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# 基于传输线法测量材料电磁参数研究

Research on Electromagnetic Parameters of Measuring  
Materials Based on Transmission Line Method

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## 摘 要

随着现代化科学技术的不断发展，微波技术已经在各个行业起到重要作用，在通信、航空、生物、医学等方面得到广泛应用。各种新型新材料的不断出现，需要完善测量理论和测量方式来加以验证，这就对材料微波电磁属性测量提出了更高的要求，随着微波工程应用和材料科学的不断发展，对材料的电磁参数测量技术的研究成为当前的一个热门课题。

本文主要研究短路微带线法测量纳米磁性薄膜的相对复磁导率。通过与传统的复磁导率测量方法对比，最终使用反射式短路微带法，测量纳米磁性薄膜材料。首先从传统的传输/反射法理论计算推导出测量复磁导率的公式，然后使用电磁仿真软件 CST 建立仿真模型，通过设置面内单轴各项异性材料属性进行模拟仿真。最后加工出自制短路微带测量夹具，应用矢量网络分析仪 E8362B 和计算机，通过编程 VEE 图形设计软件编程，搭建出 0.1GHz 至 6GHz 的试验自动测量平台，通过对一系列纳米磁性薄膜样品进行测量，并对测量数据进行系统的对比和分析，也对试验过程中涉及的注意事项进行了具体分析。

本文还重点研究了利用同轴传输线理论对介质材料的复介电常数进行测量。通过经典传输线理论推导出测量复介电常数的理论公式，设计出一种异型同轴传输夹具测量介质材料的复介电常数，并应用电磁仿真软件 HFSS 建立三维模型，模拟仿真，同时对不同结构所产生不同的电磁场进行对比优化，从而提高测量精度。我们加工出一套异型同轴传输测量夹具，利用矢量网络分析仪以及计算机搭建 1GHz 至 6GHz 频率范围内的自动测量平台，并对标准的聚四氟乙烯测量样品进行测量复介电常数，通过与理论值进行对比，结果理想，从而验证了其准确性以及可靠性。并对高频不足之处做了简要分析。

**关键词：**短路微带法，复磁导率，同轴传输线，复介电常数，纳米磁性薄膜

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## ABSTRACT

With the continuous development of modern science and technology, microwave wave technology has played an important role in industry, in communication, aerospace, biology, medicine and other aspects are widely used. The emergence of new materials requires for better measurement methods and theory, which put forward a higher demand for material properties measurement in the microwave range, for the development in the microwave engineering applications and materials science, Therefore, the investigation of the microwave electromagnetic parameters of the material measurement technology has become a hot topic.

In this paper, we study the relative complex permeability of nanometer-scale magnetic films measured by short-circuit microstrip method. By analyzing the difference compared with the traditional complex permeability measurement method, the use of reflective short-circuit microstrip method is proposed for the measurement of nano-magnetic thin film materials. Firstly, the formula of measuring the complex permeability is deduced from the traditional transmission / reflection theory. Then, the simulation model is established by using the common electromagnetic simulation software CST, and the simulation results are carried out by setting the properties of the opposite materials. Finally, the self-made short-circuit microstrip measuring fixture is used the vector network analyzer E8362B and the computer. The automatic measurement platform from 0.1GHz to 6GHz is programmed by using VEE graphic design software. By measuring a series of nano-magnetic film samples, And the measurement data are systematically compared and analyzed, and the precautions involved in the test process are analyzed in detail.

The complex dielectric constant of dielectric materials is measured by using the coaxial transmission line theory. The theoretical formula of measuring the complex permittivity is deduced by the classical transmission line theory. A complex dielectric constant is measured by a special-shaped coaxial transmission fixture, and a three-dimensional model of the electromagnetic simulation software HFSS is used to

simulate the physical model. At the same time, different field structure to optimize the comparison, in order to improve the measurement accuracy. We have built a set of special-shaped coaxial transmission measurement fixture, using of vector network analyzer and computer to build a automatic measurement platform from 1GHz to 6GHz frequency, and measured complex dielectric constant of the standard polytetrafluoroethylene sample, compared with Theoretical values, the results are correct. And we analyze the deficiencies in high frequency.

**Key Words:** short-circuit microstrip method, complex permeability, coaxial transmission line, complex permittivity, nano-magnetic thin film

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