High temperature thermal conductivity measurements are important for exploration and performance evaluation of materials existing in high temperature environments. Insulating materials with low thermal conductivities, such as furnace insulation and high fluid transport plumbing are designed and used to help heat from exiting a system into its surroundings.

Accurately measuring thermal conductivity at high temperatures using transient methods has traditionally been very hard to achieve primarily due to limitations in the sensor materials. Traditional sensors use glass or plastic dielectric coatings and silicone based sealants to protect the sensor chip, but can become soft at high temperature, damaging the sensor and/or inaccurately measuring the materials thermal conductivity. Some traditional transient methods use a mica-based insulation material, which is highly fragile and often limits the sensor to a single use. C-Therm’s Trident Thermal Conductivity Platform’s high temperature module for insulation materials is the leading approach to handling thermal conductivity measurements up to 500°C, as it utilizes a special sensor chip with an alumina dielectric and ceramic sealant to ensure no softening and proper operation at elevated temperatures. Moreover - the unique, robust single-sided design and alumina sensor chip protect the sensor against mechanical damage in standard use and are not vulnerable to delamination or breakage in routine handling, resulting in a sensor that can be reused indefinitely.
Trident’s Modified Transient Plane Source (MTPS) high-temperature sensor capabilities were demonstrated by measuring the thermal conductivity of a high-density ceramic board (Figure 1) between 300 and 500°C. The ceramic board had previously been characterized by ASTM Standard C201, a steady-state method designed for the characterization of thermal refractories, which is similar in principle to a guarded heat-flow meter apparatus. In ASTM Standard C201, where a sample is placed within a heater chamber, and a copper calorimeter is used to measure the heat-flow while a set temperature difference across the hot and cold sides of the sample is maintained. As a steady-state method, the collection of data requires the use of a large sample machined to precise specifications, and collection of data for analysis can take hours or days. The MTPS has several key advantages compared with steady-state techniques: The MTPS performs a measurement in one to three seconds, as opposed to thirty minutes or more for steady-state techniques, allowing collection of more data in the same amount of time. Using smaller samples with greater flexibility than typical steady-state techniques, the MTPS also takes less time to come to temperature than
a typical steady-state technique and does not require precision machining, allowing faster, easier collection of data for high-temperature insulation applications.

Figure 2: Thermal conductivity of a high-density ceramic insulation board between 300 and 500°C with 3% error lines from the expected values

As shown in Figure 2, C-Therm’s MTPS sensor is capable of measuring accurate thermal conductivity of materials at elevated temperatures. The measurements were in great agreement with the expected value of the ceramic insulation board between 300 to 500°C (better than 3% accuracy). This sort of fast, accurate high-temperature thermal conductivity measurement is crucial in material selection and research for high temperature applications.