Simple Dielectric Resonator Antennas using ITO, Al and Ag Coated Glass on a Transmission Line

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Abstract.A novel Dielectric Resonator Antenna (DRA), simply made of Indium Tin Oxide (ITO)and Al or Ag coated glass slide of size 15mm x 15mm is studied in the frequency range1MHz-12GHz. This study enables the applicability of such DRAs in the dual-band WLAN/WiMAX frequency range (2.4-5.85GHz). The proposed antenna consists of a microstrip feedline that excites the ITO or metal coated DRAs. The three DRAs of ITO, Al and Ag coated glass slides of the same dimension have been compared with each other with reference to the original transmission line features. Changes in the direction of propagation are observed with frequency. The bandwidth in case of ITO samples is wider than the metallic counterparts.

INTRODUCTION

Wireless Local Area Network (WLAN) has undergone a rapid development in recent years[1]. The communication systems are designed to operate at 2.45GHz (WLAN), 5.2GHz and 5.8GHz (WiMAX)[2]. WLAN requires low cost and compact antenna with sufficient bandwidth for its application in communication[3]. Previously used microstrip antennas suffer from narrow bandwidth and are large in size. Hence, as an alternative, Dielectric Resonator Antennas (DRA) was proposed[4]. Some of the advantages of DRAs include small size, low cost, high radiation efficiency, reduced conductive losses, and a flexible feed mechanism[5]. Dielectric resonators were reported as filter elements devices in microwave circuits[6]. It soon gained importance as a radiating element and by the early 1980's, the smaller size potential and higher frequency applications created the new domain of research in DRAs[7]. Today, DRA technology is a promising alternative to conventional antennas for wireless communication applications[8]. In this report the frequency band 10MHz – 12GHz, which includes WLAN, WiMAX frequency band, is investigated using simple metal coated and ITO coated glass slides as DRAs.

ANTENNA DESIGN

Figure 1 shows the geometry of the proposed DRA model. A FR-4 substrate of length, L = 50 mm (x-direction) and width, W = 45 mm (y-direction) is chosen. The dielectric constant is 4.3. The thickness of the substrate is 1.6mm. This is an industrial standard. The microstrip feed transmission line is made of copper. It has dimensions t = 3 mm and length Lt = 42 mm. These dimensions are chosen to ensure an impedance of 50 Ω. The transmission line initiates at x=0 and y=0 as described in Figure 1. The ground plane is made of copper and stretches along the width, *W*. Itspreads over a length *g* = 16 mm along the *L* of the substrate.

The ITO coated glass DRAs are placed over the transmission line at a distance of *x* = 18 mm ensuring physical contact between the two [Figure 1]. The DRA is directly fed by the microstrip transmission line. The ITO DRA samples used are cuboidal in shape with thickness 0.76mm. The square coated part has sides of length 15 mm. The dielectric constant of the glass is 4.82. The resistivity of the ITO layer is 7.2e-4 Ωcm. The coating has a 90.2% transparency to visible light.

The ITO DRAs were placed with the ITO layer in contact with the transmission line and hence the bottom surface was the conducting layer.

The antenna was fabricated using LPKF Protomat E33 PCB Fabricator. The design of the antenna was prepared on the LPKF fabricator software and the milling instrument was used to accurately cut the board into the desired shape. The fabricator uses a high-speed drilling tool to cut away the copper layers wherever necessary in order to create the design of the antenna. A sharp cutting tool was then used to cut the antenna away from the board. After this the board measurements were confirmed by using a digital Vernier calliper. The SMA connector was thereafter attached to the board.

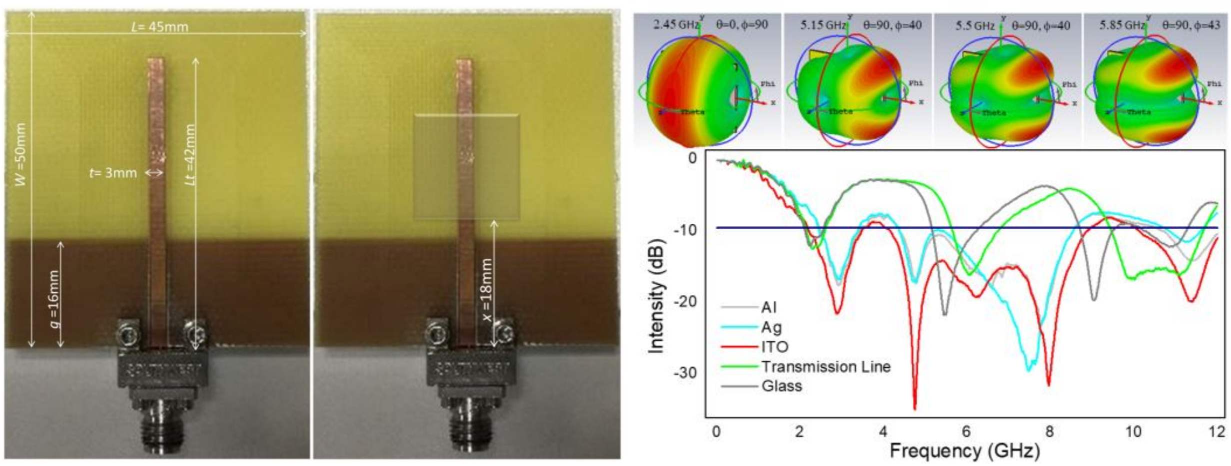

Figure 1(a): Model and dimensions of the DRA with transmission line, ground plane and the ITO glass slide arrangement;(b) Above: Simulated Far Field patterns of the ITO antenna at four important Wi-Fi frequencies: 2.45, 5.15, 5.5 and 5.85 GHz; (b) Below: S1,1 parameters of the ITO/glass DRA as compared to Al and Ag metal coated glass slides of same dimensions. A reference response of the bare transmission line and uncoated glass is also shown.

SIMULATION TECHNIQUE

MicroWave Studio Suite (MWS) of Computer Simulation Technology (CST) software is used to analyse the performance of the designed antenna. S parameter, directivity, etc. were determined using this software. The simulations are carried out using time domain analysis in CST MWS. The model described above is created using the CST design tools. The DRA model is excited using a discrete port at one end of the transmission line. Materials with losses are used in the simulations so as to get maximum accuracy in the simulation results. Each simulation is carried out over a frequency range of 0-12 GHz. Within time domain analysis, the Transmission Line Matrix (TLM) solver has been used. The TLM method provides an accurate broadband calculation and offers a very efficient octree-based meshing algorithm. This efficiently reduces the overall cell count. The scattering parameters were then collected and compared with the experimental values.

EXPERIMENTAL SETUP

An Anritsu MS46122A 40 GHz Vector Network Analyser (VNA) is used to measure the frequency dependent S1,1 scattering parameters of the DRA. The data is recorded from the VNA using a Anritsu ShockLine software.

The VNA is calibrated for a frequency range of 0.01-12 GHz and is then connected to the antenna using an SMA connector. The scattering parameters are then extracted from the software and used for further analysis.

ANALYSIS

The transmission line itself has responses at 2.45 GHz, 6.0GHz, 6.7GHz, 9.97GHz and 11.1GHz [Fig. 2]. S1,1 responses of the ITO and metal-coated DRAs are similar, with the ITO DRA yielding better return loss and wider bandwidth. The responses of the ITOcoated glass DRA havemodified maxima at 2.9 GHz, 4.76 GHz, 6.26 GHz, 7.98 GHz and 11.36 GHz. Response maxima are observed for both Al and Ag coated glass DRA at 2.92 GHz and 4.78 GHz. These three DRAs differ for the high frequency regime and while Ag reveals maxima at7.47 GHz and 11.24 GHz, for the Al coated glass DRA, maxima are observed at 6.6 GHz, 7.8 GHz, and 11.41 GHz. The intensity of these responses enhances and thereby widens the bandwidth. As the intensity of the ITO DRA is the most, it reveals a nearly continuous bandwidth ranging from 2.4 GHz to greater than 12 GHz the metallic ones show worse features. However, there are narrow frequency bands missing at ~3.56-4.04 GHz and ~8.97-10 GHz. In case of the metallic ones these missed out frequency bands are much wider. While Ag misses 3.4-4.35 GHz and 8.6-10.8 GHz, Al misses 3.47-4.35 GHz and 8.6-10.6 GHz.

The radiation patterns of an antenna provide the information that describes how the antenna directs the energy it radiates. At 2.45 GHz the radiation is omni-directional in the 'yz' plane for all samples.In the frequency range of 5.15 GHz to 5.85 GHz the radiation is in the 'xy' plane.The directions of the three different antennas are not much different and points along ($\theta=0^o$, $\phi=90^o$), (90^o, 40^o), (90^o, 40^o) and (90^o, 43^o) for 2.45 GHz, 5.15 GHz, 5.5GHz and 5.85 GHz respectively [Fig 2]. The gain is in the range of 2.33, 4.67, 4.43 and 3.65dB at frequencies 2.45 GHz, 5.15 GHz, 5.5GHz and 5.85 GHz respectively.

CONCLUSION

A simple coating of metal or ITO on glass can modify a transmission line to a wide bandwidth resonating antenna, with significant gain. The response, gain and band width obtained with ITO coated glass is better than the metal counterparts. The directions obtained are very similar to each other. These antennas are resonating at over a wide range of frequencies including ranges for WLAN and WiMAX with good gain and directivity. The antennas are thus suitable for communication applications in these frequency ranges.

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