The numerical simulations of the electromagnetic shield based on chiral honeycomb slab

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Abstract-In this paper, by means of electromagnetic numerical simulations using CST software, we determined the electromagnetic shielding proprieties of the chiral-honeycomb slab. We represented and we made an optimization of the electromagnetic transmission coefficients, depending on the unit cell's geometrical parameters of chiral-honeycomb slab. Finally we proposed some shield panels based on dielectric hexachiral-honeycomb slab coated with thin metallic layer, with a view to be used in the electromagnetic protection at the buildings level.

I. Introduction

Generally, the electromagnetic compatibility is considered at electronic component level, board level and electrical system level. In order to achieve the electromagnetic protection of the electrical devices and the human beings, it is very important to consider the electromagnetic compatibility problems and to make a corresponding design at the buildings level, such as: hospitals, control rooms of radar or radio transmitters, offices or just houses.
The materials used in electromagnetic shielding range from classical metallic plate to new advanced materials [1].
In the last time there is a great interest in the development, design and electromagnetic characterizations of the metamaterials [2] because of their potential electromagnetic applications.
Because of their good mechanical performances [3], [4] and their special electromagnetic proprieties [5], the chiral-honeycomb structures were considered to obtain the sandwich panels, used as electromagnetic absorbers or/and shields for inside or outside the buildings. Thus, we proposed two basically types of absorber or/and shielding in view to be used as panels for shielding at the building level: the sandwich panel type Salisbury screen or Jaumann layers, which use the chiral honeycomb slab as dielectric between resistive sheet and perfect electric conductive sheet [6]; the shield panel obtained by metallizing a chiral honeycomb slab made of dielectric materials.
The second type of shielding panel, which is presented in this paper, can be used also in the case of the vent hole.
Referring to the determination of electromagnetic proprieties of the periodic structures there are two basically methods: homogenisation method and numerical simulation [7]. Because of the complex configuration of the chiral honeycomb structure we used numerical techniques for electromagnetic proprieties determination. Thus, we determined the transmission coefficients and we optimised the shielding effectiveness of the panel based of metallized chiral honeycomb slab, depending on their geometrical parameters using CST software.
The determination of the absorption, reflection and transmission properties of the materials is very important in the case of the electromagnetic absorbers/shields and the periodic structures [8].

II. The proposed shield panels

We considered a hexagonal unit cell of the periodic structure as hexachiral honeycomb slab developed in CHISMACOMB FP6 EU project. Thus, the honeycomb structure shown in Figure 1a is composed of circular elements –cylinders - of inner diameter, D, each of them joint by six tangent straight ligaments with the thickness of wall, g. The distance between the centres of adjacent cylinders or nodes is L. The thickness of the hexachiral honeycomb panel is H. For the considered dimensions of the unit cell the effective-homogeneity condition ($p < \frac{\lambda}{4}$) is accomplished for frequencies ($f < 5\,GHz$).
Figure 1 shows the unit cell of the periodic structure for hexachiral honeycomb slab, respectively for classical honeycomb slab.
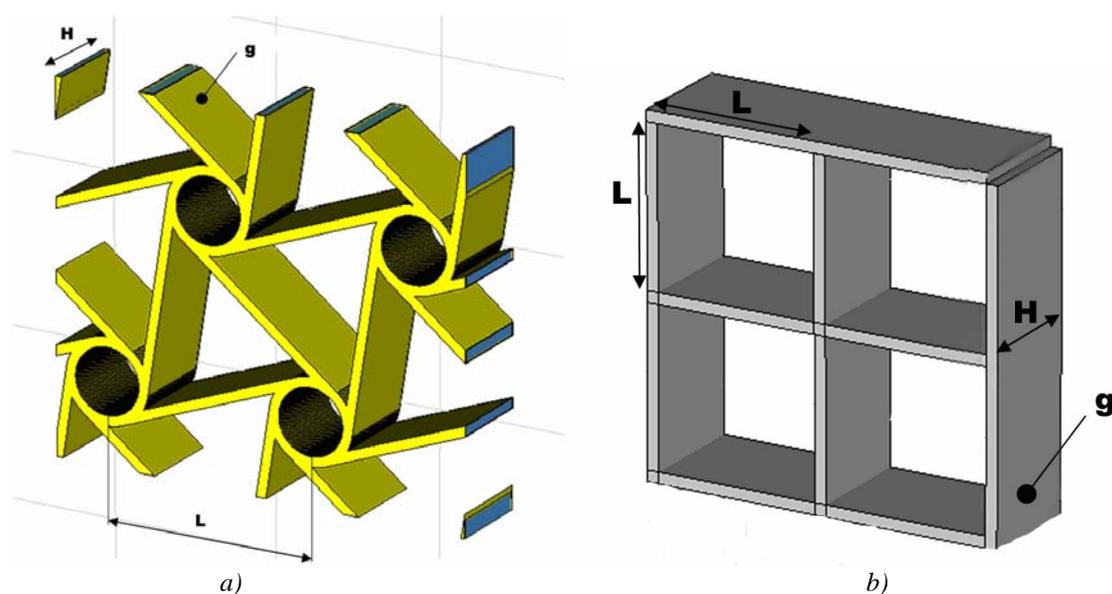
Figure 1. The unit cell: a) hexachiral honeycomb; b) classical honeycomb

As is shown in Figure 2, we propose two types of panels based on hexachiral honeycomb dielectric slab: single layer metallized hexachiral honeycomb; double layer mettalized hexachiral honeycomb, in view to be used as electromagnetic shields for electromagnetic protection of the buildings.
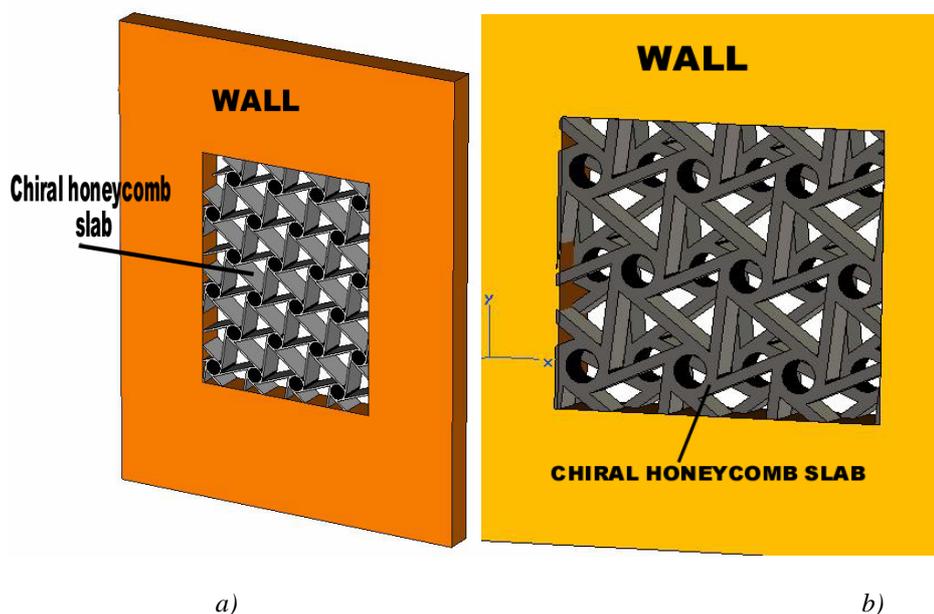

Figure 2. The proposed shield panels: a) single layer shield; b) double layer shield

III. Numerical simulation's results of shield's transmission coefficients

By means of electromagnetic simulation using CST software, we made an analysis of geometrical parameters' influence on the transmission coefficient of the proposed shield panels.

First we determined and compared the transmission coefficients of the metallic hexachiral honeycomb slab, as is shown in Figure 1a, with the transmission coefficients of the classical metallic honeycomb, Figure 1b, which has equivalent dimensions.

In Figure 3 is represented the transmission coefficient of the metallic classical honeycomb panel in 0 ÷

2.5 GHz frequency range for some thicknesses of the panel, namely H=5 mm, H=10 mm, H=15 mm, H=20 mm.
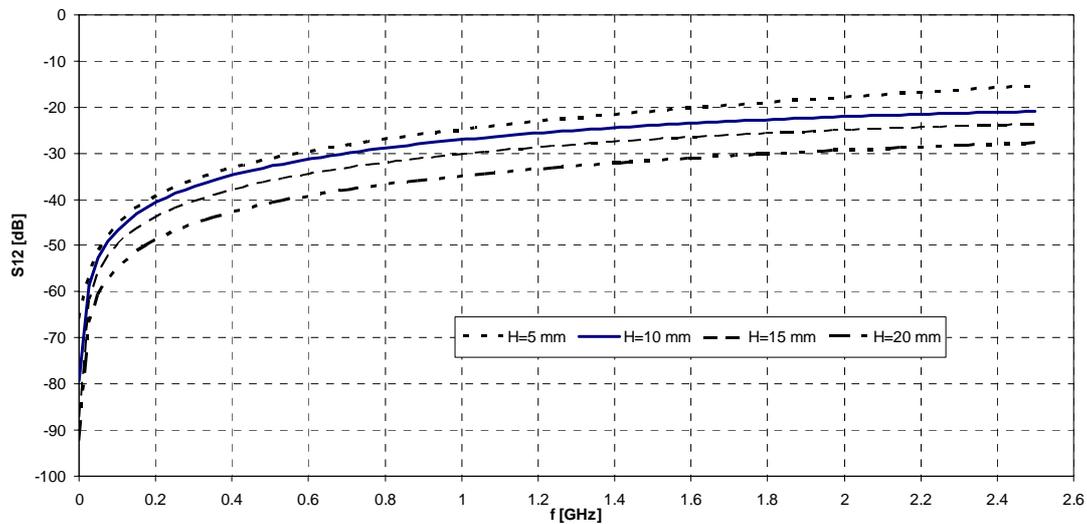

Figure 3. The transmission coefficient of the metallic classic honeycomb panel versus frequency for some values of panel's thickness, H

Figure 4 shows the transmission coefficient versus frequency of the metallic hexachiral honeycomb, with the thickness of the slab, H, as parameter, when the distance between the centres of adjacent cylinders is $L = 25\ mm$.
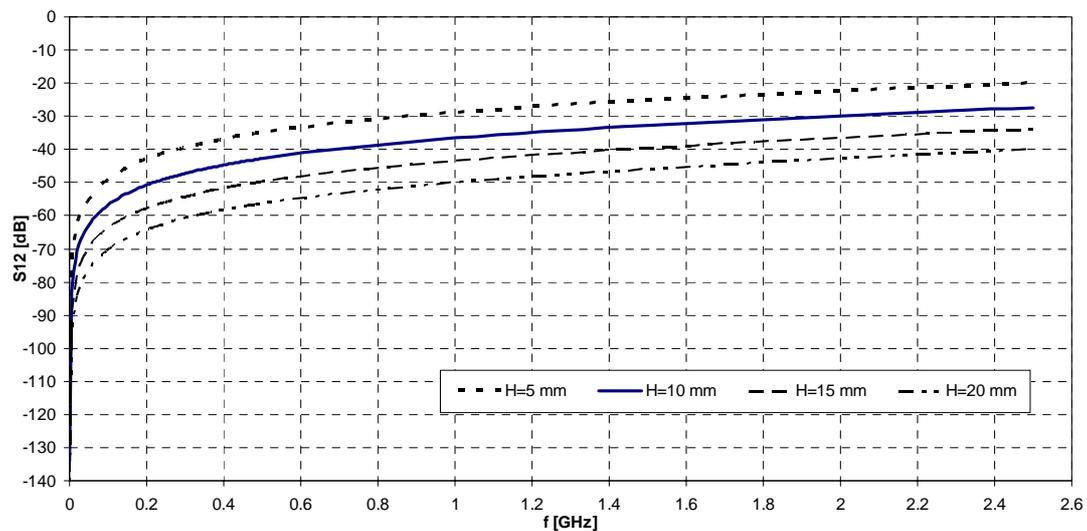

Figure 4. The transmission coefficient of the metallic hexachiral honeycomb panel versus frequency for some values of panel's thickness, H

Comparing these two types of panels configuration, result that the shield effectiveness of the metallic chiral honeycomb is about 10 dB better then the one of the metallic classical honeycomb with equivalent dimensions. Supplementary the mechanical proprieties of the chiral honeycomb panel are much better then those of classical honeycomb.

We determined and represented versus frequency, the transmission coefficients of the dielectric hexachiral honeycomb panel coated with 10 μm metallic layer, for the same values of panel's thickness, H, as in Figure 4, namely H=5 mm, H=10 mm, H=15 mm, H=20 mm. The transmission coefficients obtained in this case and shown in Figure 5 are with about 1 dB smaller then the corresponding one in the case of the metallic hexachiral honeycomb panel, thus these two types of panels have similar behaviour. For this reason the electromagnetic simulations may be made for

metallic hexachiral honeycomb panel, in view of decreasing the time of electromagnetic simulation comparing to the case of mettalized hexachiral honeycomb panel.
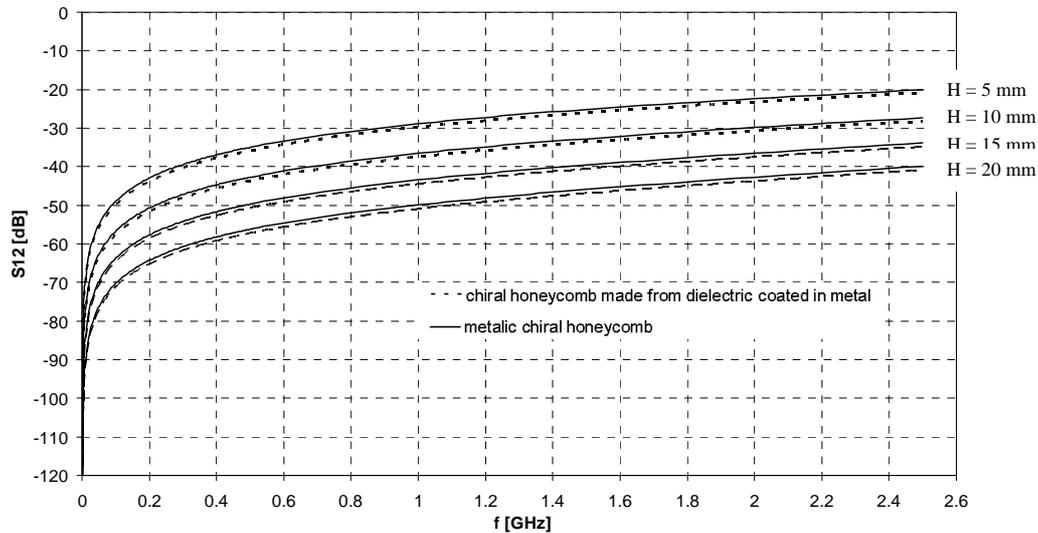

Figure 5. The transmission coefficient of the dielectric hexachiral honeycomb panel coated with 10 μm metallic layer, versus frequency for some values of panel's thickness, H , compared with the transmission coefficient of the metallic hexachiral honeycomb panel

Figure 6 shows the transmission coefficient of the metallic hexachiral honeycomb panel in $0 \div 2.5$ GHz frequency range for some values of the distance between the centres of adjacent cylinders, L, situated between 5 mm and 25 mm, when the thickness of the panel is $H = 10 \, mm$.
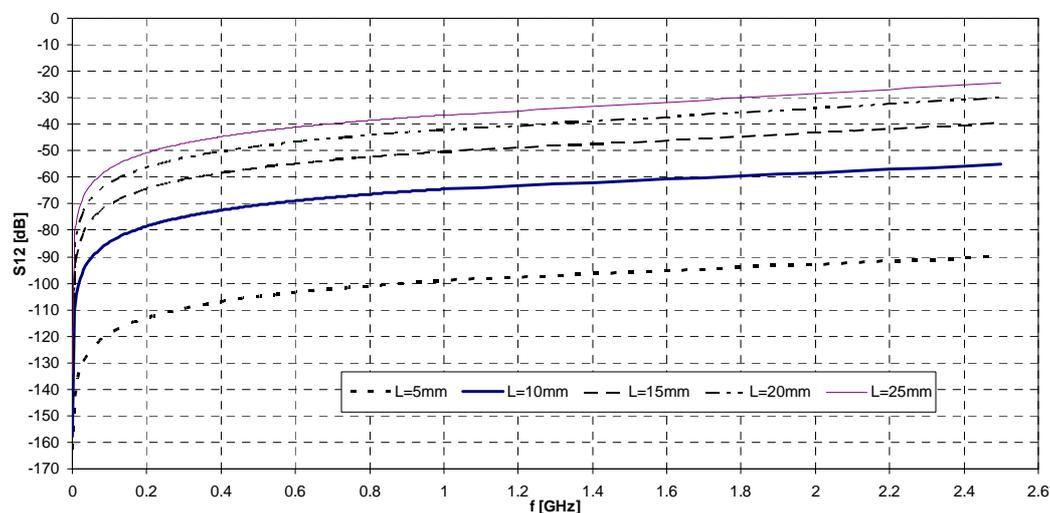

Figure 6. The transmission coefficient of the metallic hexachiral honeycomb panel depending on frequency for some values of the distance between the centres of adjacent cylinders, L

As is show in Figure 4 and Figure 6, a very important increase of the panel's shielding effectiveness can be obtained by decreasing the distance between the centres of adjacent cylinders, L, or/and by increasing the panel's thickness, H.
We propose also a shielding panel which is composed of two metallized chiral honeycomb slab, adequately arranged, as is shown in Figure 2b.
Figure 7 shows, in $0 \div 2.5$ GHz frequency range, the transmission coefficients of the single layer panel and the double layer panel having the same total panel's thicknesses.
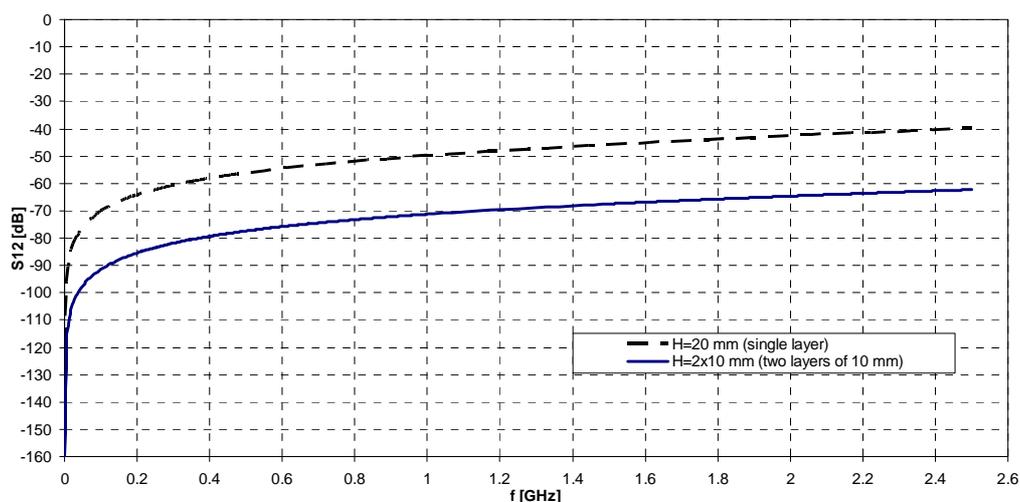
Figure 7. The transmission coefficient of the single layer panel in comparison with that of the double layer panel with the same total thickness of panel, *H*

Comparing the transmission coefficients of these types of shielding panels it can be observed a much better shielding effectiveness in the case of double layer panel. That is an important technological advantage because using a double layers panel we can obtain the same shielding effectiveness like in the case of single layer shield having in plane geometrical dimensions much smaller, especially the distance between the centres of adjacent cylinders, *L*.

IV. Conclusions

We proposed two shield panels obtained by metallizing a chiral honeycomb slab made of dielectric materials. The obtained panels can be used in the electromagnetic protection at the buildings level, having better mechanical and shielding proprieties than the classical metallic honeycomb.
By numerical simulation, we represented the transmission coefficient of the metallized chiral honeycomb panel in $0 \div 2.5$ GHz frequency range and we made an optimization of shielding effectiveness depending on the geometrical parameters of the periodic structure's unit cell.
Also, we show that the shielding effectiveness in the case of the shield panel with two hexachiral honeycomb layers adequately arranged is much better than that of the single layer shield panel having the same thickness with the double layer shield.

Acknowledgements

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