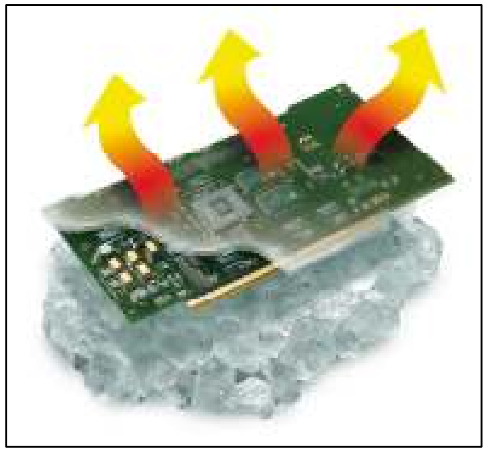
Technical Application Report

Thermal Transfer Silicones



Most electronic components produce heat when in use. The unwanted heat has to be dissipated away from the components to maintain performance and avoid premature failure of the components or device. The need for efficient transfer of heat has become a key design requirement as components continue to reduce in size and increase in power, this is particularly apparent with microchip processors, LED's and power packs.

Designs will vary but in essence all involve some form of heat sink to dissipate the heat away from the active components. It is the interface between the heat sink and component that calls for the use of thermal transfer compounds, without their use any air gaps that exist will act as an insulator and prevent heat escaping.

These transfer materials come in a wide variety of forms; liquid adhesives, pastes, gels, potting compounds, sheets, rolls, pads and sprays. They also utilise an equally large array of chemistries. Choice of material will be driven by a combination of factors including:

- Thermal requirements
- Manufacturing processes
- Environmental operating conditions
- Need for additional functionality

We will not endeavour to cover all the options available but will focus on the use of silicones as a base for manufacturing performance heat transfer compounds.

Measuring Thermal Conductivity

Heat can be transferred in 3 ways: Conduction, Convection, Radiation. As an aid to thermal management we are primarily concerned with conduction of heat away from its source. Conduction of heat relies on the transfer of thermal energy by the vibration of particles which have physical contact with each other.

Thermal conductivity can be measured in several ways. Three techniques are commonly used, in order of general usage these are:

- Lees disk method
- Hot plate method
- Laser flash method

ACC utilises the Lees disk method as this has been shown over many years to be probably, the most consistent and direct method of measurement.

The units of measurement used are;
W/m K (watts per meter degree Kelvin)

Typical Values For Thermal Conductivity For Standard Materials

Material	Value W/mK
Copper	400.00
Aluminium	300.00
Silicone	120.00 to 150.00
Aluminium + Epoxy	4.00
Plastics	1.00 to 10.00
Typical Standard Thermal Grease	0.50
FR4 (PCB Board)	0.30
Air	0.03

Why use Silicones?

Silicone polymers and elastomers have particular inherent physical properties including:

- Wide operating temperature range -115 to 300ºC
- Excellent electrical properties
- Flexibility
- Hardness range, soft gels to moderately hard rubbers
- UV resistance
- Good chemical resistance
- Resistant to humidity and water
- No or low toxicity
- Easy to use

These natural properties can be further enhanced using fillers and chemical additives to provide additional features when needed, including flame retardancy, thermal conductivity, electrical conductivity and adhesion. Through the selection of polymers and fillers it is also possible to adjust viscosity and rheology and the final hardness and modulus of the cured rubber. Control of the curing regime and speed can be achieved using the silicone chemistry to produce both heat and room temperature cure (RTV) systems. Silicones can be supplied as 1 or 2-part systems. In short silicone encapsulants are very versatile and provide design engineers with a wide product choice.

Types of Silicone Thermal Transfer Materials

Using silicone polymers we can then formulate a variety of materials that in addition to the ability to transfer heat, will also have some additional functionality which will be of benefit to the designer. We can produce three basic types of silicone material:

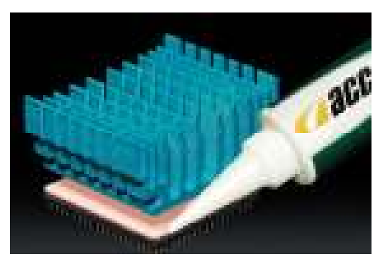
- Adhesive sealants
- Encapsulation and potting compounds
- Non-setting compounds

Adhesive Sealants

The obvious benefits of having a thermally conductive adhesive enable you to permanently bond your component to some form of heat sink and eliminate the need for additional mechanical fixings. It will also prevent the possibility of movement and air gaps forming which will reduce performance. These products can also be used to form gaskets (see separate sheet on FIPG Gaskets) which will not only transfer heat but also form a seal against moisture and other environmental contaminants.

Silicone adhesives utilise two basic chemistries:

- Condensation Cure (RTV)
  1-Part systems which will cure at room temperature
- Addition Cure
  1-Part systems which require heat to cure



Adjustments can be made to control the physical properties such as; rheology, viscosity, hardness, colour etc, which can be selected to meet specific design requirements. Using a flowable 1-part adhesive it is possible to apply a coating with thermal conductive properties. This approach has successfully been used to coat the back of large scale mega screen LED displays thereby offering environmental protection and effectively removing heat from the diodes.

As the adhesive will be in contact with sensitive metals such as copper, it is essential that there are no harmful corrosive by-products such as acetic acid. ACC have developed their AS1400, AS1700 and AS1800 ranges of neutral cure adhesives with the electronics market in mind and have included a number of thermally conductive products.

For further information regarding the benefits and certain curing chemistries please refer to the ACC Silicones application sheet for adhesive sealants.

Encapsulation and potting compounds

Using a thermally conductive encapsulant has become a very attractive option when trying to remove heat from a number of components within a single device. Selection of a suitable flowable silicone will facilitate removal of all the air gaps in and around various components, thereby providing an effective path for the transmission of any unwanted heat. In addition to the dissipation of heat, silicone encapsulants will also provide protection from harsh environments, vibration and thermal shock. Using the versatile silicone chemistry we can produce a variety of encapsulants with various physical properties. Of particular interest is the new development of thermally conductive gels which reduce mechanical stress on delicate wire connections.

Typical applications include the manufacture of power supplies, under bonnet electronics and LED packaging.

The emergency vehicle light shown here, uses a thermally conductive silicone compound to seal and protect the electronics behind the array of HB LED's and also helps keep them cool, maintain performance and improve the working life.

Encapsulation materials can be supplied as either 1 or 2-Part systems using condensation and addition cure chemistries. For a more detailed explanation of these chemistries please refer to the ACC Silicones encapsulation application sheet.

Non-setting compounds

Silicone thermal transfer compounds are non-setting in that they do not cure, have no adhesion and retain their physical properties, similar to that of grease. The main reason to choose a compound rather than adhesive is the ability to easily rework the component. Under normal circumstances the component would be held in place with some form of mechanical fixing and the compound applied to simply improve heat dissipation. These silicone compounds are work stable and will with-stand reasonably high temperatures.