Molecular Rebar® for Improved Durability, Thermal Conductivity and Shielding

Market Opportunity

The global thermal interface materials (TIMs) market is currently around USD 2 Billion at a CAGR of 9%. This growth is fueled by the growing electronics & telecom industry and rising number of applications in electrification of transportation vehicles. Asia-Pacific dominates the TIMs market, in terms of value and volume because of electronics and telecom market and production growth. The trend is expected to continue near-term.

Greases & adhesives is the largest segment of TIMs market by type. OEMs prefer to use greases & adhesives because of their flowability and ability to reduce a wide range of surface roughness of any housing, heat spreader, or heat sink surface. Thermal greases & adhesives have other competitive advantages such as low cost, reworkability, low thermal resistance, and the ability to form ultra-thin bond lines on the micron scale. Filled silicone gaskets and foams are also a sizeable market.

Performance Needs for Improved Shielding and Thermal Management

Performance needs for improved thermal interface materials are usually expressed in improvements of thermal conductivity. However, for adhesives and non-grease TIMS such as foams, other significant properties which need improvements are improved durability under cyclic strains and thermal stress crack resistance. In materials such as highly filled silicones with 80-90% wt. fillers, the tear strength of the material is low and can cause issues during manufacture of parts.

A relatively new growing opportunity are materials that provide a “dual-functional” EMI shielding and TIM. EMI absorption by any material results in its heating. The energy from EMI wave transfers to electrons and then to phonons—quanta of lattice vibrations. The conventional approach for handling the heat and EMI radiation problems is through separate materials that have different, and, often, opposite characteristics, e.g., excellent EMI material can be a poor heat conductor, while efficient TIM utilize electrically nonconductive fillers, resulting in its transparency for EMI waves. Of course, the needs for voltage breakdown requirements should be considered as Molecular Rebar can provide increased degrees of electrical conductivity when used above about 1.5% weight in a polymer matrix. Whereas the increased electron transport results in improved EMI, the dielectric strength can be much reduced. For example, at 2.5% weight Molecular Rebar the dielectric strength can decrease by an order of magnitude.

Molecular Rebar®, MR, (individual clean carbon nanotubes with tailored surfaces) is uniquely advantaged to provide a combination of needed improvements in a variety of materials by providing improved durability, shielding and thermal transport. The MR is easily incorporated into formulations followed by processes from printing to spraying to extruded sheet, blown film and foaming.

The effectiveness of a heat spreading material is directly related to its thermal conductivity. The room temperature thermal conductivity of known bulk materials used in electronics applications spans from about 3450 W/m.K in isotopically purified diamond to around 0.1 to 0.2 W/m.K for polymers. Carbon nanotubes have been quoted as having thermal conductivities along the tube of around 3000 W/m.K, but in practice composites of polymers and carbon nanotubes show very much lower values, because of inefficient transfer of phonons from the matrix into the tube. An approximate guide for polymers and filled polymers with dispersed Molecular Rebar is that 1% weight of MR, relative to the matrix material only, results in about 0.1 to 0.2 W/m.K of improved thermal conductivity. Since highly filled polymers can contain 90% weight filler then 1% wt. MR relative to the matrix only is 0.1% wt. of the filled composition.

Greases for EMI and thermal conductivity at higher MR concentrations.

The EMI shielding for 3.5% Molecular Rebar is 13 db/cm and or 8% Molecular Rebar is 27 db/cm measured at 2 GHz. The bulk resistivity is $1x10^8$ ohm-cm for 3.5% Molecular Rebar and $1x10^6$ ohm-cm for 8% Molecular Rebar.

Shown in Figure 1 are the viscosity shear rate curves for a Dow Corning silicone with viscosity 510 cst and Molecular Rebar at 3.5 and 8% by weight. 1000cst = 1 Pa.S. Note that Molecular Rebar at concentrations above about 1.5% weight can significantly increase the viscosity at a lower shear rate but exhibits strong shear rate thinning. Even at 8% weight Molecular Rebar the greases can be applied with a syringe and are easily spreadable. Above 13% weight Molecular Rebar the silicone mixture no longer flows as a grease. The thixotropic, or non-newtonian, flow characteristic is a highly advantageous for retaining the thermal/EMI grease where you place it.

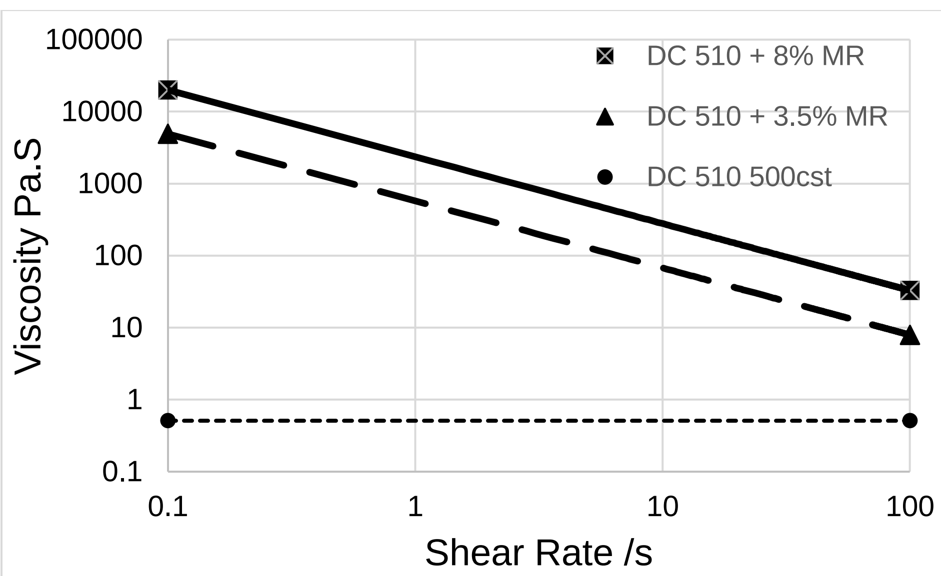

Figure 1. Viscosity versus shear rate for silicone with Molecular Rebar

For a 90% weight filled silicone, adding 3% weight Molecular Rebar relative to the silicone results in about a 3-4x increase in viscosity at 1/s shear rate.

How is MR supplied?

For greases, Molecular Rebar® is supplied as a shelf stable, masterbatch at 8% weight in silicone for ease of handling by the customer. For specific viscosity requirements the silicone base viscosity can be adjusted. Please call Molecular Rebar Design USA 512 394-0922 for your specific needs or email at info@molecularrebar.com.

For epoxy formulations, Molecular Rebar is supplied as a shelf stable masterbatch at 2% weight in a bisphenol A epoxy.

Company Summary

Molecular Rebar Design, LLC (MRD), based in Austin, Texas, was established in 2010 to develop and commercialize a breakthrough form of modified multi-wall carbon nanotubes called MOLECULAR REBAR® (MR). These carbon nanotubes are fully disentangled, cleaned and specifically functionalized for significantly enhanced performance in a myriad of high-value materials such as silver inks. The tubes are 10,000X times thinner than a human hair, being about 13 nanometers in diameter and 900 nanometers in length. MR is currently integrated into multiple advanced performance applications, such as lead-acid batteries, lithium-ion batteries, coatings, composites, drug delivery, elastomers and more. MRD has state-of-the-art laboratory capabilities to ensure consistent improvements in market applications and formulations, as well as a commercial plant, ISO 9001:2015 certified, of capacity 50 tons, going shortly to 100 tons annually. There have been 71 patents granted around the globe to MRD.

Contact Detail

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