Trident™ Thermal Conductivity Application Highlight: Characterizing Thermal Performance of Self-Adhesive Tapes for EV Battery Applications

The following Application Highlight addresses the measurement of self-adhesive tapes using the Modified Transient Plane Source (MTPS) method.

Pressure sensitive adhesive tapes provide not only structural support to a system, but can also act as a key component to addressing thermal management issues, functioning as a thermal interface material (TIM). In these scenarios, the thermal properties of the tape, such as thermal conductivity, are critical aspects to the desired performance of the system. tesa has a long-standing history of developing adhesive tapes and has implemented them across a range of industries. In recent years, a focus on e-mobility applications has moved to the forefront of material development. tesa® 5832x and tesa® 5839x are examples of high-performance thermal interface material in the form of self-adhesive tapes developed for e-mobility applications including cell-to-cell mounting, cell-array to cold-plate mounting, cell-to-side-plate mounting, temperature sensor mounting, graphite/graphene mounting, heating film mounting, and more. These materials are described as acrylic adhesives with thermally conductive fillers, offering a range of thermal conductivity performances from 0.7 W/m·K to 2.0 W/m·K.

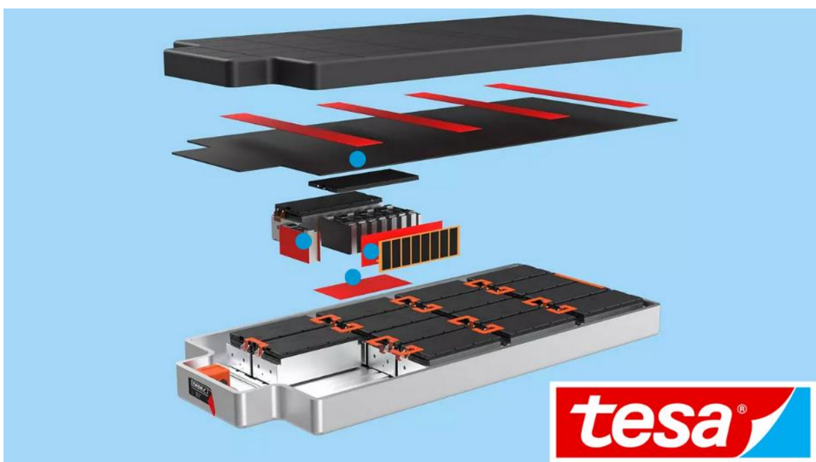

Figure 1. EV battery pack highlighting locations for adhesive tape applications.
(https://www.tesa.com/en-us/industry/automotive/applications/e-mobility)

Self-adhesive tapes such as these are very thin in their construction (ranging from 125 µm to 2000 µm). This can pose a limitation on viable test methods, as many require samples of 1 mm to several centimeters in thickness for some traditional steady-state options. C-Therm's Modified Transient Plane Source (MTPS) method available on the Trident™ Thermal Conductivity Instrument is ideal for testing compressible materials, however, a thickness of at least 1 mm is required to test most samples with the MTPS method. Due to the adhesive nature of these tapes, stacking multiple samples is the easiest way to obtain a sample with valid testing thickness. Note that stacking is not recommended for very high conductivity materials like ceramics and metals, due to high contact resistance between the layers. Soft, pliable, and adhesive materials such as these tapes do not have such limitations.

Material compression under an applied load is an important consideration when measuring thermal conductivity. Increasing densification of a material will typically result in higher thermal conductivity measurement values. This is due, in part, to the fillers in the adhesive bridging the bond line more effectively (see Figure 2). However, one must consider if the level of compressive force is truly representative of the intended application conditions for the material. One noted source of unrealistic thermal conductivity test data on a TIM's effective thermal conductivity is the result of applying a high compressive force load. The resulting thermal conductivity values can appear to be very high, which may look appealing, however, this can have unwanted repercussions in real-world applications. If these inflated values are used for product design, they can end up being applied to thermal management systems and underperforming, which can lead to a system-wide thermal management failure.

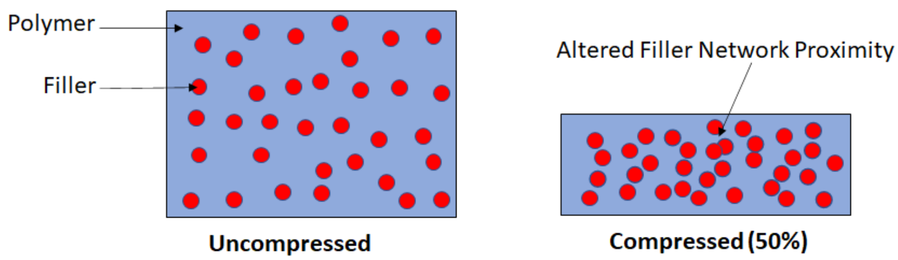

Figure 2. Left) Uncompressed filled system vs Right) compressed system resulting in improved heat transfer pathways due to filler coordination.

Compression measurement biases are an issue presented in many measurement techniques which inherently require high force loads for testing. C-Therm advocates the importance of ensuring the test setup employs representative test conditions (including compression, temperature, and humidity). This is easier to do with transient-based thermal conductivity methods, as you can apply the external sensors in a range of environments. Pictured below is the C-Therm Trident™ Thermal Conductivity Instrument with the optional Compression Test Accessory (CTA). This type of setup allows users to set precise compression levels for measurements without the need to over-compress the sample. This provides a means for control, truly representative testing conditions, and avoids the potential for measurement bias.

Figure 3. Left) MTPS mounted in the Compression Test Accessory (CTA). Right) C-Therm's Trident thermal conductivity instrument.

In the following example, two tesa tape samples and one competitor brand sample were tested using the MTPS method under ambient conditions and compared to technical data sheet (TDS) values. For measurement of all samples, testing was done under exactly 500gF compressive load. Due to the limited thickness of tesa® 58399 and the competitor brand product, samples were stacked to achieve valid testing thickness. tesa® 58328 was of sufficient thickness as produced and tested as received. Results from this testing are summarized below.

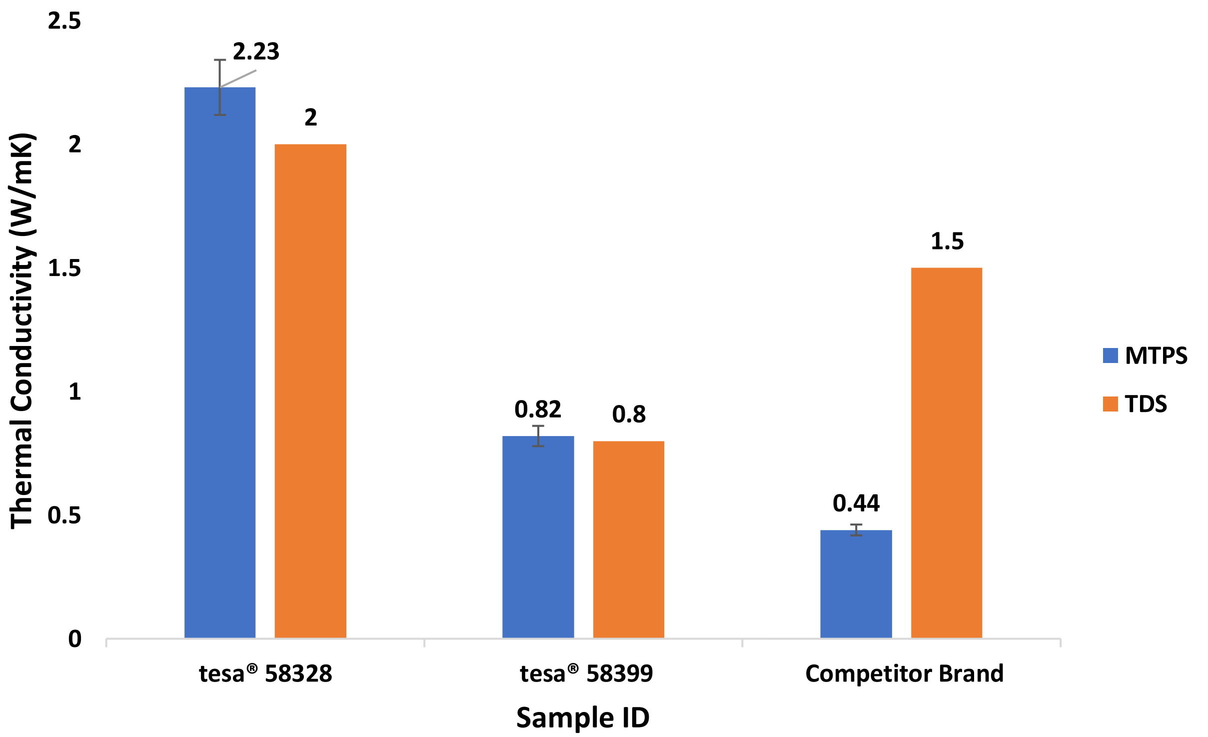

Figure 4. MTPS results compared to TDS (reported values are the average of 3 measurements (n=3), which included manual input of material heat capacity and density).

All tesa sample results on MTPS were found to be in good agreement or greater (up to 11% higher) than TDS values, while the competitor brand sample was noted to be drastically lower in performance when using the exact same testing procedure. This observation points to potential measurement bias reported in the competitor brand TDS and highlights the importance of ensuring representative testing. A difference of 1 W/m·K has been shown to influence operating temperature capacity of electric vehicle systems upwards of 30%, which can have significant implications on product performance.

To learn more about C-Therm's Trident thermal conductivity instrument, visit www.TridentThermalConductivity.com

To learn more about tesa's thermally conductive materials, visit https://www.tesa.com/en-us/industry/automotive/applications/e-mobility