



ADVANCED MATERIALS FOR THERMAL MANAGEMENT APPLICATIONS

Reaction-bonded ceramics and aluminum

Patented techniques offer widely tailorable thermal properties.



REACTION-BONDED CERAMICS

Silicon/Silicon Carbidebased-Composites

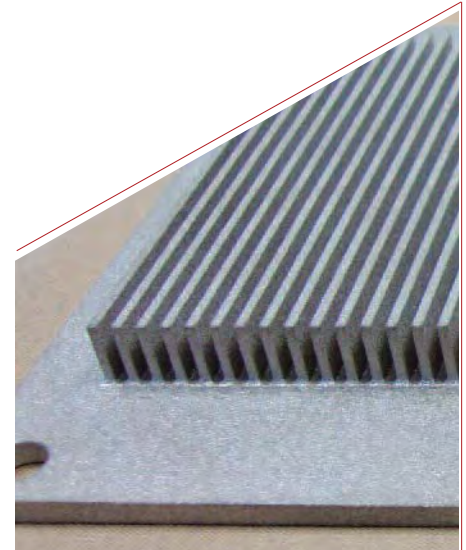
- Experts in reaction-bonded silicon carbide, with over 25 years manufacturing experience.
- Additions of alloying metals allow CTE and thermal conductivity to be tailored to the application.
- Advanced manufacturing techniques can produce complex shapes to tight dimensional tolerances.
- State-of-the-art machining, lapping, and polishing capabilities.
- Long history of SBIR and DARPA work. Strong reputation both for research and for bringing new products to market.



METAL-MATRIX COMPOSITES

Aluminum Components Reinforced with Ceramic Particles

- Wide array of compositions available, including various alloys, ceramics, and heat treatments.
- Parts can be manufactured using traditional foundry techniques.
- CTE can be tailored across a wide range, from 3 to 15 ppm/°K.
- Higher thermal conductivity than aluminum, up to 200 W/m²K.
- Multiple manufacturing options allow component size to vary from less than a pound to over 1000 lbs.
- Complex shapes can be cast to tight tolerances, and can also be machined if required.



APPLICATIONS

Heat Sinks, Optoelectronic Packages, Plates and Heat Exchangers

- Heat sinks
 - Very high thermal conductivity.
 - Components can be manufactured with fins or other features needed for enhanced heat transfer.
- Optoelectronic packages
 - Very complex components can be formed without machining.
 - Parts can also have tapped holes, and can be EDM-machined.
- Plates and heat exchangers
 - Plates can be manufactured to extremely tight flatness and finish requirements.
 - Flow-through channels can be incorporated into the component, and then pressure tested to ensure zero leakage.



Metal Matrix Composites

	Al-SiC	Al-Al ₂ O ₃
Particle Reinforcement	ASC-301	ASC-701*
Vol. % Reinforcement	MMC-S55	AAC-501
Matrix	SiC	Al ₂ O ₃
Density (g/cc)	30	50
Young's Modulus (GPa)	55	70
CTE 25-100°C (ppm/K)	11.8	6.2
Thermal Conductivity (W/m-K)	150	160

Reaction-bonded SiC

	SSC-802	HSC-702	TSC-15
Particle Reinforcement	SiC	SiC	SiC
Vol. % Reinforcement	80%	70%	80%
Matrix	Si	Si/Al	Si/Ti
Density (g/cc)	3	3.02	3.13
Young's Modulus (GPa)	380	330	390
CTE 25-100°C (ppm/K)	2.9	4.4	3
Thermal Conductivity (W/m-K)	180	200	210

Reference

	Al	GraY Cast Iron	Cu	AlN	Si	Kovar	Invar 36
Particle Reinforcement	6061						
Vol. % Reinforcement	---	---	---	---	---	---	---
Matrix	---	---	---	---	---	---	---
Density (g/cc)	2.7	~7.3	9	3.3	2.3	8.2	8
Young's Modulus (GPa)	70	~140	110	330	---	---	---
CTE 25-100°C (ppm/K)	23	~11	17	4.5	2.7	5.6	1.7
Thermal Conductivity (W/m-K)	172	~50	394	150	156	17	11

*ASC-701 is currently only available in plate form

Density determined by ASTM C-135, Young's Modulus by ASTM E-494, CTE by ASTM E-831, Thermal Conductivity by ASTM E-1461. Properties given for room temperature unless otherwise stated.

Note: All of the above information is based upon internal testing. Although we believe the results to be reliable we expressly do not represent, warrant or guarantee their accuracy, completeness or reliability.

www.mmmt.com