Numerical Analysis of Printed Antennas on Thin Film

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1. Introduction

With the development of numerical analysis method, the many kind of electromagnetic simulators are used for the analysis of antennas. Authors have calculated the dipole antenna, the linear polarized rectangular patch microstrip antenna, the circular polarized rectangular patch microstrip antenna by using the electromagnetic simulators based on the method of moment, the FDTD method and the TLM (Transmission Line Matrix) method [1]-[4]. The calculated antenna characteristics such as the input impedance, the radiation pattern, and the directivity are compared with the measured results. In these references, it was shown that the calculation condition of each simulator depends on the geometry of antenna in order to obtain the convergent result.

Recently small antennas printed on the thin dielectric film are used for the radio frequency identification (RFID) system [5], [6]. The FDTD method is a powerful tool for analyzing the antenna including conductor and dielectric material. However, the numerical calculation of the antenna on thin film is time consuming, because the maximum cell size is limited to be less than about ten times of the minimum cell size in the FDTD method.

In this paper, a dipole antenna and a rectangular spiral loaded dipole antenna printed on the polyimide film are numerically and experimentally analyzed. The input impedance of these antennas are calculated by using the electromagnetic simulator IE3D based on the method of moment [7].

2. Analytical model and numerical results

Figure 1 shows a dipole antenna printed on the polyimide film. The strip conductor of thickness 35 μm is printed on the thin film of thickness 95 μm. The antenna is covered by the film of thickness 50 μm for protection. The relative dielectric constant of film is 3.5. In this paper, we call this antenna as Antenna No.1

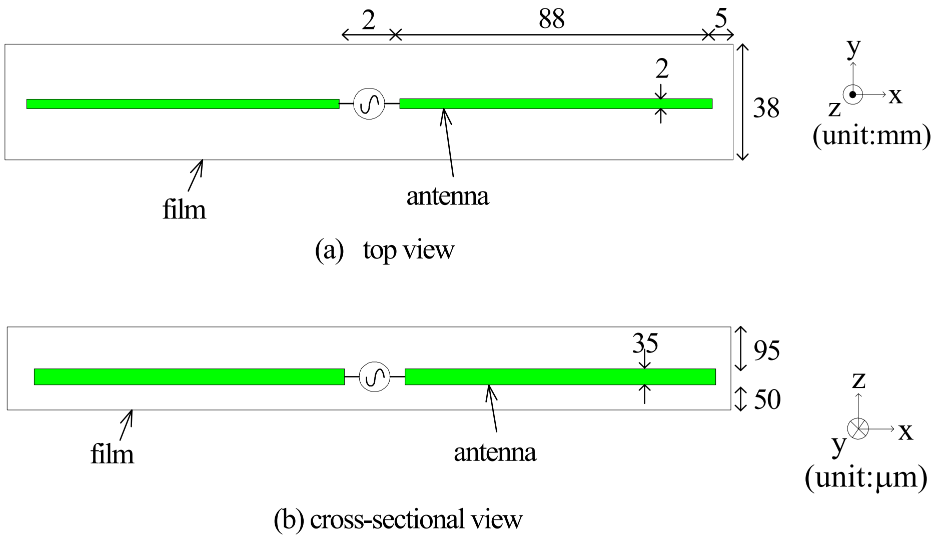

Figure 1 Dipole antenna printed on polyimide film (Antenna No.1)

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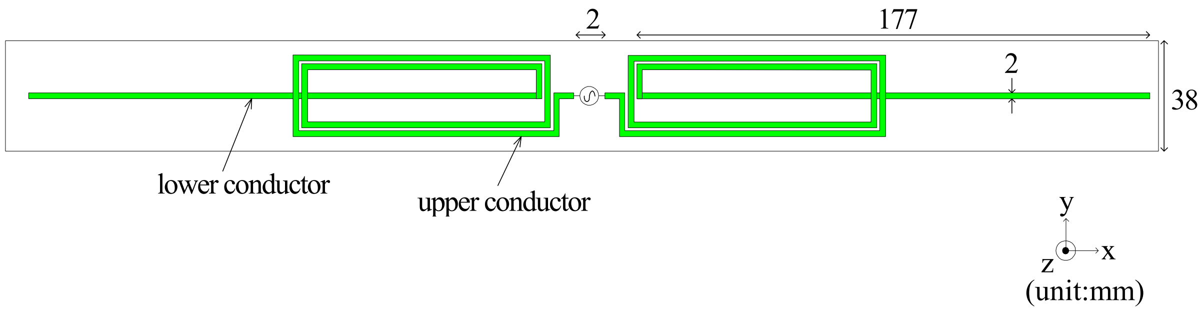
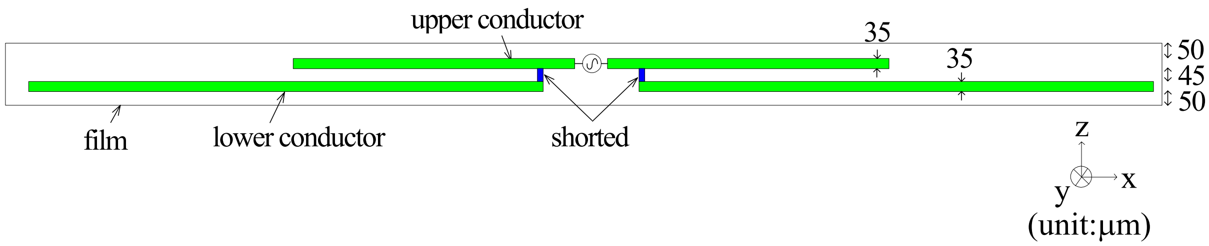


(a) top view



(b) cross-sectional view

Figure 2 Rectangular spiral loaded dipole antenna printed on polyimide film (Antenna No.2)

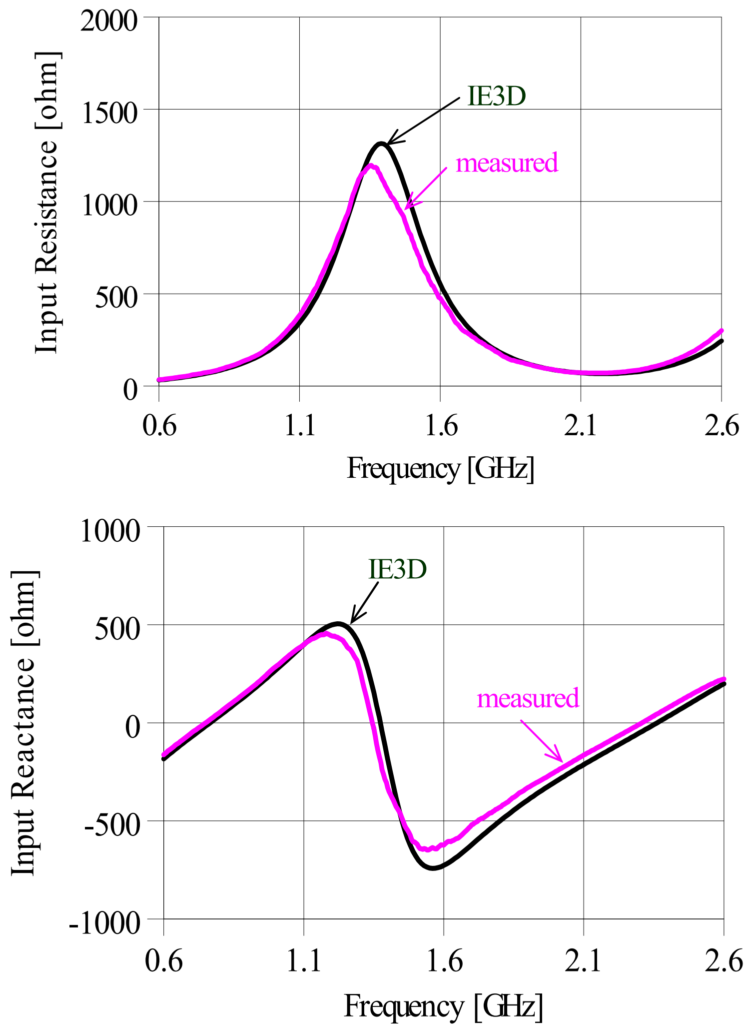


Figure 3 Input impedance of Antenna No.1

Figure 2 shows a rectangular spiral loaded dipole antenna printed on the polyimide film. The conductors with thickness of 35 μm are printed on both side of the base film with thickness of 45 μm. On the upper surface of base film, the rectangular spirals are printed. The upper and lower conductors are connected at their ends. The films with thickness of 50 μm are covered on both surfaces of base film for protection. We call this antenna as Antenna No.2

In the numerical calculation by IE3D, the infinite film is assumed. The thickness of antenna is assumed to be infinitely thin. In the analysis of Antenna No.1, the cell size is chosen as 3.84 mm, that is, 1/30 wavelength at the highest frequency 2.6 GHz. Therefore, the number of cell per wavelength Ncell becomes 30. In order to consider the singularity of electromagnetic field at the conductor edge, the edge cell width of 390 μm is assumed at both side of conductor. Figure 3 shows the input impedance characteristics of Antenna No.1. The calculated values agree well with the measured results. In the measurement of input impedance, the antenna is mounted on the ground plane of 1.6 m by 1.6 m in extent.

Figure 4 shows the input impedance characteristics of Antenna No.2. The cell size and the width of edge cell are same as those of Antenna No.1. At the higher frequencies, the calculated values disagree with the measured results. Figure 5 shows the input impedance characteristics of Antenna No.2. The cell size is reduced to 2.3 mm, that is, 1/50 wavelength at 2.6 GHz. The width of edge cell is chosen as 24 μm. Good agreement between the calculated and measured results is obtained.

3. Conclusion

The dipole antenna and the rectangular spiral loaded dipole antenna printed on the polyimide film are calculated

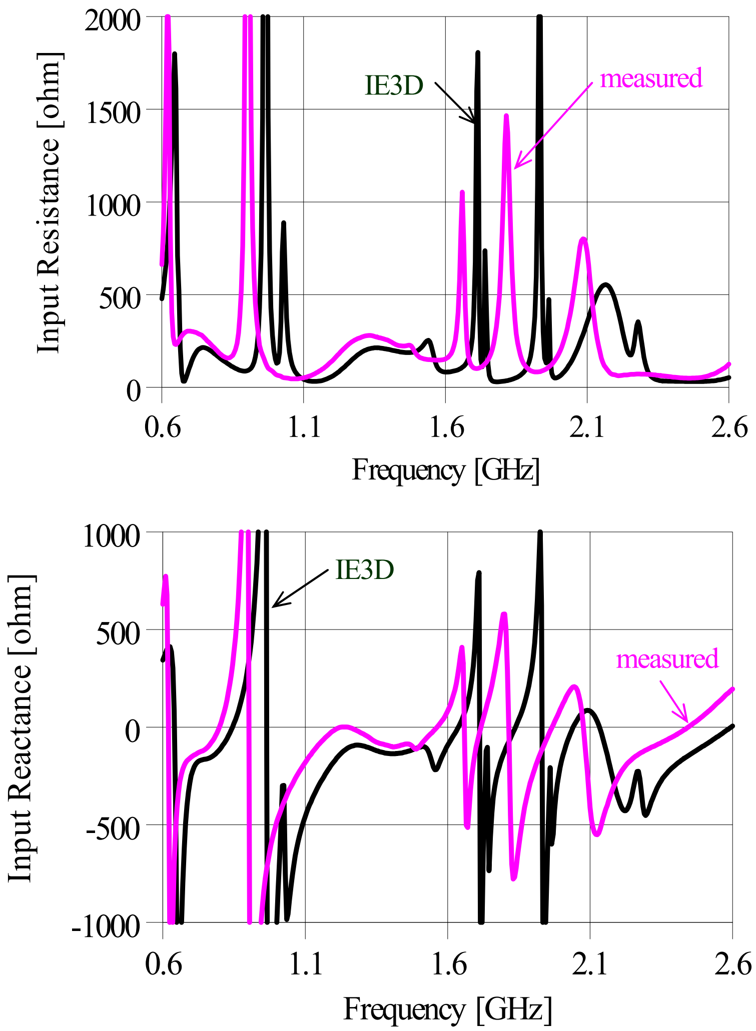


Figure 4 Input impedance of Antenna No.2. Ncell=30

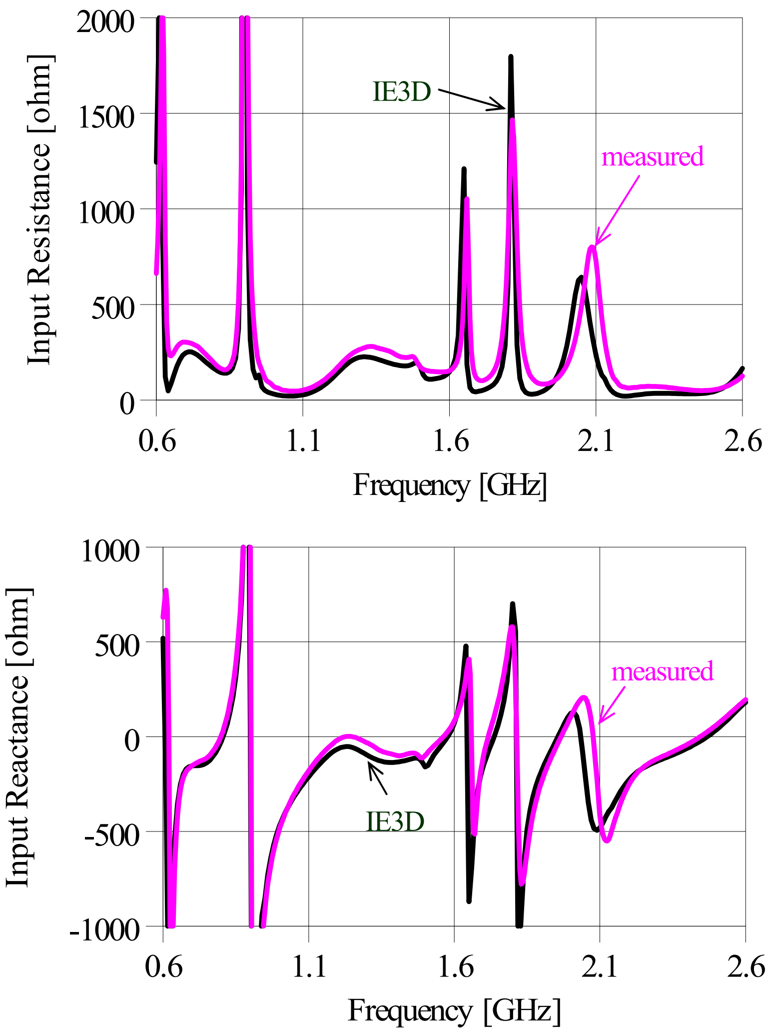


Figure 5 Input impedance of Antenna No.2.　Ncell=50

by using IE3D. The calculation conditions such as the cell size and the width of edge cell are discussed. The numerical result depends on the cell size and the width of edge cell in the calculation. The result obtained in this paper is applicable to the design of the small tag antenna for RFID system.

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