TECHNOLOGY

Apparatus for Measuring Absolute Complex Conductivity and Surface Impedance of Metals and Superconductors

OVERVIEW

Knowledge of the skin depth and surface resistance is important for accurate measurements of material conductivity. Knowledge of surface impedance and dielectric properties of materials at microwave frequencies is of increasing importance as the clock rates of computers exceed 1 GHz, the density of magnetic recording media continue to increase, and as wireless communications expand into frequency bands beyond 800 MHz and 2 GHz. New means to perform accurate measurements of metallic and dielectric properties of materials in these new and technologically important frequency domains are required.

Currently there are three techniques that have potential for becoming the standard for characterizing materials at microwave applications. These techniques include the Parallel Plate microwave Resonator (PPR), the Dielectric microwave resonator, and low-frequency inductance techniques. The dielectric resonator allows for accurate measurement of the surface resistance of superconducting thin films, but cannot measure the absolute value of the magnetic penetration depth or normal-metal skin depth. Low frequency inductance techniques can measure the absolute value of the penetration depth, but not the surface resistance. In addition, neither of these techniques are well-suited for measuring dielectric properties of materials. The new Variable Spacing Parallel Plate Resonator (VSPPR) can measure both the microwave surface resistance and absolute value of the penetration depth in superconducting thin films, as well as the skin depth of normal metals.

Characterization of materials at microwave frequencies includes measuring the absolute values of specimen microwave surface resistance, Rs, and penetration depth l, or absolute screening skin depth. Absolute values of the penetration depth and surface resistance are not easily and accurately determined by existing techniques.

Researchers at the University of Maryland have developed a technique to accurately estimate the absolute value of Rs and penetration depth of such films. It also can be used to determine the dielectric constant and loss tangent of gasses and liquids at microwave frequencies. Finally, it can also measure the absolute values of the surface resistance and skin depth in highly conducting bulk normal metals with flat surfaces.

Measurements are carried out using two nominally identical samples with flat sample surfaces. The surfaces are brought together, face-to-face, and a thin dielectric separation of variable thickness is sandwiched between the samples. Liquid Nitrogen, Liquid Helium, Vacuum, or a liquid or gas of unknown dielectric properties fills the dielectric spacer. This forms a 2-conductor parallel plate transmission line resonator which can carry an electromagnetic wave. A resonant condition of the microwave signals is established and the resonant frequency and quality factor, Q, are measured. The spacing between the plates is then systematically varied. The variation of the resonant frequency and Q with spacer thickness is then analyzed to yield the absolute values of the sample surface resistance and penetration (or skin) depth.

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For additional information please contact the Office of Technology Commercialization at the University of Maryland, 301 405-3947 or e-mail:

otc@umd.edu

CONTACT INFO

UM Ventures
0134 Lee Building
7809 Regents Drive
College Park, MD 20742
Email: umdtechtransfer@umd.edu
Phone: (301) 405-3947 | Fax: (301) 314-9502

Additional Information

INSTITUTION

University of Maryland, College Park

PATENT STATUS

U.S. Patent 6,336,096 issued.

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CATEGORIES

- Microelectronics
- Research Tools, Antibodies, & Reagents

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