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FURTHER DEVELOPMENTS IN THE 3OMEGA THERMAL CONDUCTIVITY AND DIFFUSIVITY MEASUREMENT SYSTEM

Abstract

The 3Omega method is a technique for measuring thermal conductivity and diffusivity of insulation materials using a single wire embedded in the sample which functions simultaneously as a heating element and temperature sensor. An alternating current is applied to the embedded wire and the temperature response of the sample is recorded as a function of frequency, thus revealing the thermal properties of the sample. This method has significant advantages over traditional thermal conductivity measurements, including the short amount of time required for a measurement, very small amount of heating required (since higher temperatures can actually change the thermal properties to be measured) and the very small samples required for testing, representing large savings to materials researchers and developers. A breadboard/proof of concept of the 3Omega method developed at Active Space Technologies was presented at IAC 2014, showing the ability to measure samples as small as 8cm X 1cm X 1cm, as compared to a typical 20cm X 20cm X 5cm required by flat plate measurement techniques, in only 15 minutes of measurement time and achieving very high accuracies 5% uncertainty on thermal conductivity and 10% uncertainty on thermal diffusivity. Since then, a new measurement system has been manufactured to bring the proof of concept to an industrial level, with improvements to accelerate and simplify sample preparation and measurement setup and automate parts of the measurement process. This newly developed system could eventually be sold to materials developers with large volumes of research materials (such as aerogels or resins for space craft) to be tested, and measurements, including specialty measurements in extreme environments will be provided as a service in house. The 3Omega method has proven to be extremely versatile, working with liquids, solids and powders and well suited for extreme environments such as thermal vacuum chambers. Reduced sample size is of particular interest to aerogel and resin manufacturers for space applications, where production is not at industrial levels and single research samples may cost thousands to produce even in minute quantities and ESA has recently expressed interest in the ability to perform thermal characterization measurements at cryogenic temperatures in the form of an Invitation To Tender. Current efforts to develop the ability to measure samples as small as one cubic centimeter, as well as performing measurements at cryogenic temperatures as low as 20K will be presented.