# MEASUREMENT OF DIELECTRIC CONSTANT OF SILICON WAFER USING MICROWAVE NON-DESTRICTIVE TESTING AND DIRECT CURRENT TECHNIQUE

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# ABSTRACT

This paper presents comparison between measurement of dielectric constant of silicon wafer by using MNDT which is at high frequency and by using HIOKI 3532-50 LCR HiTESTER which at low frequency. Measurement of dielectric properties of silicon wafer at microwave frequencies is performed in free space using a pair of spot-focusing horn lens antennas, mode transitions, coaxial cable and vector network analyser (VNA). A contactless and non-destructive microwave method has been developed to characterize silicon semiconductor wafer from reflection and transmission measurement made in free space at normal incident. In this method, the free-space reflection and transmission coefficients, $S_{11}$ and $S_{21}$ are measured for silicon wafer sandwiched between two teflon plates which are quarter-wavelength at mid-band. The actual reflection and transmission coefficient, $S_{11}$ and $S_{21}$ of the silicon wafers are calculated from the measured $S_{11}$ and $S_{21}$ of the teflon plate-silicon wafer-teflon plate assembly in which the complex permittivity and thickness of the teflon plates are known. Result for p-type and n-type doped silicon wafer are reported in frequency range of 10GHz to 12GHz. As a comparison, a measurement at low frequency using DC method has been conducted. The frequency range is reported from 0.2 kHz to 50 kHz.

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# CHAPTER 1

# INTRODUCTION

## 1.1 PROJECT OVERVIEW

In the construction of semiconductor devices, the control and measurement of the electrical properties of the material is very crucial. Permittivity and thickness must be evaluated since at microwave frequencies these properties may change significantly due to dielectric loss. The $SiO_2$ dielectric layer has been used for many decades due its physical and chemical properties. In addition, $SiO_2$ is also an excellent insulator because of its large 8-9 eV energy bandgap. The large barrier height of 3.1 eV and 4.5 eV for hole and electrons, respectively, keeps carriers in the channel. The dielectric properties are important for design of integrated circuits.

The semiconductor transport properties such as permittivity, resistivity must be evaluated. At microwave frequencies these properties may change significantly due to dielectric loss or other undesired spurious effects such as electromagnetic coupling thus posing problems for high frequency IC designers. At microwave frequencies, the dielectric loss is associated with formation of electric dipoles due to electronic and ionic polarizations. These dielectric losses have contributions to the permittivity and conductivity of semiconductor material.

The choice of substrate material is important for hih frequency integrated circuit design. The substrate must be a semiconductor material to accommodate the fabrication of active