Research Article

Dielectric properties of epoxy–barium titanate composite for 5 GHz microstrip antenna design

Nurulfadzilah Hasan[1] · Nurul Hazlina Noordin[1] · Mohamad Shaiful Abdul Karim[1] · Mohd Ruzaimi Mat Rejab[2] · Quan Jin Ma[2]

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Abstract

To fulfill the demands for robust, compact microstrip antenna for wireless communication, miniaturization is necessary. To achieve this, conventional dielectric microstrip antenna substrate can be replaced with high-permittivity composite dielectric material. Epoxy–barium titanate composite has potential to be used as antenna substrate. This paper focuses on fabrication of epoxy–barium titanate composite at different filler loadings. Then, the permittivity of the composite at G-band frequencies (4–6 GHz) is measured using waveguide technique. The effect of filler concentration to permittivity is observed at 5 GHz, the intended resonant frequency of the antenna. Waveguide technique determines the complex permittivity by analyzing only the measured transmission coefficient of the material, and easily noise affected reflection coefficient is not used. The experimental results show that the permittivity of epoxy–barium titanate increases steadily as the filler volume increases. At the highest filler volume (20%), the permittivity of the composite at 5 GHz is at 6.67. The results obtained are in good agreement with theoretically predicted values.

Keywords Permittivity · Polymer–ceramic composite · Microstrip antenna · G-band frequencies · Waveguide

1 Introduction

Wireless communication systems today are mostly compact, portable and multi-functional. These communication devices require small, lightweight and robust antennas to support fast and secure data transmission between devices. Microstrip antennas meet these requirements as they are robust, lightweight and have low profile. Since its discoveries in the late 1970s, microstrip antenna technology has been critically studied to improve its performance to suit the evolution of wireless communication technology, including studies on miniaturize microstrip antenna. There are several ways to meet the current demands for miniaturized microstrip antenna, and one effective way is by using high-permittivity dielectric material as antenna substrate [1–3]. The substrates' permittivity controls the physical size, the radiation, the efficiency and the bandwidth of the antenna [4]. Commonly used dielectric substrates are FR-4 and RT-Duroid, which have permittivity of 4.4 and 2.2, respectively [4]. Thus, by substituting common antenna substrate with a higher-permittivity dielectric, the overall size of the antenna can be reduced. This can be achieved by using composite material as dielectric substrate.

Composite materials are developed by adding fillers into base materials such as polymer and epoxy resin [5]. Common fillers include ceramic powders, carbon fibers, glass fibers, hollow microspheres, graphene and carbon nanotubes. The permittivity ε_r of composite material depends on the volume of filler material added to it. By

✉ Nurulfadzilah Hasan, nurulfadzilah@ump.edu.my; Nurul Hazlina Noordin, hazlina@ump.edu.my; Mohamad Shaiful Abdul Karim, mshaiful@ump.edu.my; Mohd Ruzaimi Mat Rejab, ruzaimi@ump.edu.my; Quan Jin Ma, neromaquanjin@gmail.com | [1]Faculty of Electrical and Electronics Engineering Technology, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia. [2]Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia.

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