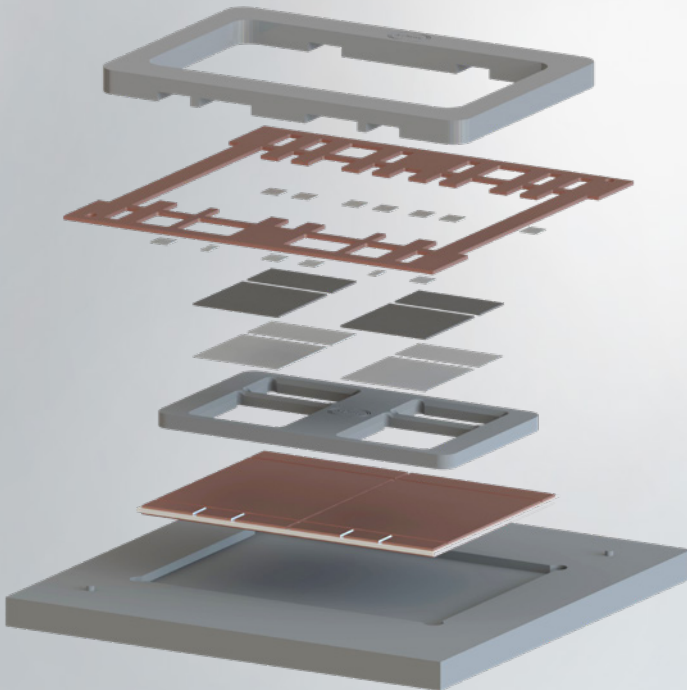




Mobility Carbon

ALUMINIUM GRAPHITE

Material Selection Guidelines for Toolings



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01 Purpose

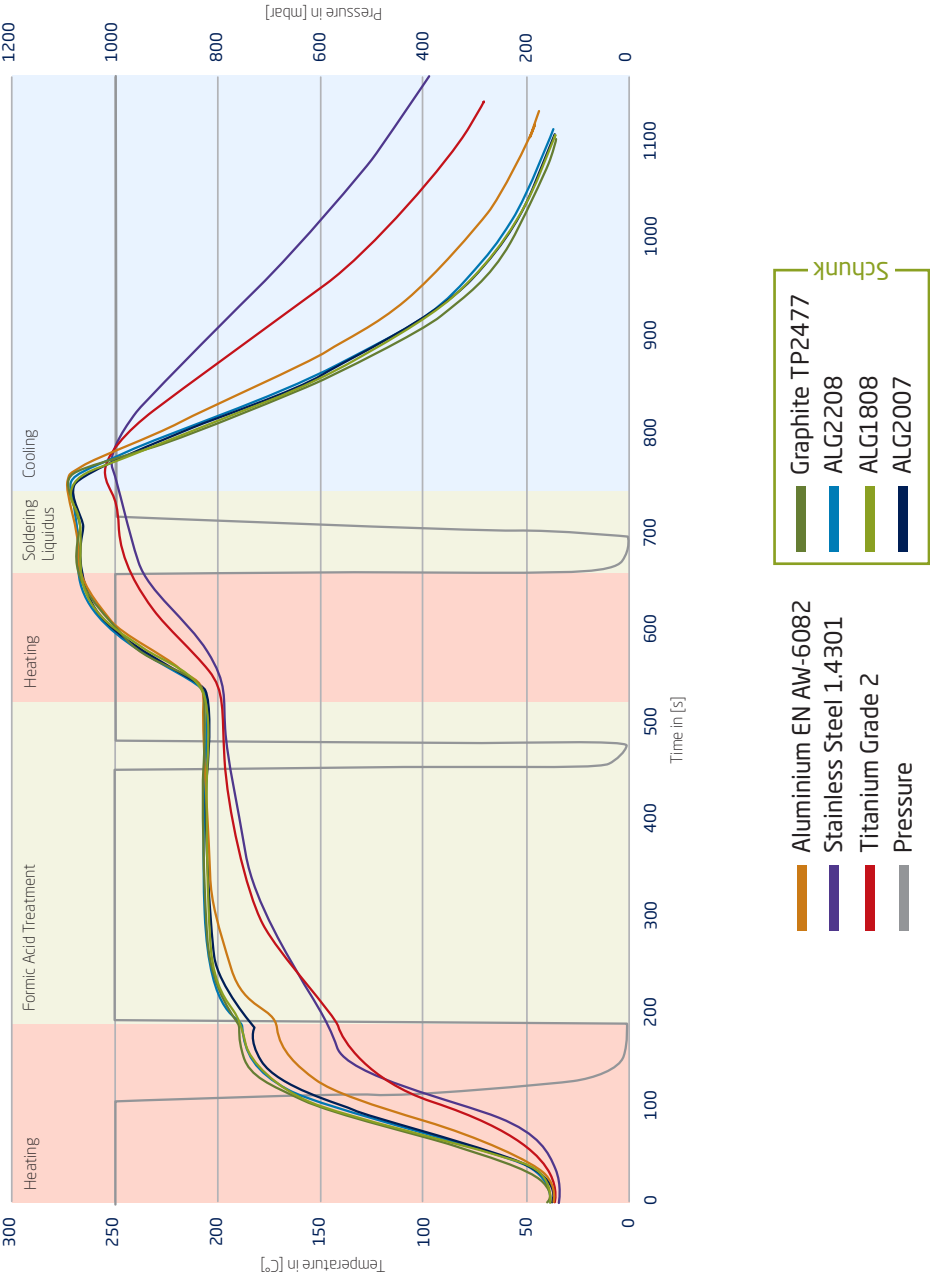
This document provides specific information on Aluminium Graphite (“ALG”) materials and their use as toolings for power electronics, micro-, and optoelectronics packaging processes. It will provide some guidelines on selecting the most suitable material grade for each specific use case and show selected examples of possible tooling designs.

02 What are Aluminium Graphite Materials?

Aluminium Graphite materials are Metal Matrix Composites that are used as toolings for semiconductor back-end processes. This is due to the material’s low coefficient of thermal expansion, high thermal conductivity, and low density. Schunk Carbon Technology offers different material grades for tooling applications, namely ALG1808, ALG2208, and ALG2007.

	ALG1808	ALG2208	ALG2007
Orientation	isotropic	anisotropic	isotropic
Density in g/cm³	2.2	2.3	2.15
Coefficient of Thermal Expansion (0-300°C) in 10 ⁻⁶ /K	9	x/y: 9 z: 13	7
Thermal Conductivity (25°C) in W/m.K	180	x/y: 220 z: 140	200
Thermal Diffusivity (25°C) in mm²/s	110	x/y: 130 z: 80	130
Specific Heat Capacity (25°C) in J/g.K	0.75	0.75	0.7
Flexural Strength in MPa	110	x/y: 90 z: 50	100
Compressive Strength in MPa	210	x/y: 110 z: 90	180

02.1 Overview of Measured Temperature Profiles



Comparative temperature measurements of Aluminium Graphite and industry standard tooling materials such as aluminium, stainless steel, and titanium, show the superior behaviour of Aluminium Graphite under standard vacuum-soldering conditions.

By using Aluminium Graphite soldering tools, such as carriers or fixtures, customers benefit from:

- ▢ Higher heating rates
 - Faster proccessing times
 - Reduced production cost
- ▢ Excellent temperature uniformity:
 - Improved oxide reduction process
 - Higher quality
- ▢ Higher cooling rates
 - Faster processing times
 - Better process control

Material	Density [g/cm ³]	Specific Heat Capacity [J/kg.K]	Thermal Conductivity [W/m.K]
Titanium Grade 2	4.51	520	20
Stainless Steel 1.4301	7.90	500	15
Aluminium EN AW-6082	2.70	896	170-220
ALG1808	2.20	750	180
ALG2007	2.15	700	200
ALG2208	2.30	750	x/y: 220 z:140
Graphite TP2477	1.75	700	105

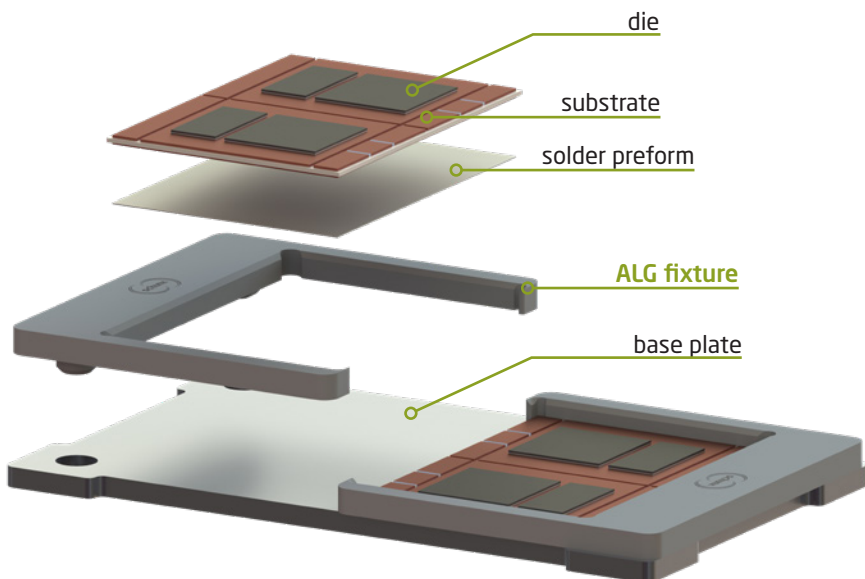
03 Typical Use Cases

Which material grade is the best choice for each particular use case? The following section should provide some guidance as to selecting the optimal solution for your particular application. It is important to note that most application examples are directed at preform-based soldering processes, but this should not be seen as a limitation. Please feel free to get in touch if you would like to discuss further application areas.

03.1 Substrate Attach

PURPOSE

Fixtures for the attachment of substrates, such as DBCs or AMBs, to base plates, coolers or heat sinks.



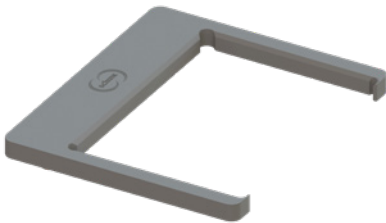
TOOLING MATERIAL REQUIREMENTS:

- High mechanical strength
- Similar thermal expansion behavior as substrate materials

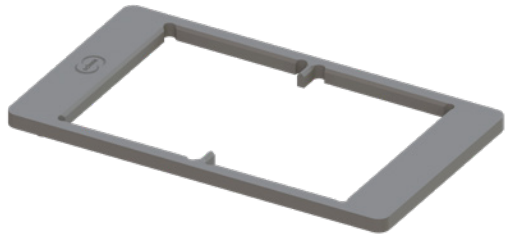
MATERIAL GRADE RECOMMENDATION:

- ALG1808
- ALG2007

APPLICATION/DESIGN EXAMPLES:



a) ALG-Fixture for substrate attach

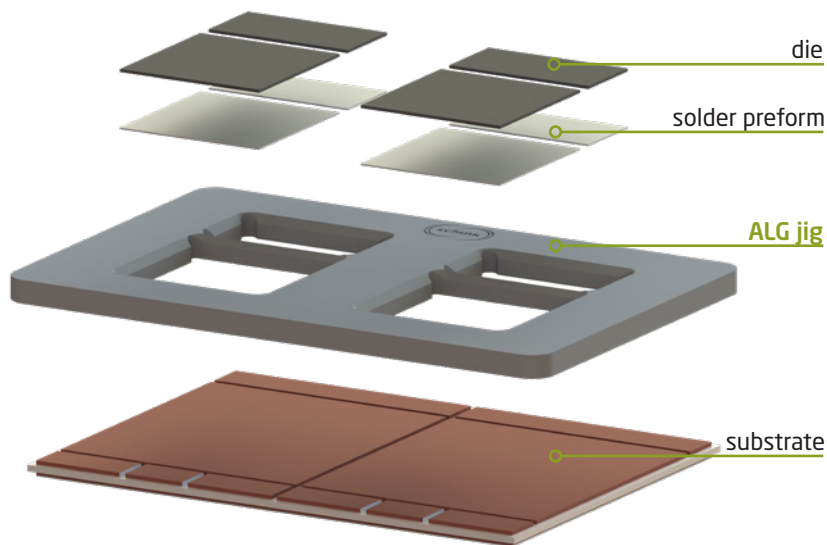


b) ALG-Frame for substrate attach

03.2 Die Attach/Component Attach

PURPOSE

Soldering/Positioning jigs for the attachment of dies (IGBTs, MOSFETs, diodes, ...) or other components (shunts, spacers, clips, ...) to substrates and dies.



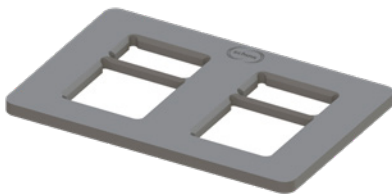
TOOLING MATERIAL REQUIREMENTS:

- High mechanical strength
- Coefficient of thermal expansion matched to dies, components and substrates

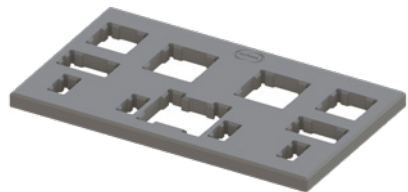
MATERIAL GRADE RECOMMENDATION:

- ALG1808
- ALG2007

APPLICATION/DESIGN EXAMPLES:



a) ALG-Soldering jig for die attach

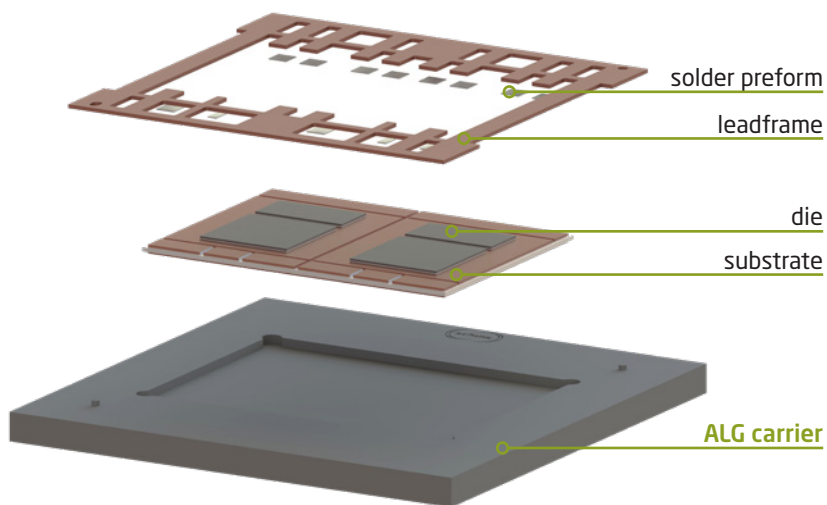


b) ALG-Soldering jig for component attach

03.3 Leadframe/Terminal/Busbar Attach

PURPOSE

Carriers for the attachment of leadframes or terminals to substrates and dies.



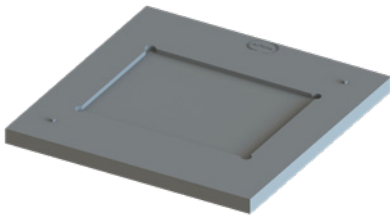
TOOLING MATERIAL REQUIREMENTS:

- High mechanical strength
- Coefficient of thermal expansion matched to dies, components and substrates

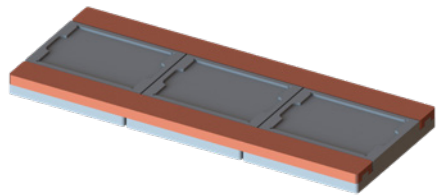
MATERIAL GRADE RECOMMENDATION:

- ALG1808
- ALG2007
- ALG2208

APPLICATION/DESIGN EXAMPLES:



a) ALG-Carrier for leadframe attach

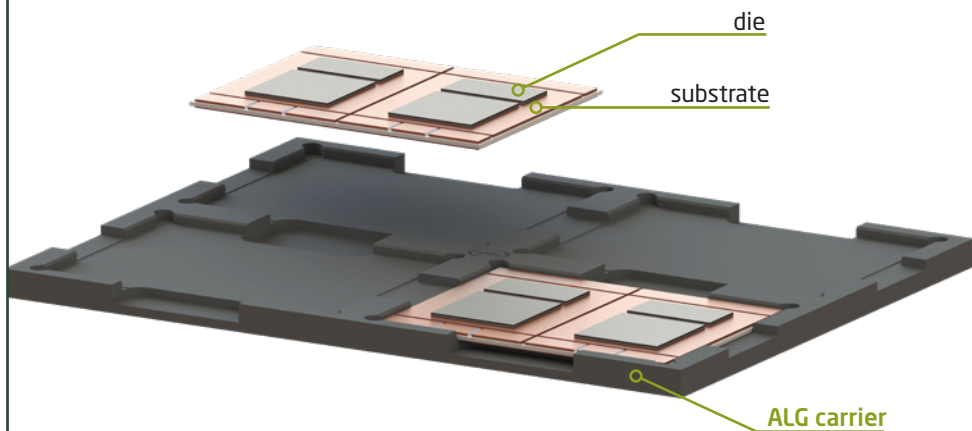


b) ALG Hybrid carrier for large-area leadframe attach

03.4 Carriers

PURPOSE

Carriers for dies, substrates, base plates or heat sinks for various assembly and inspection processes.



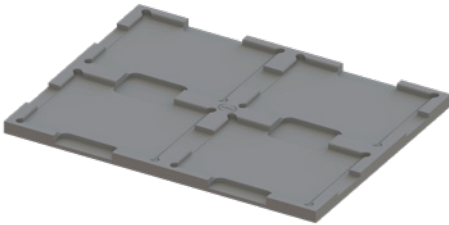
TOOLING MATERIAL REQUIREMENTS:

- High thermal diffusivity
- High mechanical strength
- Coefficient of thermal expansion matched to materials to be transported

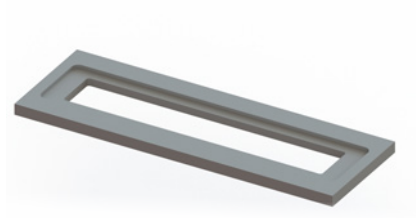
MATERIAL GRADE RECOMMENDATION:

- ALG2208
- ALG2007

APPLICATION/DESIGN EXAMPLES:



a) ALG-Carrier for multiple substrates

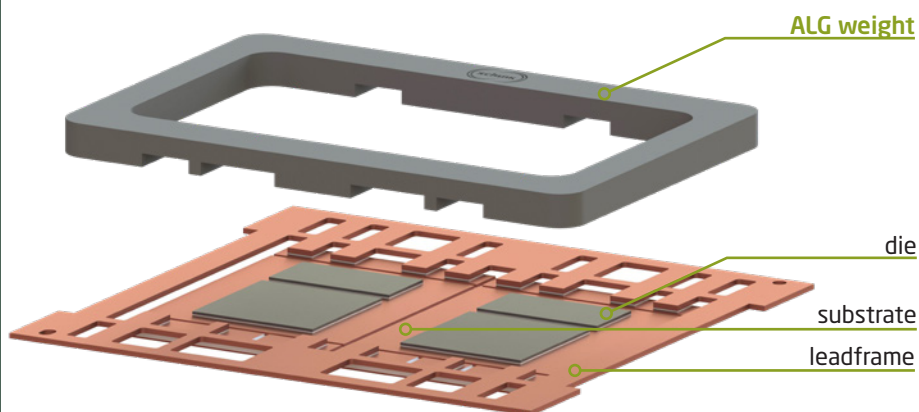


b) ALG-Carrier for pin fin cooler

03.5 Weights, Inserts, Downholders, etc.

PURPOSE

Various components aiding additional functionalities to the assembly processes, such as weights, inserts or downholders.



TOOLING MATERIAL REQUIREMENTS:

- High thermal diffusivity
- High mechanical strength
- Coefficient of thermal expansion matched to other fixturing components

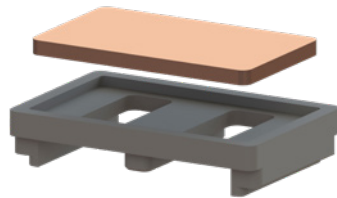
MATERIAL GRADE RECOMMENDATION:

- ALG1808
- ALG2208
- ALG2007

APPLICATION/DESIGN EXAMPLES:



a) ALG-weight for leadframe weigh down



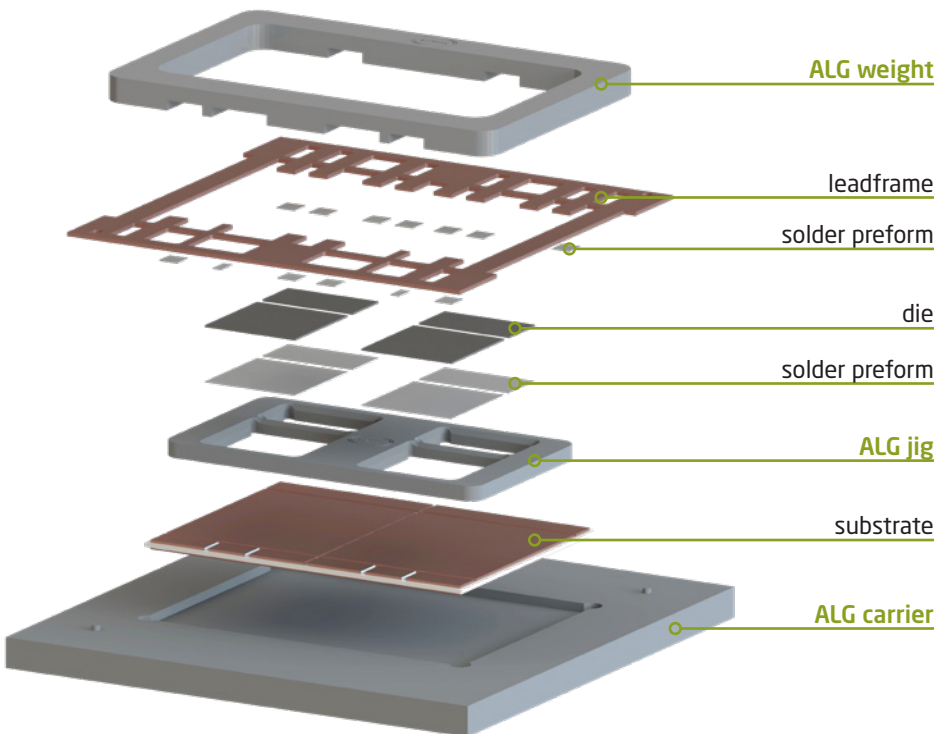
b) Combined ALG/copper weight

04 Jig and Fixture Sets, Assemblies, and Special Use Cases

It is not only possible to use single components made from Aluminium Graphite for different fixturing applications. One can also make use of jig/fixture sets or assemblies.

Stackable jig sets can be used for the attachment of multiple components in one processing step. One example is the assembly of double-sided cooled (DSC) modules. It requires a carrier for the substrate, a jig for the positioning of the dies, and another jig for the attachment of the spacers.

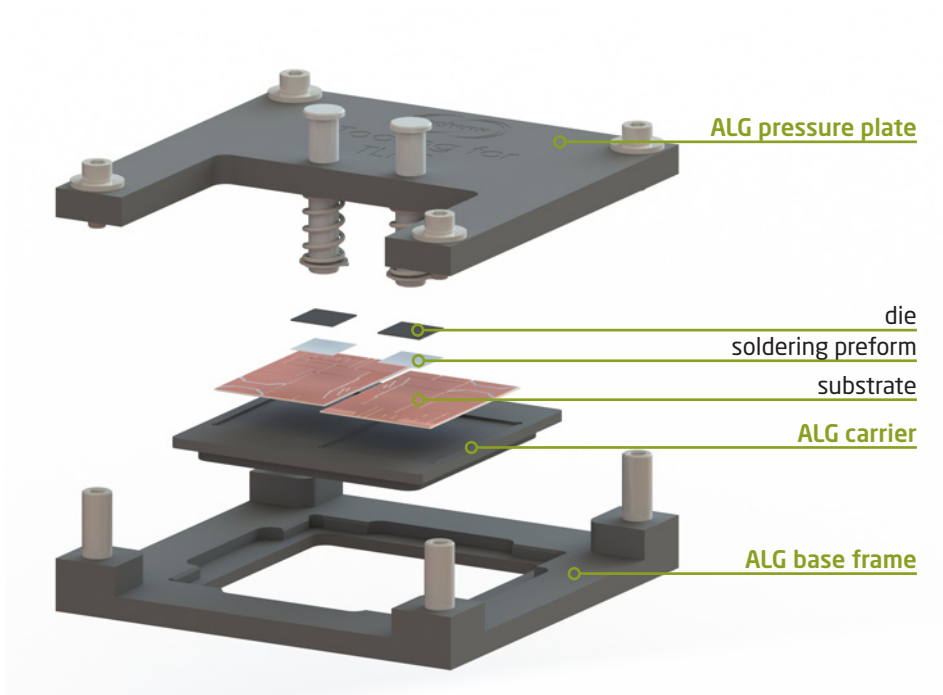
Assemblies typically consist of multiple fixturing elements made of Aluminium Graphite and other components, such as clamps, screws, or springs. The latter can be made from copper, aluminium or stainless steel. One example is the so-called ALG Hybrid carrier, which is used for the attachment of leadframes to substrates and dies.



04.1 TLPS Tooling

Transient Liquid Phase Soldering (TLPS), a variant of diffusion soldering, is an emerging technology that is mainly used for die attach. In addition to the heat input needed for standard soldering processes, TLPS also requires the application of pressure to the components being joined.

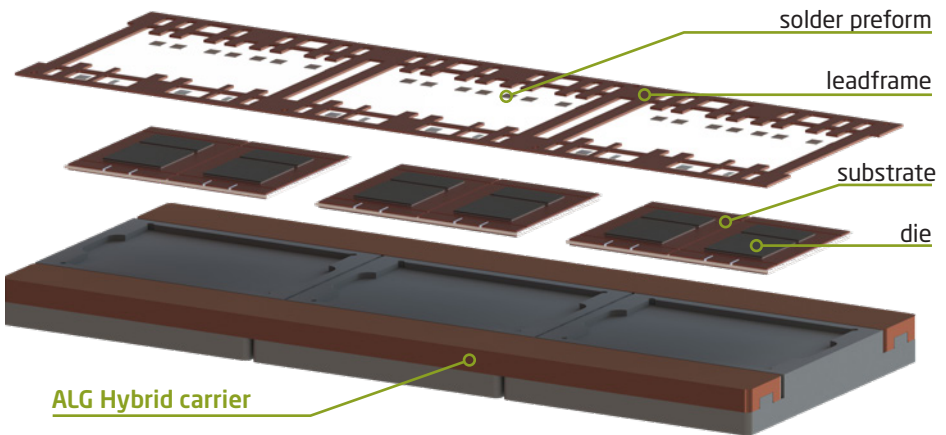
Jig sets consisting of Aluminium Graphite carrier plates and spring-loaded pins and/or weights allow for optimal heat transfer from the heating plate whilst locally applying the required pressure.



04.2 ALG Hybrid Carrier for Large-Area Leadframe Attach

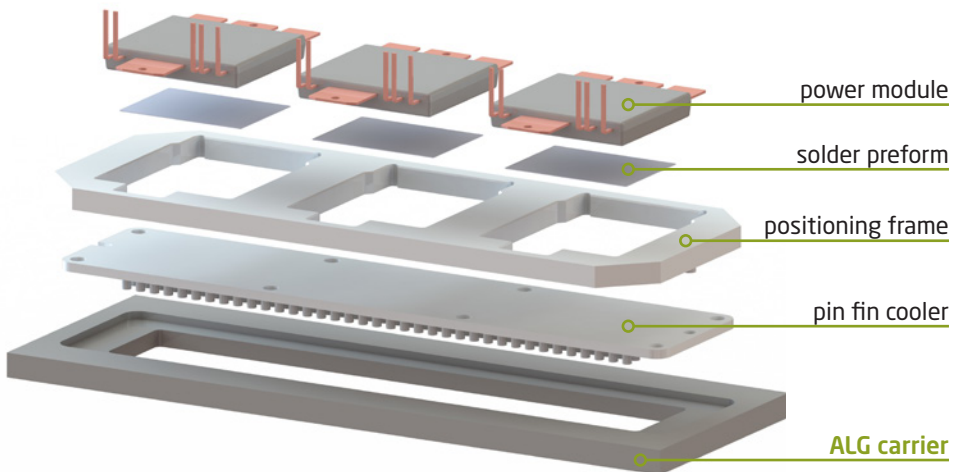
Certain components such as large-sized leadframes are prone to warpage when attached to dies and substrates, resulting in a high scrap rate due to significant CTE-mismatch between the different component materials.

The ALG Hybrid Carrier combines ALG parts or pockets that have a CTE similar to those of substrates with metal bars or frames that have a higher CTE, in line with large-area leadframes.



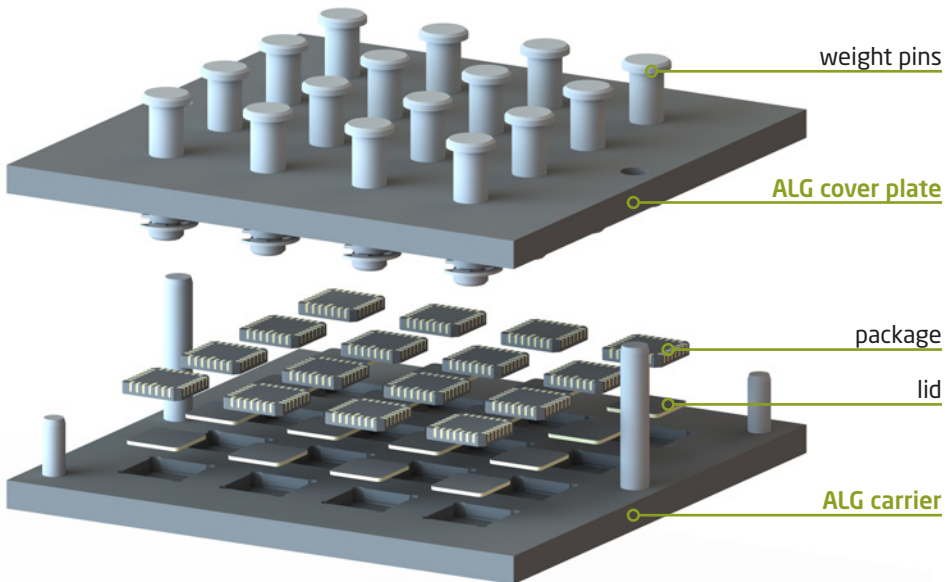
04.3 Power Module Attach

The attachment of molded power modules to heat sinks is a challenging process that requires very specific sets of toolings. Aluminium Graphite jig or fixturing sets combine several properties that provide a notable advantage compared to existing solutions. Each tooling is individually designed in close cooperation with the customer to get the most out of their production process.



04.4 Sealing of (Hermetic) Packages

Aluminium Graphite toolings can not only be used for typical module assembly processes but also for various micro- and optoelectronic package assemblies. Examples range from sealing of LCC packages to attachment of lids on cover frames. These applications benefit from the adapted CTE and high thermal conductivity of the Aluminium Graphite toolings ensuring proper component alignment and efficient heat transfer.



05 Design Engineering Services

In addition to producing the composite material, Aluminium Graphite, and machining parts, Schunk Carbon Technology also provides design engineering services for their customers.

This service covers all aspects of the design from conception, to manufacturability to quality and optimization to ensure that the parts align perfectly with customer requirements whilst keeping costs low. Our team works with the customer each step of the way and is on hand to assist with any questions or queries when and as they may arise.



06 Other Points to Consider when Working with Aluminium Graphite Toolings

SOLDERING EQUIPMENT

The selection of the optimal Aluminium Graphite grade doesn't only depend the specific use case, but also on the type of soldering equipment. In particular, the available heating and cooling concepts of the equipment should be considered:

Heating via conduction:

The heating and cooling speed is higher, if materials with

- a high thermal diffusivity/conductivity,
- a low density and
- a low specific heat capacity

are used. So, processing times can be reduced by a careful material choice.

ALG2208 and ALG2007 are the recommended material grades for carriers which are in direct contact with the heating plate.

Heating via radiation:

When using infrared-assisted soldering processes, the heating speed is higher, if materials with

- A high thermal diffusivity/conductivity and
- A high emissivity

are selected. All Aluminium Graphite grades effectively absorb radiant energy due to their high emission coefficient. Fastest processing times are possible when using either ALG2208 or ALG2007 in infrared-assisted processes.

It is also possible to use the toolings for heating via convection (vapour phase soldering).

MAXIMUM PART SIZES

Material Grade	Dimensions
ALG1808 (isotropic)	265 x 170 x 35-45 mm
ALG2007 (isotropic)	265 x 170 x 35 mm
ALG2208 (anisotropic)	280 x 180 x 35-45 mm

STORAGE OF ALUMINIUM GRAPHITE TOOLINGS

It is recommended to store Aluminium Graphite Toolings in a nitrogen cabinet before and after use. If this is not possible, it is recommended to heat them up to 250-300°C in a non-oxidizing atmosphere (e.g. typical soldering temperature profile) before using them for production. This procedure should be repeated when the toolings have not been used for more than 24 hours.

SCHUNK GROUP

ENGINEERING COMPETENCE IN MATERIALS

TECHNOLOGY AND MECHANICAL ENGINEERING

The Schunk Group is a global technology company. The company is a leading supplier of products made of high-tech materials – such as carbon, technical ceramics and sintered metal – as well as machines and systems – from environmental simulation to air conditioning technology and ultrasonic welding to optics machines. The Schunk Group has around 10.000 employees in 26 countries and generated a turnover of 1.6 billion euros in 2023. The company is divided into ten different Business Units.

In the fast lane with innovative strength – as a component and development partner to the automotive industry, we provide mobility with components for power transmission and with tribologically highly resilient slide bearing and sealing elements made of carbon graphite, graphite and silicon carbide. With several hundred million carbon brushes per year in electric motors for starters, fans, petrol pumps and window regulators, we are the global leader.

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