A New Pulse Method for the Measurement of the Thermal Diffusivity of Solids Over a Wide Temperature Range

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The paper describes the construction and operation of a new instrument based on the pulse method for the measurement of the thermal diffusivity of solid samples over a wide temperature range. The principle of the instrument involves illuminating the front face of a right cylindrical sample of a solid material with a beam of light, historically generated by a pulse laser. The novel approach that was taken for this device is to produce this light pulse with an array of LEDs for a prescribed period of time from 100 ms to 1s and to observe the temperature rise on the back face of the sample as a function of time as it rises and falls during the illumination and afterwards. The sample is maintained in a chamber that can be evacuated or filled with a gas of choice, thus allowing for the change and investigation of heat losses from the sample. The use of small temperature changes reduces heat losses significantly, nevertheless accounted for by a theoretical analysis.

The difference between this technique and the more familiar laser-flash technique is that the perturbation of the temperature of the solid is kept relatively small and followed over the entire evolution of the back face temperature. Given that the experimental process can be modeled in some detail using theories of transient heat conduction that were originally set out some time ago, it is possible to describe the temperature evolution of the back face of the sample rather precisely and thus determine the thermal diffusivity of the sample with low uncertainty. Evidence will be presented which shows that the experimental realization of the technique conforms to the theoretical description of it to a high degree. Preliminary work suggests that the uncertainty in the thermal diffusivity measurements of homogeneous, non-translucent samples is comparable to that obtained using laser flash instruments.