Optical Scanning Technology for Measurements of Solids Thermal Conductivity and Thermal Diffusivity and Its Application Results

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The optical scanning method and instruments have been developed for non-contact measurements of thermal conductivity, and thermal diffusivity of solids. It is based on scanning a solid sample surface with a focused, movable optical heat source in combination with a movable temperature sensor. A series of theoretical and experimental investigations were carried out to evaluate its potential, and measuring instruments were constructed. Optical scanning allowed us to record the variations of thermal conductivity and diffusivity along the inhomogeneous sample, and determine thermal conductivity and diffusivity tensor components for three-dimensional anisotropy. The other merits of optical scanning include (1) high precision (1.5%) and accuracy (1.5% at a confidence probability of 0.95) of thermal conductivity measurements within the range of 0.1…70.0 W/m×K, (2) high precision (2.0%) and accuracy (2.0%) of thermal diffusivity measurements within the range of $(0.1…5.0)\cdot10^{-6}$ m^2/s, (3) the ability to sample deeply using a slow scanning rate, (4) freedom from constraints for sample size (within 1 cm up to 70 cm in sample length) and shape and quality of mechanical treatment of the sample surface, (5) a contactless mode of measurements, (6) short time of measurement (10–30 s) for every sample, and (7) the ability to measure on a flat or cylindrical sample surface. In our practice, the optical scanning technology has provided numerous non-destructive measurements on representative collections of crystals of rock-forming minerals (about 200 crystals), cores from deep boreholes drilled in crystalline and sedimentary rocks (more than 50,000 cores), and industrial materials.