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Inverted HTS rectangular patch antennas: Theoretical investigation

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ABSTRACT

In this paper, we propose a full-wave analysis for characterizing the resonant frequencies and bandwidths of high-temperature superconductor inverted microstrip printed on anisotropic substrates. Our proposed approach is based on Galerkin procedure in the Fourier transform domain (FTD) combining with the complex resistive boundary condition. With the use of suitable Green's functions in the FTD, the analysis is performed for the case where the superconducting rectangular patches printed on anisotropic substrate. The numerical results obtained using the proposed approach are compared with previously published numerical results computed by means of the electromagnetic simulator "IE3D software". These comparisons were very good, which prove the correctness and the validity of the proposed method. It is found that the optical properties combined with optimally chosen structural parameters of anisotropic materials can be maintaining control of the resonant frequency and exhibiting wider bandwidth characteristics.

1. Introduction

High temperature superconducting (HTS) materials have been widely used in the manufacturing of diverse microwave devices for mobile. satellite and space communication [1,2]. The use of superconductive materials is expected to increase rapidly due to their low loss property at temperatures below the critical temperature (Tc) [3]. Also, they have the largest power gap size arrangement which extends their response well in the THz range [4]. The superconducting antenna is one of the first microwave components presented as an application of a high temperature superconductive material [5]. The main advantage of using superconductive materials in antenna systems is to reduce the loss associated with the adaptation lines of the transmission circuits and the power supply networks. in particular, at the microwave and millimeter frequencies where the ohmic losses begin to significantly affect system performance [6]. Thereby, HTS materials are often used in the manufacture of antennas to increase radiation efficiency and gain. Due to the low surface resistance in HTS thin films compared to copper and gold [7]. However, high temperature superconducting antennas like other conventional microstrip antennas suffer from narrow bandwidth, which severely limits their application [8].

Various techniques are used to enhancing the bandwidth of HTS antennas such as multi-layers of dielectric substrate, a stacked patch antenna, and cutting slots in the ground plane [8–10].

Furthermore, the antenna substrates have a very important role in achieving the desired physical and electrical properties. Anisotropic layer provides flexibility, delicate design. and an additional degree of control, which can be properly exploited to increase the efficiency and the gain of the antenna [11,12]. The presence of a cover layer can seriously alter the microstrip antenna characteristics, thus can increase the gain and the bandwidth of the antenna by changing the effective permittivity of the microstrip structure [13]. The inverted antenna is a particular type of superstrate antenna configuration [13,14]. The characteristic of the inverted configuration is mainly due to the air gap layer between the inverted patch and the ground plane [15]. Therefore, the optimal integration of external components is very easy because only the air dielectric is present under the patch and the ground plane. Thus, it improves the bandwidth without any modification of the radiation pattern or radiation efficiency [13]. Moreover, a lot of materials in current use as substrates-superstrates exhibit a dielectric anisotropy (especially of the uniaxial type). Therefore, there is definitely a need to rigorously investigate the characteristics of microstrip antennas with anisotropic cover behavior. One of the well-established tools for the analysis more thoroughly of resonant characteristics of microstrip antennas on anisotropic substrates is the method of moments. which numerically solves integral equations formulated by using the dyadic

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