World Academy of Science, Engineering and Technology
International Journal of Electronics and Communication Engineering
Vol:10, No:09, 2016

Microwave Dielectric Constant Measurements of Titanium Dioxide Using Five Mixture Equations

Authors : Jyh Sheen, Yong-Lin Wang

Abstract : This research dedicates to find a different measurement procedure of microwave dielectric properties of ceramic materials with high dielectric constants. For the composite of ceramic dispersed in the polymer matrix, the dielectric constants of the composites with different concentrations can be obtained by various mixture equations. The other development of mixture rule is to calculate the permittivity of ceramic from measurements on composite. To do this, the analysis method and theoretical accuracy on six basic mixture laws derived from three basic particle shapes of ceramic fillers have been reported for dielectric constants of ceramic less than 40 at microwave frequency. Similar researches have been done for other well-known mixture rules. They have shown that both the physical curve matching with experimental results and low potential theory error are important to promote the calculation accuracy. Recently, a modified of mixture equation for high dielectric constant ceramics at microwave frequency has also been presented for strontium titanate (SrTiO3) which was selected from five more well known mixing rules and has shown a good accuracy for high dielectric constant measurements. However, it is still not clear the accuracy of this modified equation for other high dielectric constant materials. Therefore, the five more well known mixing rules are selected again to understand their application to other high dielectric constant ceramics. The other high dielectric constant ceramic, TiO2 with dielectric constant 100, was then chosen for this research. Their theoretical error equations are derived. In addition to the theoretical research, experimental measurements are always required. Titanium dioxide is an interesting ceramic for microwave applications. In this research, its powder is adopted as the filler material and polyethylene powder is like the matrix material. The dielectric constants of those ceramic-polyethylene composites with various compositions were measured at 10 GHz. The theoretical curves of the five published mixture equations are shown together with the measured results to understand the curve matching condition of each rule. Finally, based on the experimental observation and theoretical analysis, one of the five rules was selected and modified to a new powder mixture equation. This modified rule has show very good curve matching with the measurement data and low theoretical error. We can then calculate the dielectric constant of pure filler medium (titanium dioxide) by those mixing equations from the measured dielectric constants of composites. The accuracy on the estimating dielectric constant of pure ceramic by various mixture rules will be compared. This modified mixture rule has also shown good measurement accuracy on the dielectric constant of titanium dioxide ceramic. This study can be applied to the microwave dielectric properties measurements of other high dielectric constant ceramic materials in the future.

Keywords : microwave measurement, dielectric constant, mixture rules, composites
Conference Title : ICEDC 2016 : International Conference on Electronic Devices and Circuits
Conference Location : London, United Kingdom
Conference Dates : September 29-30, 2016

Open Science Index, Electronics and Communication Engineering Vol:10, No:09, 2016 publications.waset.org/abstracts/50454.pdf