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Measurement of Ultrasonic Velocity and Attenuation at Elevated Temperatures

V. Rajendran and S. Muthu Kumaran
Dep. of Physics, Mepco Schlenk Engg. College, Mepco Engineering College (PO) 626 005

T. Jayakumar, P. Palanichamy and Baldev Raj
Metallurgy and Materials Group, Indira Gandhi Centre for Atomic Res., Kalpakkam 603 102

Abstract

Ultrasonic non-destructive testing is a sensitive tool not only for the defect detection and evaluation in plant components and structures, but also to characterise the microstructural features and for evaluation of mechanical properties. Even though, it provides high sensitivity and reliability for such measurements and very versatile to use at ambient temperatures, the technique fails when it is extended for high temperature studies beyond 600 K. This is due to the loss of piezoelectric properties of the transducer materials at higher temperatures. In order to overcome the above problem, an indigenous experimental set up has been designed and fabricated to carry out the ultrasonic velocities and attenuation measurements in solid materials over wide range of temperatures from room temperature to 800 K. In the present experimental set up, the through transmission technique has been employed for the ultrasonic measurements, using recrystallised alumina rods as waveguides. In the present experimental set up one can obtain the required temperature either in a dynamic mode or in a static mode as required, employing a microprocessor based temperature controller. The accuracy of the temperature in the sample region is ± 1 K. The experimental set up has been calibrated for the velocity measurements by measuring the precise transit time (t_1) using only the assembly of waveguides without any sample and the transit time (t_2) by inserting the sample between the waveguides, whose velocity is to be determined, corresponding to the same temperature condition. Thus, the transit time of the sample has been measured by taking the difference in the transit time ($\Delta t = t_2 - t_1$) at different temperatures. The present paper deals with the details of measurement procedure adopted for ultrasonic velocity and attenuation in solid samples as a function of temperature. The paper also gives the details of the calibration and validation of the experimental setup carried out through benchmark measurements made in materials with known phase transformations that occur at specific temperatures and are expected to influence ultrasonic parameters.