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A Modified Complex Permittivity Measurement Technique at Microwave Frequency

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ABSTRACT

Transmission/reflection coefficients measurement technique for determining materials complex permittivity at microwave (MW) frequencies with a modified inexpensive arrangement setup is examined in this paper. The general consideration is to use only the amplitudes of the transmission and reflection coefficients in presence of material sample to do permittivity determination. According to the analysis, the permittivity can be uniquely determined by measuring these two amplitudes when sample is prepared with large enough attenuation that multiple reflections between the two surfaces of the sample can be neglected. The validity of the method was proven by experiments, and numerical solutions of the measured data where achieved with the assistance of MathCAD™.

KEYWORDS

Amplitude, Complex permittivity, Frequency-domain, MathCAD™, Microwave measurement, Time-domain.

1 INTRODUCTION

Many well-established frequency domain [1]-[94] and time-domain [95]-[103] techniques are available for microwave measurement of the materials complex permittivity. Microwave techniques using one-port method were described in [56], [59], [65], [72], [79], [82], [84]-[86], [89], [90], [91], [98], [99], while microwave techniques using two-port techniques were described in [1]–[55], [57], [58], [60]-[64], [66]-[71], [73]-[78], [80], [81], [83], [95]-[97], [100]-[103]. Some of these methods are suitable for solid materials [1]-[24], [27]-[29], [31]-[37], [39]-[45], [47]-[57], [59]-[62], [64]-[83], [85], [91], [103], while other methods are suitable for liquid or other amorphous materials [20], [25], [26], [30], [38], [43], [46], [58], [63], [84], [41], [42], [44], [47], [49], [54], [59], [81], [87], [91], [95], [98]-[100]. Some of the microwave measurement techniques are simple and inexpensive [25]-[84], [89], [91], [98] while others are complex and expensive, and need for complex measurement apparatus, such as network analyzer or optical devices [31], [41], [47],[55], [83], [85], [95], [100].

Complex permittivity measurement at microwave frequencies with transmission and reflection coefficients was adopted widely using guided wave geometries, where the material sample is put inside precisely to fill the space with a certain width [24], [53], [82], [85], [96]. In [100] a microwave technique was used to measure materials complex permittivity using transmission and reflection coefficients at free space with a material filling a container placed between a pair of antennae for