NANOSECOND MEASUREMENT OF MICROWAVE REFLECTION COEFFICIENTS AND PROPERTIES OF MATERIALS*

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ABSTRACT

This paper presents a technique of measuring the change in the microwave reflection coefficient and Hall rotation angle while an explosive-generated, high-pressure shock wave propagates through a dielectric or semiconductor material in a magnetic field. With this technique, the permittivity, conductivity, and Hall coefficient can be calculated. The technique is widely applicable to measurement of fast changes (10 nanoseconds) in microwave properties; furthermore, the principles are adaptable to lower and higher frequency measurements.

SUMMARY

A microwave technique for measuring the changes in complex reflection coefficients (magnitude and phase) has been developed for dielectrics, semiconductors, and semimetals. The change can be resolved in less than 10 nanoseconds.

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NOTES

Detector voltages are recorded and used to determine the magnitude and phase of the reflection coefficient of the material. The properties of the materials are than calculated from the complex reflection coefficient. Since the shock wave travels through the material slowly compared to the response time, the properties of the material as a function of time and shock position are calculated. The technique has been used in explosive-generated shock-wave experiments which yield pressures of 10^5 to 10^6 bars. At these pressures, properties of materials such as onset of electrical conductivity in a dielectric and sudden increases in dielectric coefficient can be used to determine changes in solid, liquid, and gaseous phases, crystal structure; energy band gap, and chemical composition.

The measurable range of the relative dielectric coefficient extends to 400, while the conductivity is $5(10^{-5})$ to $5(10^{2})$ mhos/cm. The measurable range of the Hall mobility is dependent on the conductivity of the sample and the receiver sensitivity; however, the range can be several orders of magnitude. The rise time, which was limited by the recording oscilloscope, was 3 to 4 nanoseconds in these experiments.

The 35-GHz microwave circuitry consists of a reflectrometer bridge for the conductivity and permittivity measurement and a dual mode transducer with another bridge circuit for the Hall mobility measurement. The crystal diode detectors are calibrated and used in 50-ohm circuits to allow the fast rise time. The bandwidth of the microwave system easily exceeds the electronic recording bandwidth.