USER GUIDE

UG015 | Graphite Sheet – WE-TGS

Sebastian Mirasol-Menacho

1. INTRODUCTION TO WE-TGS

The WE-TGS series is a graphite-based heat spreading material that enhances the distribution of heat across a surface. The spreading helps cool high power density areas, especially when the cooling assembly is significantly larger than the source. The heat spreading sheet is both thin and adhesive, which makes it ideal for sticking onto a flat surface or for bend around soft corners.

Graphite sheets are particularly effective for managing thermal performance in compact electronic devices where space is limited. By spreading heat more evenly, these sheets prevent hotspots that can lead to component failure or reduced efficiency.

This makes them an essential component in the design of high-performance electronics, such as handheld devices, processors or battery assemblies, where maintaining optimal operating temperatures is crucial for performance and longevity.

The WE-TGS series sheets are designed to be lightweight and flexible, allowing for easy integration into various electronic assemblies without adding significant bulk or weight. Their adhesive properties ensure a secure fit, even in applications with complex geometries or where traditional cooling solutions might be impractical. This versatility makes them suitable for a wide range of applications, from consumer electronics to industrial equipment, providing a reliable solution for thermal management challenges.

2. MATERIAL SPECIFICATIONS

The graphite pad has three main components, shown in Figure 1:

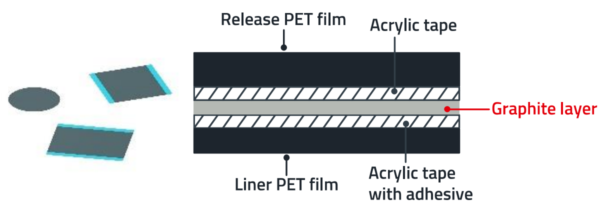

Figure 1: WE-TGS cross-section.

- PET film: protects the adhesive and prevents the acrylic films from suffer any scratches.
- Acrylic tape: thin films that ensure electrical insulation between the contact surfaces and the graphite layer.
- Graphite: synthetic graphite is bonded horizontally at a molecular level, providing very high thermal conductivity in the in-plane axis and nominal thermal conductivity in the through-plane axis.

The properties of the WE-TGS graphite sheet can be grouped into three categories, shown in Table 1, Table 2, and Table 3.

Material properties	
Color	Dark Gray
Thickness	37 µm
Peel Adhesion	750 g/25 mm
Specific Gravity	1.9 g/cm^3
Operating Temperature	-50 up to 120°C

Table 1: Material properties of WE-TGS.

Thermal Properties	
Thermal Conductivity XY Axis	1800 W/m · K
Thermal Conductivity Z Axis	5 W/m · K

Table 2: Thermal properties of WE-TGS.

Electrical Properties	
Breakdown Voltage	1 kV

Table 3: Electrical properties of WE-TGS.

3. DESIGN CONSIDERATIONS

The design-in process of a graphite heat spreader is not as straightforward as calculating the thermal resistance of a gap filling application; instead we must consider both in-plane and through-plane thermal conduction.

Let’s consider a power-dense area in our electronic design where multiple small components are dissipating 5 Watts of heat energy in an area of 4 cm^2. This area is in contact with a steel housing used to transfer energy to the ambient.

Steel has a relatively low thermal conductivity when compared to other metals such as aluminum or copper. In order to extend the heat over the housing we will evaluate the use of the WE-TGS graphite heat spreader in the following use-case scenario (Table 4).

Parameter		Symbol	Value
Ambient Temperature		T_A	25°C
Heat Source			5 W
Heat Source Area		A_S	4 cm²
Steel	Area	A_{STEEL}	2500 cm²
	Thickness	d_{STEEL}	2 mm
	Thermal Conductivity	λ_{STEEL}	50 W/m · K
Graphite	Area	A_{SPREAD}	2500 cm²
	Thickness	d_{SPREAD}	17 µm
	Thermal Conductivity	λ_{SPREAD}	1800 W/m · K

Table 4: Parameters to evaluate the WE-TGS graphite heat spreader.

To analyze how a graphite heat spreader on a steel housing can improve heat transfer from a heat source to the ambient, we will break down the problem into two main parts: the heat conduction (Q_{COND}) through the graphite heat spreader and the heat dissipation to the ambient through natural convection (Q_{CONV}).

Heat Conduction

Fourier's law for heat conduction is given by:

$$Q_{COND} = -\lambda \cdot A \cdot \frac{dT}{dx} \qquad (1)$$

We can rewrite it as:

$$Q_{COND} = \lambda \cdot A \cdot \frac{T_1 - T_2}{d} \qquad (2)$$

And rearrange it to find the temperature difference across a surface:

$$T_1 - T_2 = \frac{Q_{COND} \cdot d}{\lambda \cdot A} \qquad (3)$$

To calculate the temperature drop across the steel housing:

$$T_{STEEL1} - T_{STEEL2} = \frac{5\,W \cdot 2 \cdot 10^{-3}\,m}{50\,\frac{W}{m \cdot K} \cdot 0.25\,m^2} = 0.8\,m \cdot K \qquad (4)$$

And that of the graphite:

$$T_{SPREAD1} - T_{SPREAD2} = \frac{5\,W \cdot 17 \cdot 10^{-6}\,m}{1800\,\frac{W}{m \cdot K} \cdot 0.25\,m^2} \qquad (5)$$

$$T_{SPREAD1} - T_{SPREAD2} = 0.18\,m \cdot K$$

As expected, the temperature drop across the surface of the graphite is significantly lower than the steel, since it has a higher thermal conductivity value. We can assume the total temperature drop of the graphite applied on the steel housing as:

$$T_{DROP} = 0.98\,m \cdot K \qquad (6)$$

Heat Dissipation

The heat dissipated by natural convection over the surface of the steel housing of our electronic design is defined as:

$$Q_{CONV} = h \cdot A \cdot (T_1 - T_2) \qquad (7)$$

Since we are considering a natural convection environment, we can assume a heat transfer coefficient value of $h = 10\,W/m^2 \cdot K$.

$$Q_{CONV} = 10\,\frac{W}{m^2 \cdot K} \cdot 0.25\,m^2 \cdot (T_{SOURCE} - T_A) \qquad (8)$$

$$Q_{CONV} = 2.5 \cdot (T_{SOURCE} - T_A)\,W$$

Heat transfer is defined by the temperature difference between the source and the ambient. The larger the difference the more energy will flow.

If we assume $T_{SOURCE} = 75°C$:

$$Q_{CONV} = 2.5 \cdot (75°C - 25°C)\,W = 125\,W \qquad (9)$$

With the graphite applied to the steel housing, we are able to transfer up to 125 W to the ambient through natural convection. These calculations estimate the effect of the graphite heat spreader on a steel housing. For a more detailed analysis that also considers other environmental parameters, it is encouraged to perform FEM simulations of your design.

4. THERMAL PERFORMANCE

Synthetic graphite is manufactured such that carbon molecules are bonded in thin layers, giving the material excellent thermal conductivity in the in-plane axis.

Compared to other commonly used heat spreading materials such as aluminum and copper, the WE-TGS provides superior heat spreading capabilities, as shown in Figure 2 and Figure 3 while being significantly lighter.

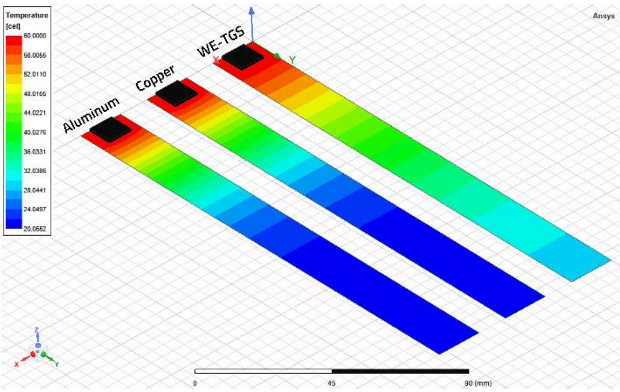

Figure 2: 18 × 18 mm strips with 5 W heat source.

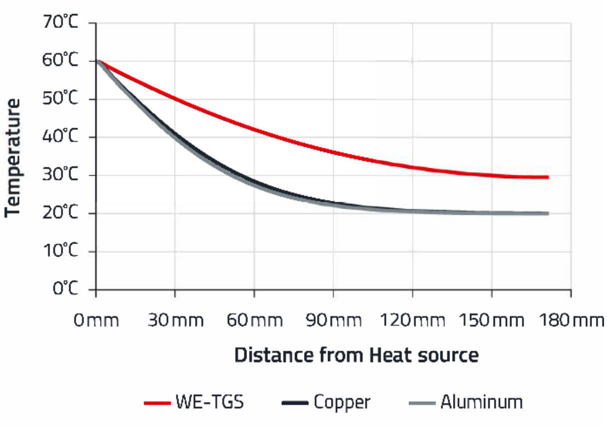

Figure 3: Thermal performance process.

The WE-TGS shows a smaller temperature difference over its surface. In an application-like environment, any surface with heat more evenly distributed across it will be able to transfer more heat energy to the ambient.

5. INSTALLATION AND HANDLING

To avoid air bubbles trapped between the contact surfaces and the adhesive pad when applying a flexible material, place the edge of the pad on the surface and remove the protective liner as a 1 kg roller is rolled over the opposite surface.

To ensure correct application, the following steps are recommended:

- The surface of the component and cooling assemblies must be clean and dry. It is recommended to use isopropyl alcohol applied with a lint-free wipe or swab to remove any particles on contact surfaces.
- Remove the protective liner from one of the pad's surfaces.
- Place the adhesive with a rolling motion to avoid air bubbles. If possible, apply pressure with a 1 kg roller to activate the adhesive.
- When the other part is ready for assembly, remove the protective liner.
- Apply the component or assembly with a rolling motion and pressure.

Cutting

The WE-TGS can be cut into shape with any sharp object. Laser cutting is discouraged as it can fuse the part with the protective liners, making handling of the adhesive pad very difficult.

Cutting the WE-TGS will also expose the edges of the graphite layer, a profile shape clearance of at least 4 mm is encouraged.

Reworking

The WE-TGS is not a reworkable pad. If separation of the stack is difficult, apply heat and torque or peel to separate the substrates. This will result in the destruction of the pad.

If there is any leftover material, carefully pry it with plastic or wooden tool to avoid damaging the contact surfaces. It is recommended to clean the surface areas with isopropyl alcohol on a lint-free wipe.

6. MODIFICATION AND PROTOTYPING SERVICE

Würth Elektronik provides a shape modification service that supports you from prototyping to manufacturing.

Modified shapes are produced by using die-less cutting. This technique allows a knife to cut the adhesive pad into any desired shape within the machine's tolerances. The parts will be delivered cut into a sheet with the graphite edge exposed. A profile clearance of at least 4 mm is recommended to avoid contact with any component on the PCB (Figure 4).

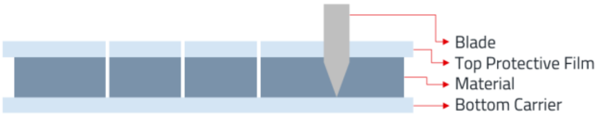

Figure 4: Die-less cutting of parts.

Reach out to your Würth Elektronik representative with the following information and they will get back to you with a personized quotation:

- Number of parts needed
- Technical drawing of desired part
- Any special requests you may have.

IMPORTANT NOTICE

USEFUL LINKS

Application Notes
www.we-online.com/appnotes

REDEXPERT Design Platform
www.we-online.com/redexpert

Toolbox
www.we-online.com/toolbox

Product Catalog
www.we-online.com/products

CONTACT INFORMATION

appnotes@we-online.com
Tel. +49 7942 945 - 0

Würth Elektronik eiSos GmbH & Co. KG
Max-Eyth-Str. 1 74638 Waldenburg Germany
www.we-online.com