

Chapter 2

Basics of Material Characterization

In this section, the basic principle for material characterization, which is finding or measurement of permittivity and permeability of a material is discussed.

According to microwave theory, material characterization can be categorized into non-resonant methods and resonant methods. If the electromagnetic properties of a material over a frequency range is to be known then non-resonant methods are used, whereas to know the dielectric properties of a material for a specific frequency, resonant methods are used. To know the exact properties of materials both resonant and non-resonant methods are used hand in hand. The properties of materials over a frequency range is improved using the non-resonant methods with the help of the information received by using resonant methods for the same material at a particular frequency.

2.1 Non-resonant Methods

In this method, the properties of the materials are inferred from their impedance and wave velocity. The propagation of electromagnetic waves from free space to samples results in changes in characteristic impedance and wave velocity of the material. Due to these changes, partial reflection of electromagnetic wave occurs, at the interface between the two materials.

Non-resonant method can be further categorized into two methods, they being reflection method and transmission/reflection method. In reflection method, estimation of material properties are done on the basis of reflection from the sample. In transmission/reflection method, estimation is done on the basis of reflection from the sample and transmission through the sample, in this method, the electromagnetic energy needs to be guided towards the material and then acquiring the reflected energy from the material as well as through the material.

2.2 Resonant Method

The accuracy and sensitivity using resonant methods are higher as compared to non-resonant methods and are most likely for low-loss sample. The two categories of resonant methods are resonator method and resonant-perturbation method. In the former method, the permittivity and permeability helps in the calculation of resonant frequency and quality factor of dielectric resonator for the given dimensions. The later method is rooted from resonant-perturbation theory. According to this theory when changes are made to electromagnetic boundaries of a resonator, a visible variation is observed in the resonant frequency and quality factor of the sample. Analysing these changes the properties of the sample can be deduced.

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