On the Far-Field Characteristics of a 3D-printed Antenna Using Wood-Based PLA and Conductive Silver Nanoparticle Ink

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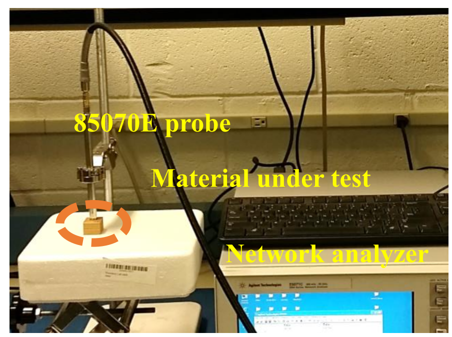
***Abstract*—This paper reports the far-filed characteristics of a class of 3D-printed dipole antenna fabricated using wood-based polylactic acid (PLA). The electromagnetic properties (dielectric constant and dielectric loss factor) of the wood-based PLA are measured from 200 MHz to 20 GHz, using a Keysight 85070E Performance dielectric Probe, and its loss tangents values (tan δ) are calculated accordingly. The conductive parts of the antenna are fabricated using silver nanoparticle ink. The antenna is fabricated using a desktop 3D printer. The reflection coefficient and radiation patterns of the fabricated antenna are measured and the results are presented and compared with the simulation.**

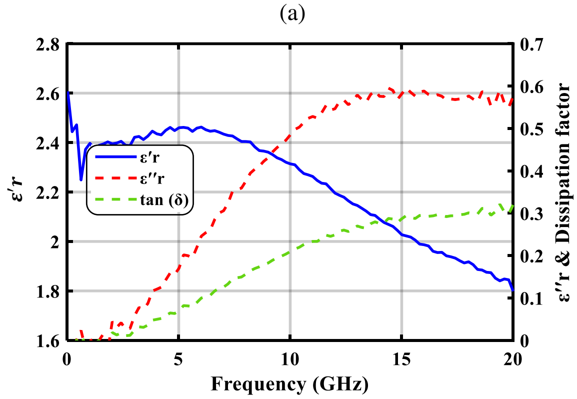
I. Introduction

The growing demand for quick prototyping and low-cost manufacturing methods has drawn attention to additive manufacturing (AM) technology (also known as 3D-printing technology) as a possible alternative to traditional manufacturing processes. Different techniques have been developed in recent years to fabricate antennas and radio frequency (RF)/ Microwave components using AM. Metalization using conductive materials has been proposed for the fabrication of antennas with previously 3D-printed substrates [1]. In another study, ultrasonic embedding was investigated to submerge the wire mesh in to the 3D-printed substrate to from a small patch antenna [2]. Polylactic acid (PLA) and conductive acrylonitrile butadiene styrene (ABS) were used to fabricate a class of bowtie antennas using 3D-printing technology in a single fabrication process [3]. In [4], a dipole antenna was fabricated using 3D-printed nylon resin co-polymer and PLA-based conductive graphene. The use of 3D printing technology to fabricate substrate integrated waveguide (SIW) components is reported in [5]. In [6], a bowtie antenna with a 3D-printed substrate is reported. In this work, the conductive parts of the antenna are fabricated using annealed copper.

According to recent research, biodegradable wood-based computer chips can function just as well as chips typically used for wireless communication [7]. Recently, wood-based PLA (70% PLA, 30% recycled wood fibres) has been characterized and used for the fabrication of 3D-printed antennas using different conductive materials [8]. In [8], it was demonstrated that the wood-based PLA antenna with conductive



(a)



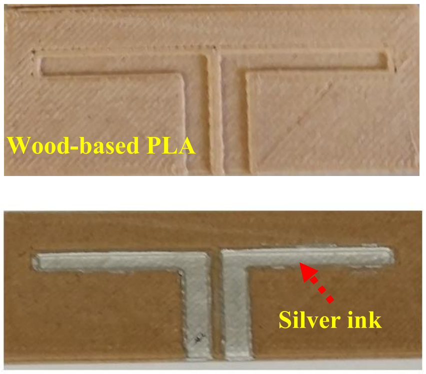
(b)

Fig. 1: (a) Permittivity measurement setup, and (b) real/ imaginary parts of permittivity and loss tangent.

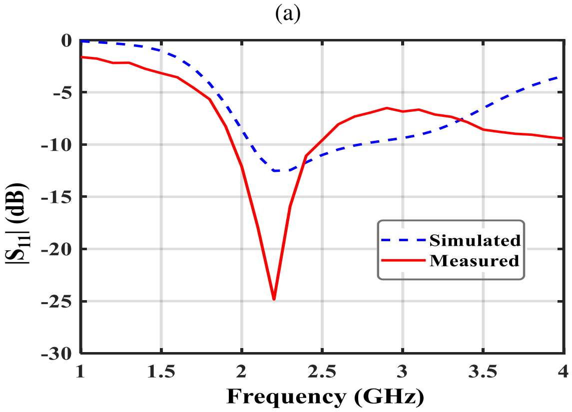
Silver nanoparticle ink provides the best S_{11} performance; however, the far-field characteristics of the antenna have not been reported. In this paper, the far-field characteristics of the dipole antenna using wood-based PLA and conductive silver nanoparticle ink are reported. Moreover, the complex permittivity and loss tangent of the wood-fill PLA for the frequency range of 200 MHz–20 GHz are presented.

II. Antenna Fabrication and Measurements

The wood-based PLA was characterised using 85070E Performance Probe [8]. Fig. 1a shows the measurement setup. The real and imaginary parts of complex permittivity ($\epsilon^{'}$ and $\epsilon^{''}$) are



(a)



(b)

Fig. 2: (a) Photograph of the fabricated antenna before and after metalization, and (b) simulated and measured reflection coefficients.

shown in Fig. 1b. Based on the obtained data, a dipole antenna was designed and simulated to operate across the $2-3$ GHz frequency range. The antenna was fabricated using ROBO 3D desktop printer. Fig. 2a shows the fabricated antenna before and after metalization processes. Fig. 2b compares the simulated and measured reflection coefficients. The simulated and measured radiation patterns are shown in Fig. 3. As seen, the simulated and measured radiation pattern are in a good agreement. The total efficiency and gain are measured as -3.45036 dB and 2.1764 dBi, respectively.

III. Conclusion

This paper presents the far-field characteristics of a dipole antenna fabricated using wood-based PLA and conductive silver nanoparticle ink using 3D-printing technology. The simulated and measured radiation patterns are in a good agreement. Moreover, the antenna provides a measured total efficiency and gain of -3.45036 dB and 2.1764 dBi, respectively.

ACKNOWLEDGEMENT

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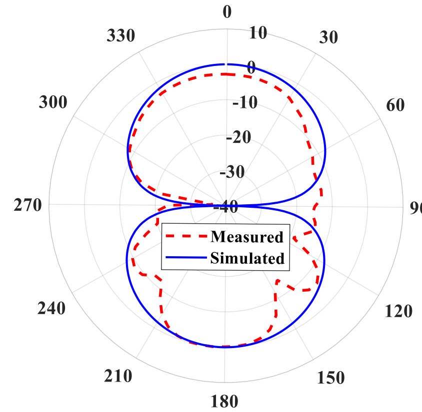
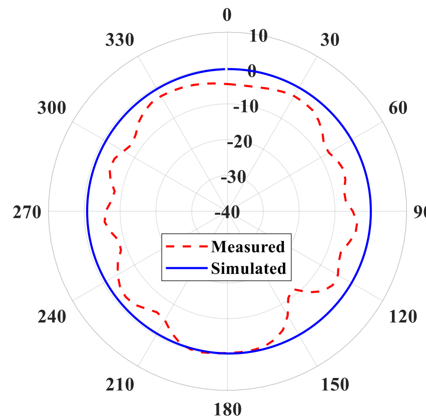


(a)



(b)

Fig. 3: (a) Radiation patterns (E-palne), and (b) radiation patterns (H-palne).

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