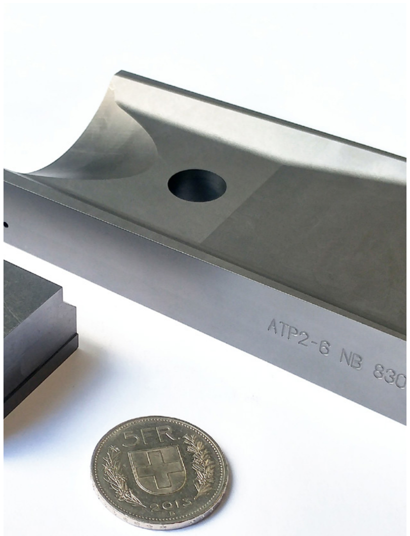
THERMAL MANAGEMENT MATERIAL



Innovative Graphite Composites for Thermal Management Applications.

As part of its accelerator R&D programme, CERN has developed a family of novel, graphite-based composite materials to perform reliably in extreme thermo-structural conditions. The most outstanding results have been with Molybdenum Carbide-Graphite composites (MoGr) — developed in collaboration with Brevetti Bizz (IT) — that exhibit thermal conductivities up to 900 W m-1K-1 , very low coefficients of thermal expansion, and a density lower than aluminium.

These properties make the materials suitable for applications where efficient thermal management and/or high temperature operability are of significant importance. The composition may also be modified to have properties required for specific applications.

AREA OF EXPERTISE

- Material Science

IP STATUS

- Licensing of CERN proprietary materials and methods
- Collaborative R&D on development of similar materials
- Consultancy on material design and production methods

CONTACT

kt@cern.ch

Find out more at: kt.cern

APPLICATIONS

Thermal management components for...

- High-end electronics (e.g. heat spreaders and cooling blocks)
- Automobile components (e.g. cooling for advanced braking systems)
- Aerospace components
- Other thermal-management devices

FEATURES

- Thermal conductivity up to 900 W m-1K-1
- Density as low as 2.5 g cm-3
- Coefficient of thermal expansion similar to semiconductors
- Resistant to temperatures higher than 2000 °C (in inert atmosphere) or 400 °C in air
- Resistance to radiation damage
- Produced by Pulsed Electric Current Sintering (PECS), also known as Spark Plasma Sintering (SPS) or Field Assisted Sintering
- Milled to final shape with conventional machining techniques
- Optional superficial coatings such as metallic molybdenum can be applied

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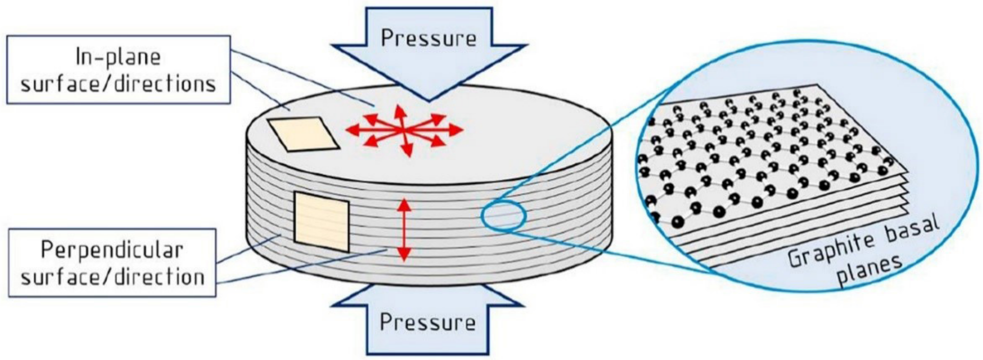
>> The morphology of the components and the manufacturing process lead to a transversely isotropic material: the in-plane and perpendicular directions are defined as those parallel and perpendicular to the graphite basal planes.



>> Summary of thermo-mechanical characterisation results of different grades of MoGr, at room temperature.

Physical and mechanical properties*	‖	⊥	
Density	2.5-2.6		$[g\cdot cm^{-3}]$
Electrical conductivity	0.9-1.1	0.05-0.07	$[MS\cdot m^{-1}]$
Specific heat	0.6-0.65		$[J\cdot g^{-1}\cdot K^{-1}]$
Thermal diffusivity	430-530	28-37	$[mm^{2}\cdot s^{-1}]$
Thermal conductivity	650-900	45-65	$[W\cdot m^{-1}\cdot K^{-1}]$
CTE 20-200°C	1.7-2.7	8-12	$[10^{-6}\cdot K^{-1}]$
Flexural strength	60-80	10-12	[MPa]
Elastic modulus	60-85	4-5	[GPa]
Flexural strain to rupture	0.18-0.26	0.45-0.72	[%]

* Transversely isotropic material: In-plane (‖) and through-plane (⊥) directions. At 20°C.

ADVANTAGES

- Excellent performance in extreme thermo-structural conditions
- Performance validated in use at CERN
- Twice the thermal conductivity and ¼ of the weight as copper

LIMITATIONS

- Requires complex production equipment
- Production currently limited to block sizes of 230mm diameter, 30mm height

Further reading >>

Development and properties of high thermal conductivity molybdenum carbide – graphite composites. Carbon Journal, volume 135 (2018) https://doi.org/10.1016/j.carbon.2018.04.010