NOVEL DIELECTRIC EBG ANTENNA WITH OMNIDIRECTIONAL PATTERN IN AZIMUTH

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Abstract: This paper presents a novel EBG antenna which has an omnidirectional radiation in the azimuth plane and a low beamwidth in the elevation plane. It is built with dielectric tubes and a centre metallic core, and the excitation is realized with a wire-patch antenna. The operating frequency is 5.8 GHz and the gain reaches 9 dB. So this antenna, called coaxial EBG antenna, is ideal to work as a transmitting antenna on a base station of a wireless network (HiperLAN or mesh network).

1. INTRODUCTION
The photonic crystal or electromagnetic band gap (EBG) structures are periodic metallic or dielectric materials (Yablonovitch[1]). They can control the propagation of electromagnetic waves whatever their direction of propagation. They gained a growing interest in the antenna domain since they became very useful to improve patch antenna performances (as it is shown by Gonzalo[2], Colbourn and Rahmat-Amii[3] or Yasushi Horii and Makoto Tsutsumi[4]) or to control the beam radiating (Poilasne[5][6]). EBG materials are also very interesting to design directive antennas (Thevenot[7], Serier[8], Jecko[9], Biswas[10] and Min Qiu and Sailing He[11]).

We present here a novel EBG antenna which exhibits an omnidirectional pattern on azimuth plane. The revolution symmetry structure antenna has been created by analogy with planar EBG antenna like Thevenot[7].
This antenna works at 5.8 GHz and was conceived to be on a base station of a wireless network (HiperLAN or mesh network). It has been designed to have a gain equal to 9 dB in order to cover quite large cells.

2. PRINCIPLE : ANALOGY WITH PLANAR EBG ANTENNAS
The structure that has been used to make the analogy is described by Serier[8]. The planar EBG antenna is composed by a ground plane, an air defect which has a dimension of λd/2 and some dielectric slabs with a thickness of λd/4 spaced out λd/4 (air). By extension to 360°, we can obtain a novel structure, called coaxial EBG antenna. It is composed by a metallic centre core and some dielectric tubes with a thickness of λd/4 spaced out λd/4 (air) (figure 1).

Fig. 1 : 1-D EBG structure and coaxial EBG structure

The 1-D EBG structure presents a directive pattern with high gain and low sidelobes. The coaxial antenna has an omnidirectional pattern in azimuth and presents a low beamwidth in the other plane. In the air cavity with a thickness of λd/2, we can observe the electromagnetic field Ez (figure 2). To excite the coaxial antenna, we have to choose a feed with the right polarization.

Fig. 2 : Ez electrical field magnitude distribution
2. EXCITATION OF THE STRUCTURE
The excitation of the structure has to be omnidirectional and must present Ez electromagnetic field. The more widely-known excitation for this structure is the half-wave dipole. But it can not be used because of the center core in the structure. So the second method is the use of a monopolar wire-patch antenna (Delaveaud[12]). This antenna has the structure of a classical microstrip antenna with two thin metallizations of arbitrary design deposed on each face of a dielectric strip. The antenna is fed by a coaxial probe which is connected to the patch through the ground plane and the dielectric substrate. The peculiarity is that it has at least one ground wire which connects that patch to the ground plane.

The structure proposed was adapted to accept the centre core and keep an omnidirectional pattern in azimuth. So our wire-patch antenna presents two ring metallizations, a coaxial probe and four ground wires. The dielectric is replaced by air (figure 3). This antenna radiates like a dipole and is very well adapted to the excitation of the coaxial EBG antenna.

3. DESIGN AND PERFORMANCES OF THE ANTENNA
The computed antenna is described figure 4. It has been simulated by a software that uses FDTD method. The wire-patch antenna presented before realizes the excitation and the coaxial EBG antenna is composed of two tubes in alumina ($\varepsilon_r = 9$). The expected directivity (9 dB) depends indeed on the number of tubes and their permittivity. The operating frequency is 5.8 GHz.

The radiation of this antenna is omnidirectional on the azimuth plane and presents a half-power beamwidth equal to $9^\circ$ in the elevation plane (figure 5). The maximum gain obtained is 9.2 dB at 5.8 GHz with a variation in the azimuth plane lower than 0.2 dB.
Evolution of gain versus frequency is presented figure 6. We determine half-power bandwidth thanks to figure 6, but also versus sidelobes level. As we can see, the gain is bigger than 6.2 dB before 5.45 GHz and till 5.85 GHz. But the patterns between 5.45 and 5.55 GHz present important sidelobes. Dynamic between the main lobe and the sidelobes is higher than 10 dB for frequency between 5.55 and 5.85 GHz so the bandwidth is equal to 5.6%.

![Fig. 6: Evolution of antenna gain versus frequency](image)

It is important to notice that the coaxial EBG antenna is very adaptable. In fact, the use of a dielectric with a lower permittivity can give less gain with a bigger bandwidth.

4. CONCLUSION
We present here a novel EBG antenna which has an omnidirectional pattern in the azimuth plane and gives 9.2 dB of gain with a variation in the circumference lower than 0.2 dB. This antenna is very well adapted to be a transmitting antenna for wireless network. A prototype is currently in work in order to confirm the simulation results.

REFERENCES