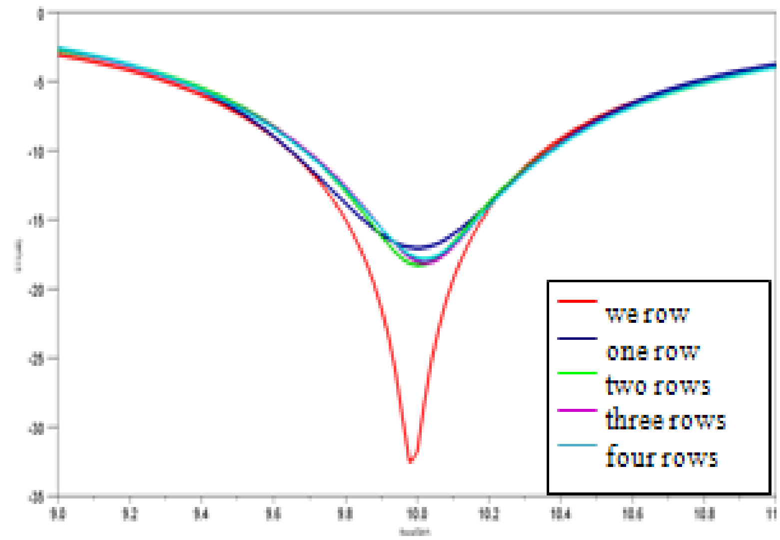

Figure 6**:** Return loss of the antenna with different number EBG rows.

Table 2: Comparisons details between the results obtained with and without EBG rows

EBG	**Resonance Frequency (GHz)**	**S11 (dB)**	**Band Width (GHz)**	**Gain (dB)**
With out	9.98	-32.61	0.708	7.27
One Row	10	-17.06	0.721	6.64
Two Rows	10	-18.30	0.68	6.80
Three Rows	10.02	-18.13	0.68	6.20
Four Rows	10.02	-17.85	0.68	6.05

The performance of the antenna without EBG row is about the same as the antenna with EBG rows, except that the return loss is dropped from -32.6 dB to about -18dB. With increasing EBG rows from 2 to 4 rows, the bandwidth variation is negligible which is the indication of parasitic effects dominations. The figure 7 is shown the return loss of antenna with 5 rows of EBG structures in the E-plane, figure 8 represented E-plane pattern for antenna with 5 rows. With 5 EBG rows, bandwidth suddenly decreases (0.708GHz to 0.401GHz) which is the indication of cavity effect domination.

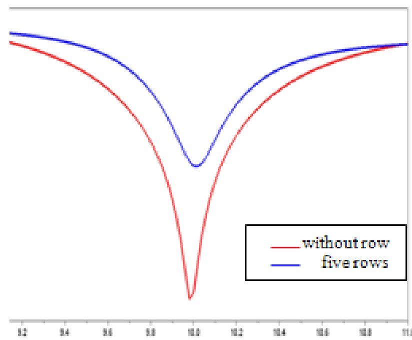

Figure 7: Return loss of the antenna with 5 EBG rows and without.

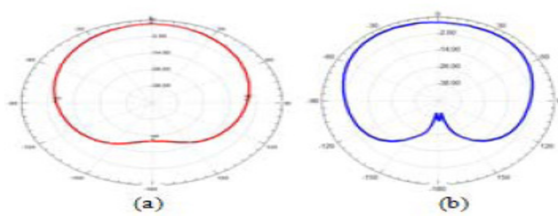

Figure 8**:** E-plane patterns of patch antenna (a) without (b) with 5 EBG row.

The reference antenna shows large radiation in the backward direction, and the antenna integrated with 5 rows of conventional mushroom like EBG patches produces a lower backlobe, with less power wasted in the backward direction. Also, surface wave is reduced in EBG antenna. The same process is repeated in this part. The only different is that the spacing between patch is wider, that is 22.5mm (three quarter wavelength) from antenna radiating edges in E-plane to the row of conventional mushroom like EBG patches edge.

4. CONCLUSION

The patch antenna mostly used in modern mobile communication. The goals of this paper is to design patch antenna with and without EBG should have same physical dimensions that can operate at 10GHz and study the influence of the side effects of EBG structure on the performance of the antenna. it is obvious that for 2 rows of EBG structures, an acceptable bandwidth is achieved.When 4 rows of EBG rows are used, bandwidth variations is negligible, but side and back lobe levels decreases in the cost of larger size consumption. The spacing from antenna radiating edges in E-plane to the row of conventional mushroom like EBG patches edge controls the degree of influence of the side effects of EBG structure on the performance of antenna.

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