Improved Approach to Ultrasonic Sample Characterization Using an Optical Mask (Case 1403)

Published date: June 11, 2012

Technology description

Brief Description:
In non-destructive, optically-based material analysis and characterization systems, light pulses of picosecond and sub-picosecond duration generate a localized stress in a sample that result in propagating strain waves. These systems detect changes in optical constants of the sample material caused by the propagating strain waves. In the general area of picosecond ultrasonic sample characterization, there are two techniques known as the standard and grating methods. Both employ pump light pulses directed at a sample surface to cause regional stress/disruption.
The standard method uses one pump light pulse directed at the sample to raise the temperature of a layer near the surface causing the stress. A probe light pulse is applied to the sample at a later time for detection. The grating method divides the pump light into two beams directed at the substrate surface at oblique angles, resulting in periodic variance across the surface in terms of pump light intensity, temperature, induced stress and strain disturbance, optical constants and displacement. Also, a fraction of the probe pulse is diffracted, and the strain field acts as a diffraction grating. Diffraction intensity as a function of time can be measured to investigate sample strain propagation and determine physical properties. Both methods determine sample characteristics such as, but are not limited to, film thickness, adhesion between a film and substrate or another film, size and orientation of crystalline grains in a film, crystal phase and electrical resistivity of a film, and the rate of electro-migration within, and yield stress of, a film.
These existing two methods each have limitations and therefore, an improved approach to ultrasonic sample characterization is warranted.
The technology is an improved method and apparatus for pico- or sub-picosecond ultrasonic sample characterization, which incorporates an optical mask and is based on a substrate and at least one film disposed on/over the substrate surface. The innovation generates and detects strain pulses in a sample, while retaining many of the advantages of the standard method, and measuring directly the sound velocity without the need for a prior value. This novel system can measure the electrical resistivity of a metal film, provided the film thickness is within a certain range. Sample characteristics identical to those of existing methods can also be determined. Data analysis may be performed through comparison with known reference samples or by comparison with simulations, together with adjustment of parameters and iteration to achieve a best fit.

A transparent plate or optical mask, with a periodic grating etched into its surface, is placed over the sample for the pump light pulse and a time-delayed probe pulse to be directed through and onto the sample. The mask distorts the wavefront of the pump light pulse resulting in a periodic variance in the intensity of light incident onto the free surface of the film with position across the sample surface. This optical mask enables a more complete, optimal characterization, i.e., repeat distances of the mask can be selected and measurements for a number of different mask repeat distances can be made. Also, the use of an optical mask relaxes the requirement that the sample characterization apparatus be constructed to ensure that the phase relation between a plurality of pump beams remains constant, as a single pump beam is sufficient to provide the spatially distributed heating effect at the sample surface. Furthermore, the mask has advantages when characterizing altered materials, e.g., samples with implanted ions.

Application area

The primary market for this technology is in scientific analytic instrumentation, with market segments in industry, academia/non-profit/government, and military scientific R&D laboratories. Applications are numerous across multiple industries and may include, among others: identification and characterization of samples or unknown substances (e.g., military defense, NASA space samples, research reaction products, etc.) quality control of samples or products (industrial, consumer/ commercial, scientific, electronic) material science, engineering or other basic research experiments.

Institution

Brown University

Inventors

Humphrey Maris
Professor of Physics
Physics

联系我们

叶先生

电 话：021-65679356

手 机：13414935137

邮 箱：yeyingsheng@zf-ym.com