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Superstrate loading effects on the resonant characteristics of high Tc superconducting circular patch printed on anisotropic materials

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ABSTRACT

In this paper, the effects of both anisotropies in the substrate and superstrate loading on the resonant frequency and bandwidth of high-*Tc* superconducting circular microstrip patch in a substrate-superstrate configuration are investigated. A rigorous analysis is performed using a dyadic Galerkin's method in the vector Hankel transform domain. Galerkin's procedure is employed in the spectral domain where the TM and TE modes of the cylindrical cavity with magnetic side walls are used in the expansion of the disk current. The effect of the superconductivity of the patch is taken into account using the concept of the complex resistive boundary condition. London's equations and the two-fluid model of Gorter and Casimir are used in the calculation of the complex surface impedance of the superconducting circular disc. The accuracy of the analysis is tested by comparing the computed results with previously published data for several anisotropic substrate-superstrate materials. Good agreement is found among all sets of results. The numerical results obtained show that important errors can be made in the computation of the resonant frequencies and bandwidths of the superconducting resonators when substrate dielectric anisotropy, and/or superstrate anisotropy are ignored. Other theoretical results obtained show that the superconducting circular microstrip patch on anisotropic substrate-superstrate with properly selected permittivity values along the optical and the non-optical axes combined with optimally chosen structural parameters is more advantageous than the one on isotropic substrate-superstrate by exhibiting wider bandwidth characteristic.

1. Introduction

High-*Tc* superconducting (HTS) thin films are being increasingly used in the fabrication of high-performance frequency selective elements, such as resonators and filters, for defense and space communications [1–3]. They show superior performance at high frequencies to the normal metal devices such as: One is the lower surface resistance in high *Tc* superconducting thin films compared to normal conductors, corresponding to a higher quality factor [4–6] and improved performance in passive microwave devices. Also, because of lower losses in superconductors, the reduction in size is another advantage using high *Tc* superconducting thin films [6]. The second advantage is the frequency independent penetration depth, unlike the normal conductor. This means that dispersion introduced in superconducting devices will be negligible up to frequencies as high as hundreds of gigahertz [6]. The third advantage is the propagation time can be significantly reduced because of the smaller size and the shorter interconnects [4,6]. High-temperature superconducting microstrip antenna was one of the first microwave components to be demonstrated as an application of high-temperature superconducting materials [7]. Microstrip antennas have become popular for their compactness, less weight, conformal structure, low manufacturing cost, and ease of fabrication and integration with solid-state devices [8–10]. They are used in a wide range of microwave systems, such as wireless equipment, aircraft radomes, missiles, satellites, and sensors [11,12]. Therefore, a considerable amount of researchers have been devoted to the characterization of different geometries of these structures. Particularly, a circular microstrip resonator can be used both as a separate antenna and as a component of oscillators and filters in multilayered microwave and millimeter wave integrated circuits (MWICs) [13]. However, the microstrip antennas also offer some demerits like spurious feed radiation; higher cross polarization and narrow bandwidth that need to improve through the application of efficient technique and/or design [2]. One of the solutions to increase the bandwidth in microstrip antennas is addi-

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