Artificial Magnetic Conductor based on InP Technology

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***Abstract*- Artificial magnetic conductor (AMC) is a kind of periodic structures and it introduces a zero degrees reflection phase shift to incident wave. In order to reduce size of artificial magnetic conductor and increase their working bandwidth, InP process is used to design AMC in this paper. InP material has advantages of large forbidden bandwidth, high electron mobility, negative resistance effect etc. AMC based on InP process has been analyzed and results show that the proposed AMC has a good bandwidth compared with that of CMOS process for its smooth reflection phase variation and its whole size is greatly reduced.**

***Keywords*- AMC, InP, reflection phase.**

I. INTRODUCTION

Photonic band-gap (PBG), as a type of artificial periodic dielectric structure, has been involved in research fields of optical, electromagnetic, and acoustic. It is also called as electromagnetic band-gap (EBG) structures in microwave and millimeter wave fields. Research of EBG technology was beginning in the late 1990s. D. Sievenpiper presented high impedance surface (HIS) by using periodic arrangement of metalized via to connect with the ground plane. It has unique performance of surface wave propagation prohibition within the specific frequency band. For this characteristic of high impedance surface similar to magnetic conductor, it also be called artificial magnetic conductor (AMC) [1]. Artificial magnetic conductor can introduce effective isolation between antenna and its lossy dielectric substrate. Antenna radiation efficiency is improved and back lobe level is reduced for its characteristics of surface wave suppression. Artificial magnetic conductor shows a zero degrees reflection phase shift to incident wave within a certain frequency band. This characteristic make AMC can be used as reflector with nearly zero thickness replacing a conventional backed ground with a thickness of one-quarter wavelength [3]-[6]. AMC has been investigated by many researchers. Some novel AMCs have been presented, such as uniplanar compact photonic band gap (UC-PBG), which is easy to be fabricated because metallized vias have been removed.

In this paper, an AMC structure based on InP technology is presented. InP is one of the most important compound semiconductor materials. It is a new generation of functional materials after Si, GaAs. The InP material preparation is difficult and expensive. The researches of components and devices based on InP technology are far less than those of Si, GaAs, and GaN, etc. However, due to the unique advantages of InP materials, such as large forbidden bandwidth, high electron mobility, significantly negative resistance effect, more its investigations become more and more popular. InP materials is widely used in optical fiber communication. It is also an ideal substrate material of microwave and millimeter wave devices and devices for high speed and high frequency applications.

II. DESIGN

InP process is simpler than the common CMOS process, whose cross section is shown in Fig.1. There are only two metal layers in an InP structure and the proposed AMC is constructed at the bottom metal layer M1. From Fig.1 it can be found that the bottom layer is an InP substrate, its dielectric constant ε_r=12.4. BCB is a high performance dielectric material, whose curing temperature is relatively low and its dielectric constant is low and stable. Its dielectric constant is ε_r=2.65, loss tangent δ=0.0008. Thicknesses of each layer are listed in Table I.

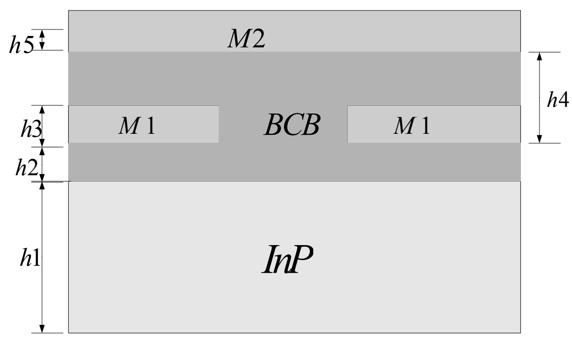


Fig.1 Cross section of an InP structure.

Table 1. Thicknesses of different materials.

material	Thickness (um)
BCB	h2+h4=4.5
M1	h3=1
M2	h5=2
INP	h1=620

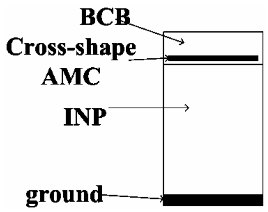


Fig. 2(a).Side view of a unit cell of the proposed AMC.

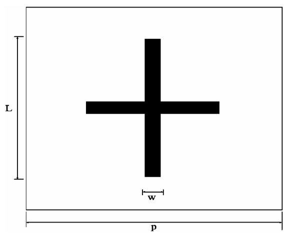


Fig.2(b).Top view of a unit cell of the proposed AMC.

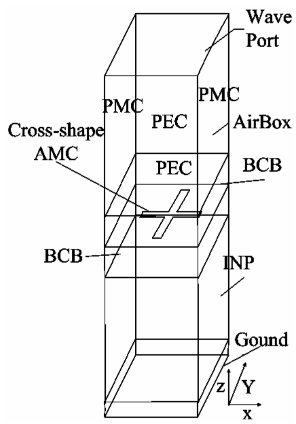


Fig.3. Simulation model of the proposed AMC.

In this paper, a periodic cross-shaped array presented in [7] is adopted in AMC design. Its side view and top view are shown in Fig.2 (a) and (b). In practice an AMC is constructed by finite periodic element array. But in simulations it should be treated as infinite periodic element array. It can be accomplished by introducing image boundary conditions around a single unit cell. Simulation model of the proposed AMC is shown Fig.3, in which the incident plane wave is propagating in the negative *z* direction with its electric field in the positive *y* direction. The image boundary conditions are defined by setting the two parallel x-z surfaces as perfect electric conductors (PEC) and setting the two parallel y-z surfaces as perfect magnetic conductors (PMC). Wave port at the negative *z* direction end is used as excitation source. A reference plane calculating the phase of reflection coefficient is set at the surface of the cross-shape AMC.

III. RESULTS AND ANALYSIS

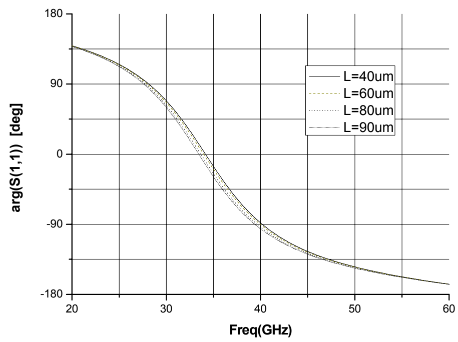
AMC constructed by periodic metallic cross-shape elements at the bottom metal layer M1 has been investigated and a sample operating at 35GHz has been presented. Its geometrical parameters are listed in Table 2.

Table 2. Parameters of the proposed InP AMC (Unit: um).

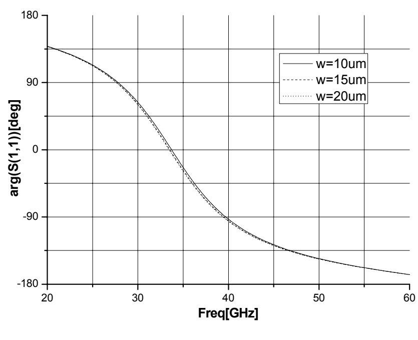
L	W	P
40	20	100

Phase responses of reflection coefficient of the proposed AMC are shown in Figs.4. From those figures it can be found that reflection coefficient phase of the proposed AMC is approaching to zero at the frequency of 34.5GHz. AMC operating bandwidth is defined as the frequency range in which its reflection coefficient variation from -90^0 to 90^0 [8]. From these figures we can find that bandwidth of the proposed AMC is more than 12GHz (from 28GHz to 40GHz).

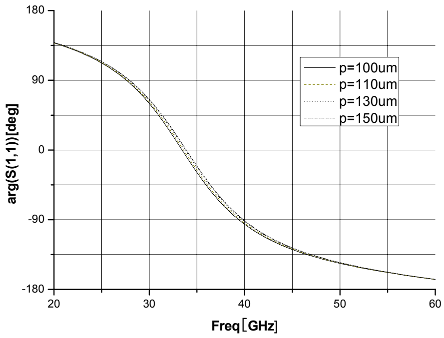
Variations of the reflection coefficient phase with different geometrical parameters of the proposed AMC have been studied. From Figs.4 it can be found that length of the cross shape L has the largest influence on the reflection coefficient phase and width of the cross shape W has the least influence on the reflection coefficient phase. Operating frequency and bandwidth of the proposed AMC increase with length L or width W of the cross shape reduction, or periodic space P between two elements increment.



(a)



(b)



(c)

Fig.4. Phases of reflection coefficients vs. different parameters.
(a) L: length of cross shape.
(b) W: width of cross shape.
(c) P: periodic space between two cross shape element.

As a reference, an AMC comprised of periodic cross shape element based on standard CMOS process is presented, whose geometrical parameters are listed in Table 3. Comparison between phases of reflection coefficients of the proposed two AMC based on InP and CMOS processes is shown in Fig.5.

Table 3. Parameters of the compared CMOS AMC (Unit: um).

L	W	P
300	200	302

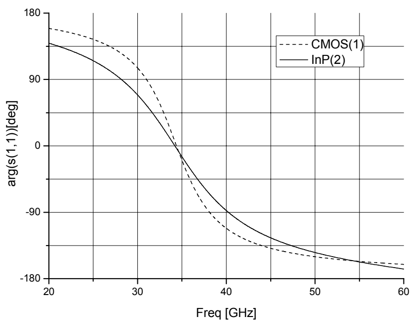


Fig.5. Phases of reflection coefficients of the proposed cross shape AMC based on InP and CMOS technology

In Fig.5, the dot line represents reflection coefficient phase of the cross shape AMC based on CMOS technology, and the solid line represents reflection coefficient phase of the cross shape AMC based on InP technology. From the figure it can be found that the phase curve of cross shape AMC based on InP technology is more smoother than that of the AMC based on CMOS technology. Operating bandwidth of the InP AMC is 12GHz (28~40GHz), which is about 50% more than 8GHz (30~38GHz) of the CMOS AMC. Furthermore, by comparing Table 2 and 3 it also can be found that the whole size of the proposed InP AMC is far less than that of the proposed CMOS AMC.

IV. CONCLUSION

AMC constructed by a periodic cross shape array based on InP technology has been studied in this paper, whose phase variation curve is smoother than that of a corresponding AMC based on CMOS technology. The whole size of an InP AMC is far less than that of the corresponding CMOS AMC. These advantages make the AMC based on InP technology be more suitable for application with a lower cost.

V. ACKNOWLEDGEMENT

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