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The Effect of the Uniaxial Anisotropy on the Resonance of Microstrip Patch Antennas

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Abstract

Dielectric Substrates (DS) have an important attention in the fabrication of Microstrip Patch Antennas. In this work, the effect of the uniaxial anisotropic materials on the operating frequency of microstrip patch antennas is presented. Rectangular patch is studied and analyzed using the software package high frequency structure simulator (HFSS). The simulation results show, that the uniaxial anisotropy strongly affects the resonant frequency.

1.Introduction

Microstrip Patch Antennas (MPA) have many advantages in particular low profile and conformity to planar and non-planar surfaces that are highly recommended in nowadays technologies. However, its low radiation efficiency, low gain and narrow bandwidth are the most disadvantages.

Dielectric substrates are a critical choice for improving the performances of microstrip patch antennas, this poster presents the effect of the uniaxial anisotropic materials on the operating frequency of rectangular microstrip patch antennas.

This paper presents a study of a rectangular patch antenna excited with a micostrip feed line technique, the design is analyzed using the finite elements method (FEM) integrated in software package High Frequency Structure Simulator (HFSS). The results show that the rectangular patch antenna using anisotropic substrates, has a higher effect on the resonant frequency.

2.Design and Simulations

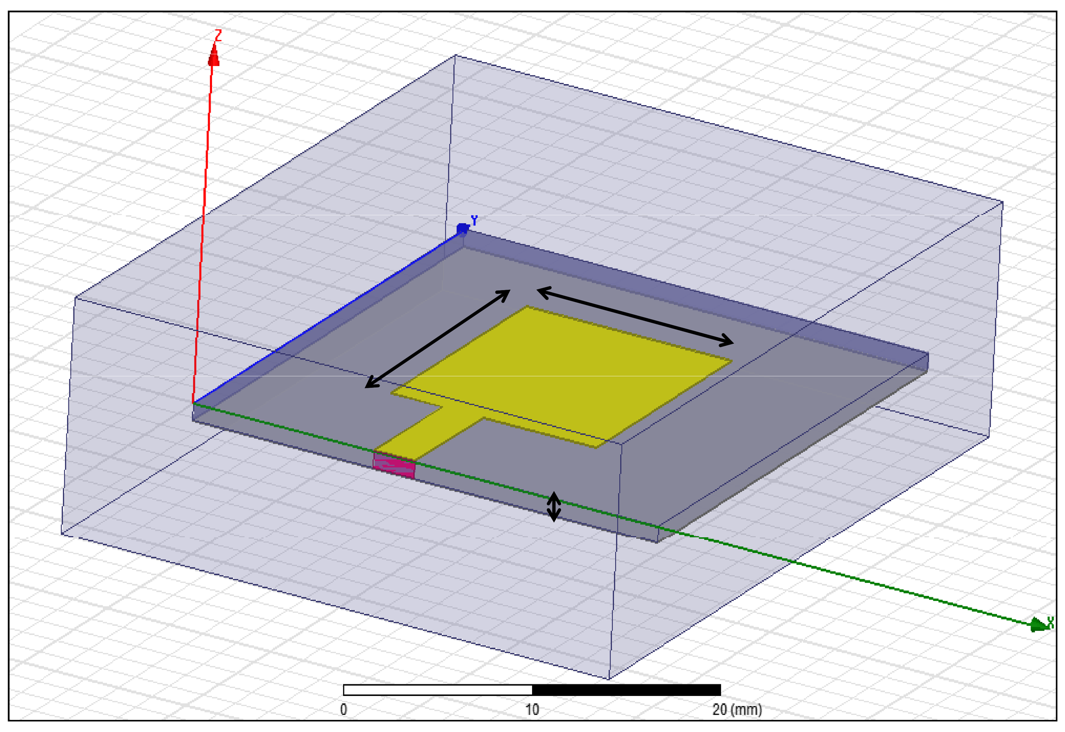


Fig.1: Rectangular Patch Antenna, excited by microstrip feed-line, the size of the patch is WxL=12.45x16mm, the size of the feed line is $W_f x L_f$=2,46x8mm, height of the substrate is h=0,794mm. Three different uniaxial anisotropic substrates are used: Pyrolytic boron nitride, Epsilam-10 and Sapphire.

Based on the simplified analytic formulation for thin substrate, a design procedure is outlined which leads to practical designs of rectangular microstrip antennas. The procedure assumes that the specified information includes the dielectric constant of the substrate ε_r, the resonant frequency f_r, and the height of the substrate h; W denotes the width of radiating patch, L is the length of radiating patch, given in the following relations:

$$W = \frac{c}{2f_r}\left(\frac{\varepsilon_r+1}{2}\right)^{-\frac{1}{2}} \qquad (1)$$

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} - 2\Delta L \qquad (2)$$

Where ε_{eff} is the effective permittivity given by the following equation:

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+\frac{12h}{W}\right] \qquad (3)$$

The dimensions of the radiating patch along its length direction extend on each ends by a distance of ΔL, called fringing field region, given by:

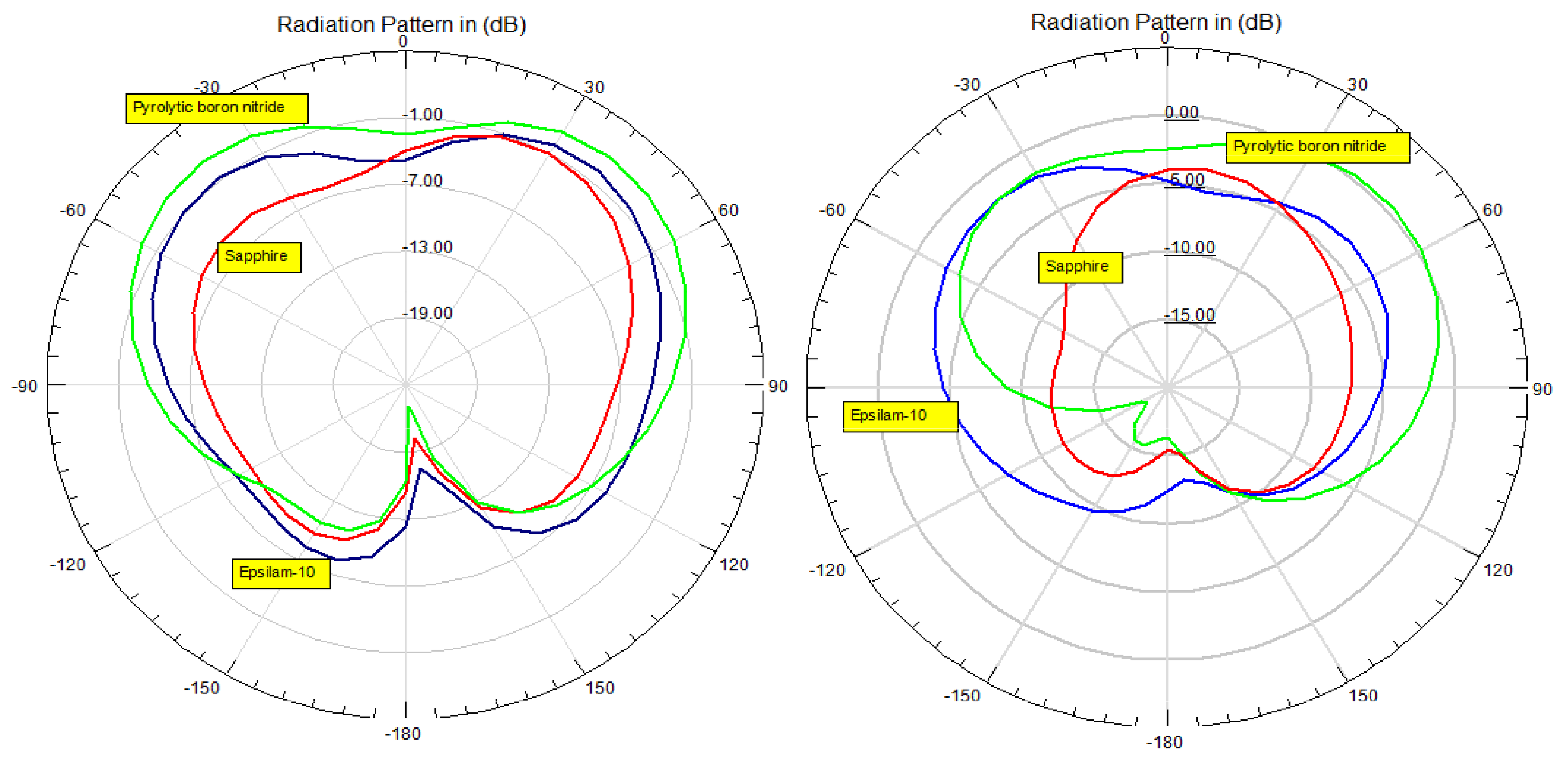
$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)\left(W/_h-0.264\right)}{(\varepsilon_{eff}-0.258)\left(W/_h+0.8\right)} \qquad (4)$$

If the material property is anisotropic, its characteristics are defined by its anisotropy tensor. For the uniaxiale anisotropic material, its uniaxial anisotropy tensor given by:

$$\bar{\varepsilon} = \varepsilon_0\begin{bmatrix}\varepsilon_x & 0 & 0\\ 0 & \varepsilon_x & 0\\ 0 & 0 & \varepsilon_z\end{bmatrix} \qquad (5)$$

Where ε_x is relative permittiviy in the both x and y directions; and ε_z is relative permittivity in the z direction. And ε_0 is the permittivity of vacuum.

Radiation Patterns in figure 2, indicated that the Pyrolytic boron nitride substrate, has a larger pattern compared to the Epsilam-10 and Sapphire substrates, where the Sapphire substrate has the lower one. Furthermore these results are confirmed in figure3, also indicated that the Pyrolytic boron nitride substrate has a lower return loss of -20.5545 dB, wheras the Sapphire substrate has lower one, almost at -6.9526 dB.



(a) (b)

Fig.2: Radiation Pattern in (dB), (a) phi=90 degrees; (b) phi=0 degree, at 7.5 GHz three different substrates are used: Pyrolytic boron nitride (ε_x, ε_z)=(5.12, 3.4); Epsilam-10 (ε_x, ε_z)=(13, 10.3) and Sapphire (ε_x, ε_z)=(9.4, 11.6).

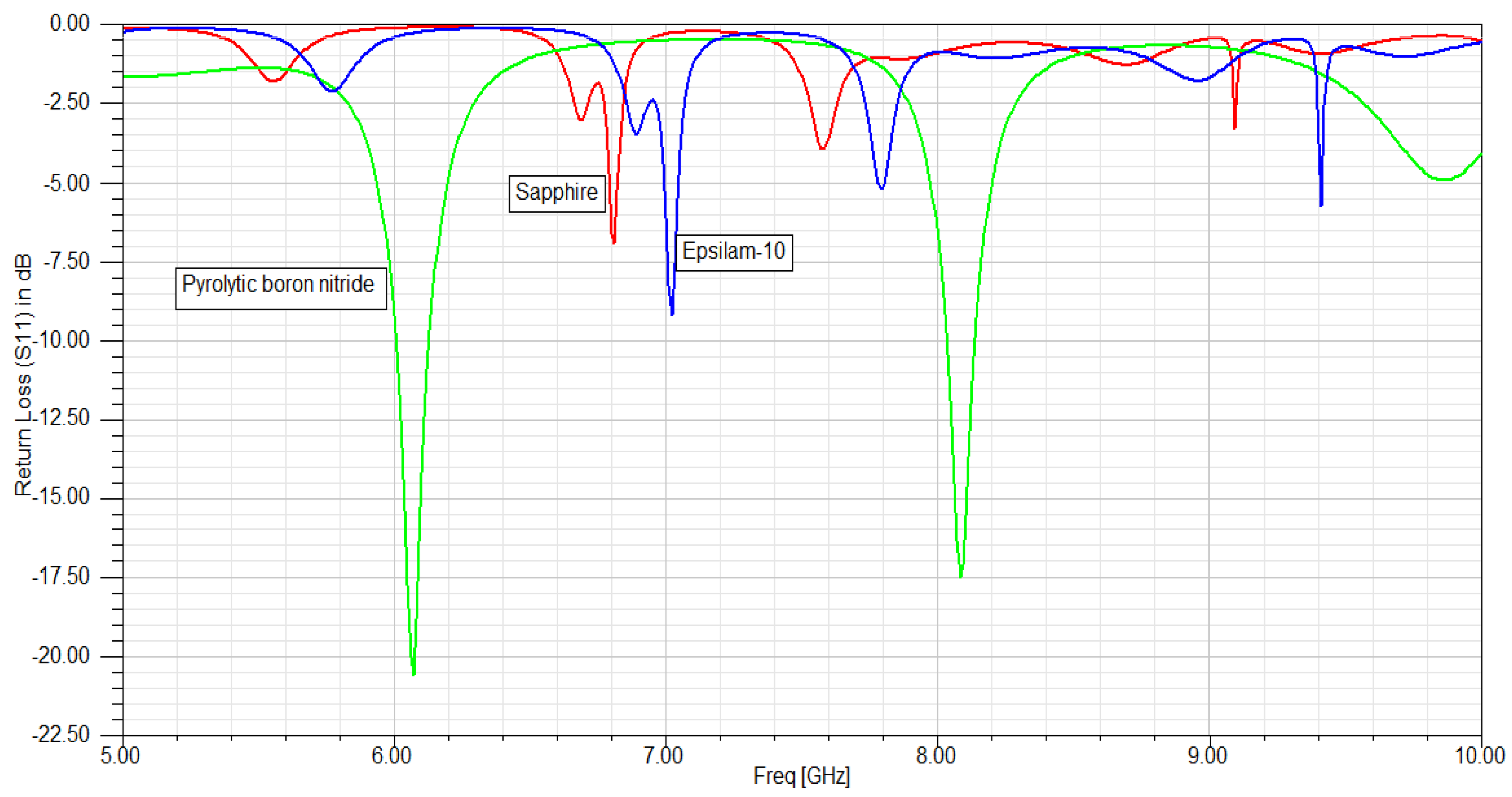


Fig.3: Return Loss in (dB) versus Frequency in (GHz), three different anisotropic substrates are used: Pyrolytic boron nitride (ε_x, ε_z)=(5.12, 3.4); Epsilam-10 (ε_x, ε_z)=(13, 10.3); Sapphire (ε_x, ε_z)=(9.4, 11.6).

3. Conclusion

A comparison between a several uniaxial anisotropic materials has done. The design are analyzed using the finite elements method (FEM) integrated in the software package High Frequency Structure Simulator (HFSS). The results shown, that the rectangular patch antenna has a different operating frequency when we use different uniaxial anisotropic substrates, conserving the same dimensions of the rectangular patch antenna. Also the Pyrolytic boron nitride substrate has presented a lower return loss compared to the Epsilam-10 and Sapphire.

Perspectives :

-Comparison between isotropic and anisotropic materials and their impact on the resonant frequency.

-The effect of the dielectric loss tangent on the resonant frequency.