

Carbon Fiber and Advanced Composite Materials



Carbon Fiber and Advanced Composite Materials



Mitsubishi Chemical

Material | Products | Solutions

Mitsubishi Chemical is a leading material and solution providers for composite products worldwide. Close to our customers – our global production and R&D presence in Europe, America, Japan, China and Asia enable us to serve customer requirements as well as developing sustainable solutions for today's and future industry needs.

Mitsubishi Chemical and its group companies are dedicated to the market segments such as mobility, wind, medical, sports and leisure, and industrial applications.



*Mitsubishi Engineering-Plastics is a joint venture between Mitsubishi Gas Chemical (50%) and Mitsubishi Chemical (50%)

Our Market Segments

Product Overview

KAITEKI Value for Tomorrow: Why Carbon Fiber

Mitsubishi Chemical is a leading global manufacturer of high-performance thermoset and thermoplastic materials in the form of semi-finished products and finished parts.

Our intermediate products for composites are superior in performance to metals and other materials, and are used in a wide range of applications, primarily in the capital goods industry and beyond.

Working closely with industry leaders in a broad variety of customer markets, Mitsubishi Chemical is continuously developing new applications for carbon fiber composites.

Our materials offer high mechanical strength and stiffness, high toughness, low friction and very good chemical resistance, making them ideal replacements for a wide variety of materials from metal to composites.

Our products can be used for applications between -200°C to 310°C and have many application areas in different key industries such as Mobility (aerospace and transportation), Renewable Energy/Wind, Sports and Leisure, Industrial applications and Semi-conductor industries.



Mobility



Renewable Energy/Wind



Medical



Sports and Leisure



Industrial

A large roll of carbon fiber fabric is shown, with a section cut out to reveal the internal structure. The fabric has a dark, woven appearance with a distinct diagonal pattern. The cut section shows a smooth, light-colored interior surface. The background is a plain, light gray.

CARBON FIBER

For lightweight applications to reduce fuel consumption and CO₂ emissions

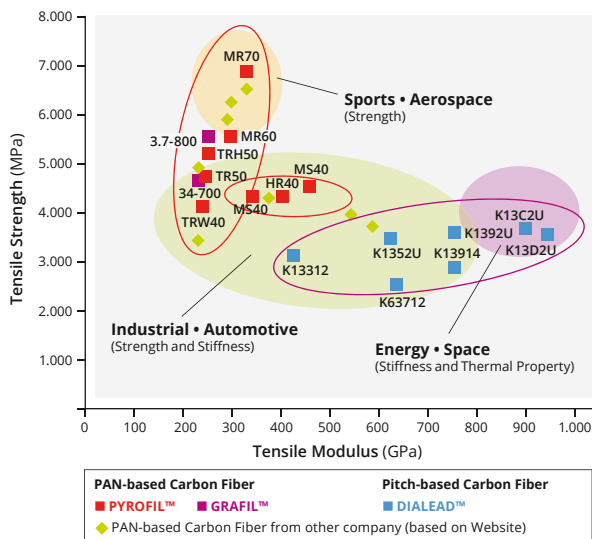
KAITEKI Value for Tomorrow

GRAFIL™ and PYROFIL™ – PAN-based Carbon Fiber

Mitsubishi Chemical Carbon Fiber and Composites offers one of the most diverse carbon fiber product ranges on the market today. Our PAN-based Carbon Fibers produced in Japan and the USA are available in filament counts ranging from 3K to 60K. PYROFIL™ and GRAFIL™ Carbon Fiber are advanced high-performance materials born from technology centered on synthetic high polymer chemistry, in which Mitsubishi Chemical excels.

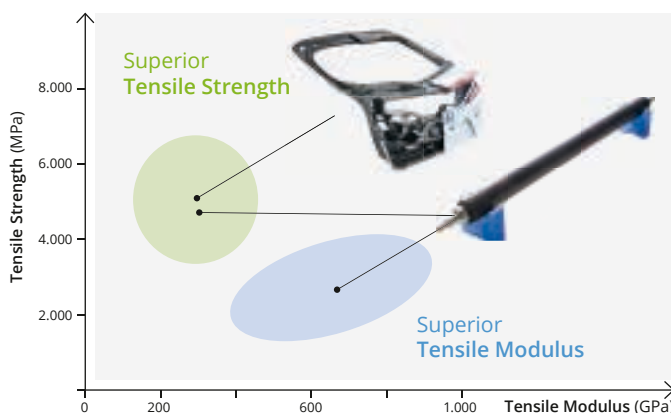
In addition to the extensive continuous Fiber portfolio, we also offer a broad range of PRECISION CUT™ chopped Fiber suitable for compression and injection molding compounds for applications such as machine parts, gears and chemical valves. Carbon Fiber is stronger than steel and lighter than aluminium, ideal for light-weight structural applications.

PROPERTIES OF PAN-BASED AND PITCH-BASED CARBON FIBER



PITCH-BASED CARBON FIBER

DIALEAD™ is a Pitch-based Carbon Fiber that was developed through years of Mitsubishi Chemical's proprietary technological developments in the coal industry. DIALEAD™ has a high carbon content ratio, which allows for the chemical stability of composite materials. It has a high vertical-orientation due to its graphite structure. This results in such features as lightweight, high stiffness, high thermal conductivity and ultra-low thermal expansion coefficient, which makes it ideal for aerospace, sports and industrial applications.



PYROFIL™ | GRAFIL™
PAN-based Carbon Fiber

- Excels in Strength and Stiffness
- Dimensional Stability
- Large Scale Production in USA/JP

DIALEAD™
Pitch-based Carbon Fiber

- High Modulus → Stiffness
- High Thermal Conductivity
- Ultra low thermal coefficient expansion

Our High-Performance PYROFIL™ / GRAFIL™ PAN-based and DIALEAD™ Pitch-based Carbon Fiber are well established in innovative and advanced large scale CFRP applications.



HIGHT TENSILE STRENGTH CARBON FIBER

Strong, light and safe hydrogen tanks
ensure an emission-free environment

KAITEKI Value for Tomorrow

High Tensile Strength Carbon Fiber

Our Carbon Fibers are widely used in filament winding, weaving and prepregging in several innovative applications. PYROFIL™ GRAFIL™ High Tensile Strength Carbon Fibers, with outstanding processing characteristics, have evolved as the material of choice for high strength and performance for high-performance composite pressure vessels. Mitsubishi Chemical Carbon Fiber and Composites has developed three dedicated high tensile strength grades that are ideal for the filament winding of industrial pressure vessels such as compressed natural gas tanks, storage tanks and type 4 hydrogen tanks. Available in 18K and 30K tow sizes.

MECHANICAL PROPERTIES

PYROFIL™

Type	Filament Count	Filament Diameter	Yield	Tensile Strength		Tensile Modulus		Elongation	Density
		µm	mg/m	GPa	Ksi	GPa	Msi	%	g/m³
TRH50 18M	18.000	6	1.000	5,30	770	250	36	2,12	1,82
TRH50 30M	30,000 ¹⁾	6	1.670	5,60	255	255	37	2,15	1,82

¹⁾All properties are tentative

GRAFIL™

Type	Filament Count	Filament Diameter	Yield	Tensile Strength		Tensile Modulus		Elongation	Density
		µm	mg/m	GPa	Ksi	GPa	Msi	%	g/m³
37-800	30.000	6	1.675	5,52	800	255	37	2,16	1,81

**PYROFIL™ | GRAFIL™
HIGH TENSILE STRENGTH CARBON FIBER**

6 Micron Fiber Diameter → High Strength

- 30K Fiber with Conventional 24K TEX
- 18K Fiber with Conventional 12K TEX

High Performance

- Stable Tensile Strength → Low Variation
- Excellent Processability → High Productivity
- Developed for High Strain Applications

Stable and sustainable production in the USA and Japan



FORGED MOLDING COMPOUND™ – CF-FMC

For lightweight Composite Parts
and less CO₂ emissions

KAITEKI Value for Tomorrow



Forged Molding Compound | CF-FMC

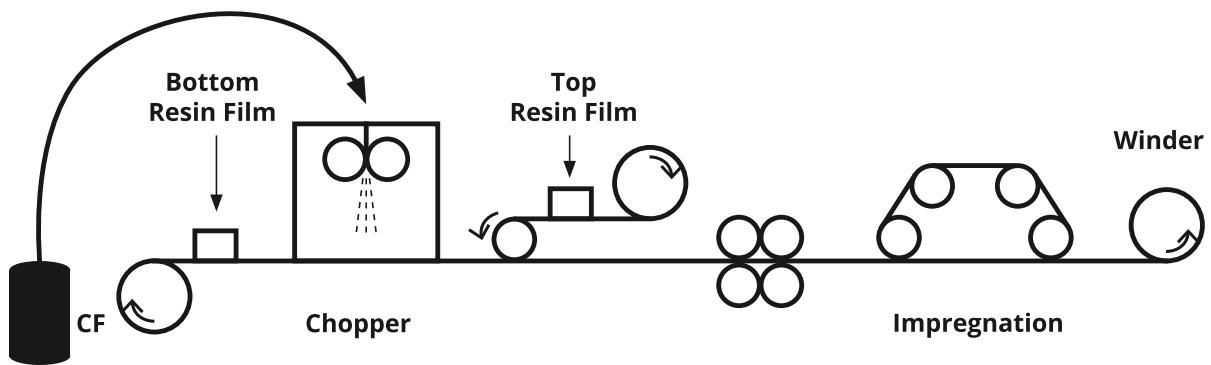
Material | Mechanical Performance

Carbon Fiber Forged Molding Compound (CF-FMC) is a combination between industrial 25mm long Carbon Fiber and a resin. With a proprietary combination of fiber mass content and resin system (epoxy, vinyl ester and pheholic), we can offer material systems with high mechanical properties for a broad range of applications.



Foto | Toyota

CF-FMC PRODUCTION PROCESS

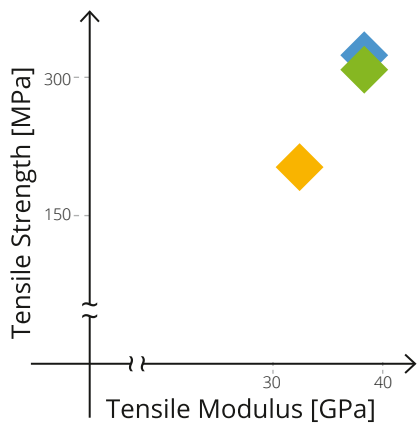


MECHANICAL PERFORMANCE

Items		Unit	Product Family		
			Standard Regular Tow	Conventional Small Tow	Split Tow
CF tow count		-	15K	3K	Split Tow
Tensile Property	Strength	MPa	185	320	315
	Modulus	GPa	34	39	39
Product Readiness			Commercially Available	Commercially Available	Under Development

* All products based on modified Vinyl Ester resin and 60% fiber mass content

* All properties based on Low Flow Molding (> 85% mold coverage)



MATERIAL DATA CARD | SIMULATION

For high loaded CF-FMC structural Composite Parts Mitsubishi Chemical provides:

- Material definition database for statical analysis
- Material Card for post failure analysis, crash
- Design of metal molds
- Composite design of CF-FMC parts

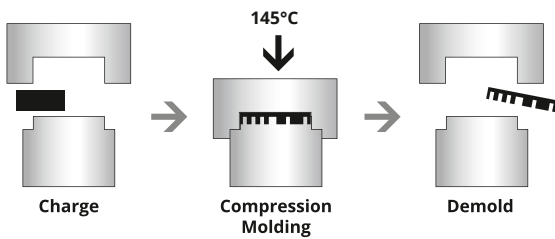
Forged Molding Compound | CF-FMC

Composite Production | Design | Benefits



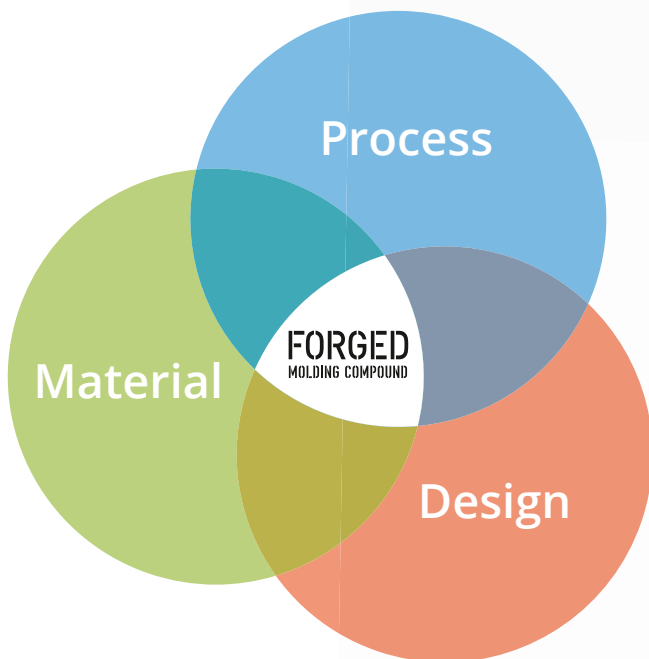
PRODUCTION OF CF-FMC COMPOSITE PARTS

The CF-FMC compound can be molded to complex CFRP parts with pressure and temperature. Functions like ribs, metal inserts and hybrid molding together with prepreg materials generates a variety field of applications.



MOLDING CONDITIONS

- Temperature: 130°C – 150°C | Mold Coverage > 85% | Low-flow Molding
- Molding pressure: 5 – 10 MPa
- Cure time 2 – 5 min at 145°C | 1 min/mm



CF-FMC BENEFITS

- Short cycle time – ideal for volume automated production
- Design of complex geometries
- Integration of functions (inserts, ribs, ...)
- High mechanical properties
- One shot hybrid molding with various materials like rubber or combination with Carbon Fiber Prepreg/Towpreg intermediates
- New stylish Carbon look



Foto | KTM Technologies



Foto | KTM Technologies



Foto | Toyota



Foto | Toyota



CARBON FIBER PREPREG MATERIALS

For lightweight Composite Parts
and less CO₂ emissions

KAITEKI Value for Tomorrow



APPLICATIONS FOR PREPREG COMPRESSION MOLDING (PCM)

Woven and UD Prepreg materials have been developed for lightweight body panels, with high quality visual Carbon Fiber roofs or body color painted composite parts such as

- Front hoods
- Lids
- Fenders
- Doors



ADVANTAGES OF PCM TECHNOLOGY

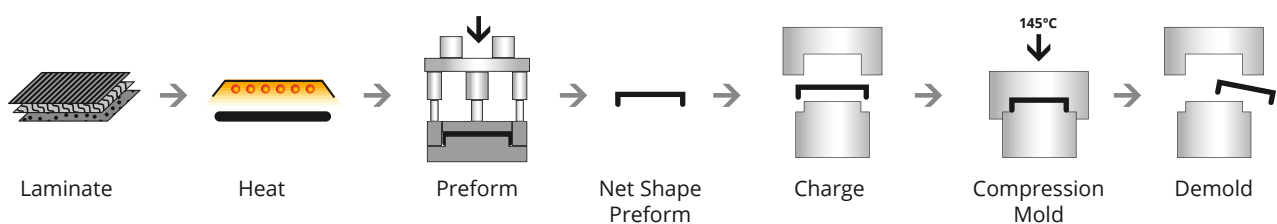
- Short cycle times – quick cure resin systems
- Passes climate cycle test (e.g. PV1200)
- Suitable for inline/online painting process at OEM
- Less investment costs for tooling compared to metal solutions
- Process automatization for volume production



CUSTOMER BENEFITS AND ADVANTAGES

- Lightweight – 33% weight saving vs. aluminum
- Lower center of gravity/superior driving dynamics
- Individualization and special geometry like power-domes are possible

COMPOSITE PARTS PRODUCTION



CONDITIONS TO PRODUCE PCM PARTS WITH QUICK CURE RESIN SYSTEM

- Temperature: 130°C–150°C
- Molding pressure: 3–10 MPa
- Cure time: 3 min at 150°C

THERMOPLASTIC COMPOSITE MATERIALS

For future mobility concepts

KAITEKI Value for Tomorrow



Glass-Mat-Reinforced Thermoplastics | GMT

Protective and Structural Applications

GMT | GMTex® - COMPOSITE SHEETS

Mitsubishi Chemical Advanced Materials Composites is considered the world market leader in the production of Glass-Mat-Reinforced Thermoplastics (GMT).

The material can be pressed into complex 3D structural components or can be used as panels. GMT offers outstanding impact resistance and benign crash behavior at the same time. Its low relative density, excellent hardness and rigidity even at low temperatures, resistance to moisture and chemicals, durability and ease of recycling, have established GMT as an extremely successful material for automotive applications. Its special long glass fiber mat technology ensures high energy absorption before fracture and thereafter benign failure behavior without sharp lines of fracture.

GMTex®

Based on GMT, the glass weave composite GMTex® has been further developed for applications demanding high impact resistance, strength and durability. Depending on the part requirements GMT material can be additionally reinforced with moldable GMTex® in one press stroke and replace steel, aluminum and magnesium parts. Also hybrid combinations of GMT | GMTex® | SymaLITE® | QTex® | Steel are possible.



Pressure Vessel Carrier in GMT

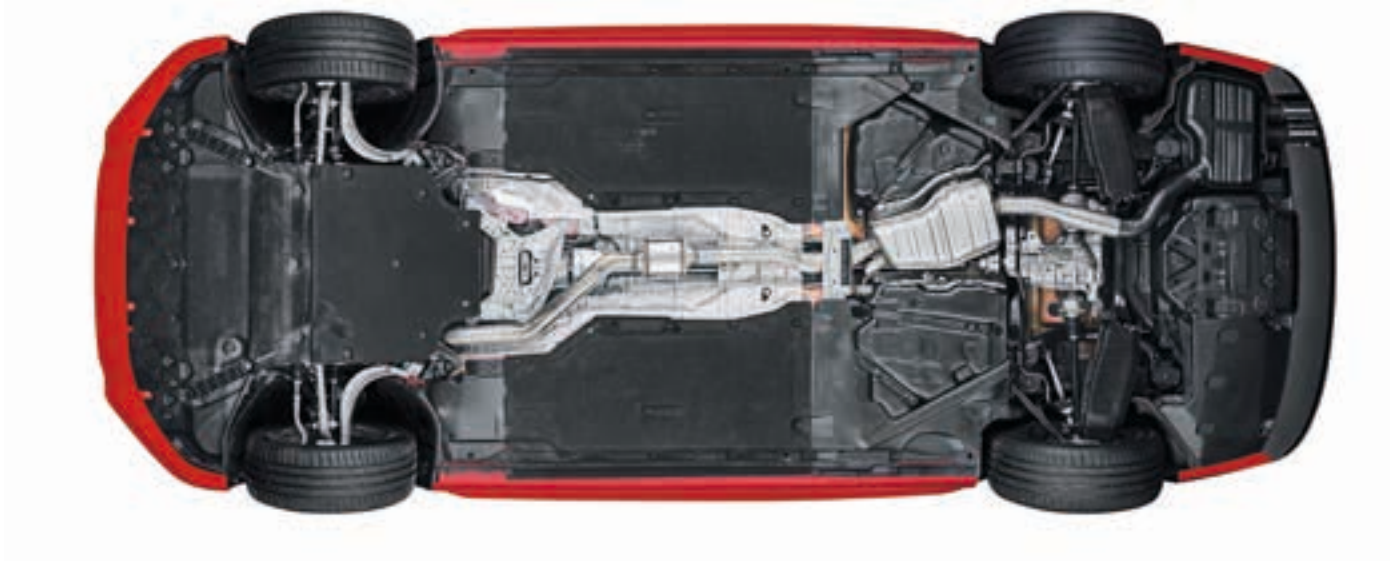
BATTERY BOX AS GMT | GMTex® HYBRID

Mitsubishi Chemical Advanced Materials developed this battery protection in close cooperation with the OEM and the Tier1. A combination of GMT and GMTex® have been used to pressmold this battery protection part. GMT was beneficial due to its 3-dimensional flow to fill the tool cavity. GMTex® contributed to fulfill the mechanical stiffness, impact and crash requirements.



Structural Wireless Charging Carrier in GMT





SymaLITE®

SymaLITE®, Low Weight Reinforced Thermoplastics (LWRT from Mitsubishi Chemical Advanced Materials Composites) make up a product group of special lightweight plastic composites with low thermal expansion and excellent mechanical and physical properties.

The mixed glass and polymer fiber fleeces produced in a special textile process are supplied as rolls or boards and can be cost-efficiently further-converted into 3-dimensional components by low-pressure molding. The ultra-light, freely shapeable SymaLITE® thermoplastic is noise-absorbent and can be faced directly with functional and decorative cover layers without the need for adhesives. This eliminates an entire production step.

- Sound absorbing
- Chemically resistant: Oleo-/Hydrophobic
- Flame retardant
- Impact resistant
- Mechanical/acoustical properties adjustable: AW 700 to 2200 g/m²
- Lightweight glass- and Polypropylene (PP) Fiber reinforced material
- Area weights between 700 to 2200 g/m²
- Glass Fiber content: 40% / 50%
- Functional layers applied inline
- High stiffness due to lofting behavior

Low Weight Reinforced Thermoplastics | LWRT

Lightweight and Acoustics

SymaLITE® provides a considerable weight saving potential compared to conventional solutions as well as good acoustic performance.

Typical SymaLITE® applications in the automotive industry are underbody shields, load floors, headliners and parcel shelves which can often be molded by one press-stroke.

INTERIOR APPLICATION

PARCEL SHELF IN SymaLITE®



EXTERIOR APPLICATION

ENGINE SHIELD IN SymaLITE®



EXTERIOR APPLICATION

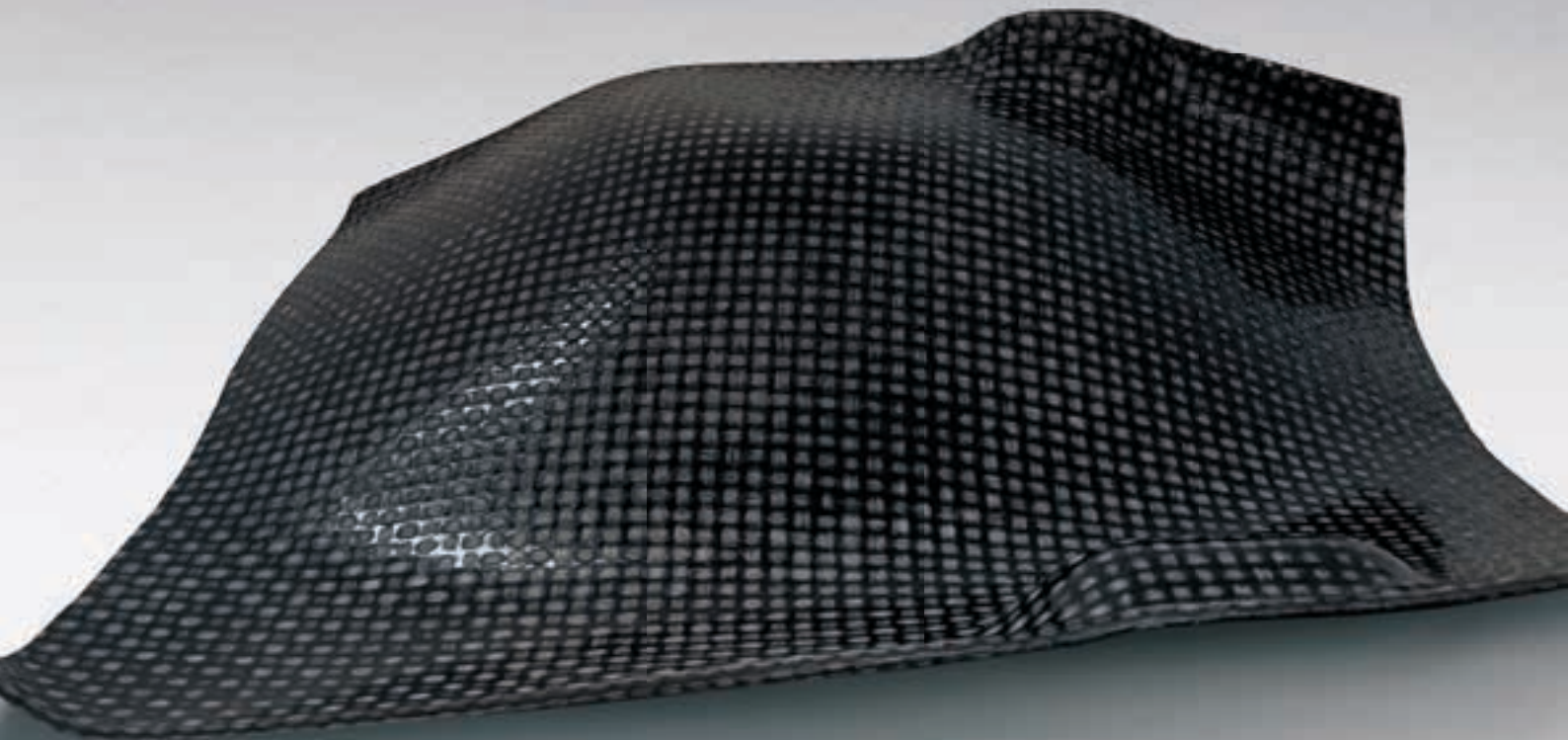
HYBRID ENGINE SHIELD IN GMT | GMTex® | SymaLITE®



THERMOPLASTIC COMPOSITE MATERIALS

For future mobility concepts

KAITEKI Value for Tomorrow

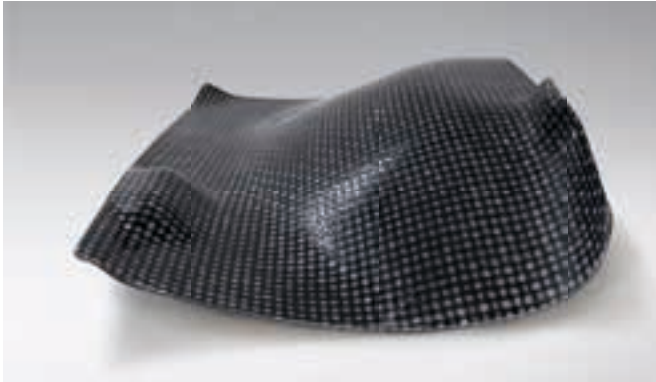


Thermoplastic Prepregs and Sandwiches

Light and Stiff Applications

SYTex®

The SYTex® thermoplastic sandwich panel combines SymalITE® with QTex® Organo Sheet as the covering material. Lightweight yet extremely rigid components with different wall thicknesses can be produced by compression molding. Large area applications for underbodies with high mechanical requirements, such as in sports and luxury cars are now possible with SYTex.



THIN SEMI-FINISHED PREPREGS: QTex® ORGANO SHEETS

QTex® is a high performance composite made with thermoplastic polymer (PP). The combination of glass fiber weave with thermoplastic polymers results in exceptionally high strength and rigidity. QTex® can be used to reinforce components to improve their performance. The material is available from 0.6 mm thickness, suitable for thermoform-pressing and other technologies. It can be provided as blanks or rolled goods.

APPLICATION EXAMPLE

QTex® ORGANO SHEET | GMTex® - FUEL TANK PROTECTION

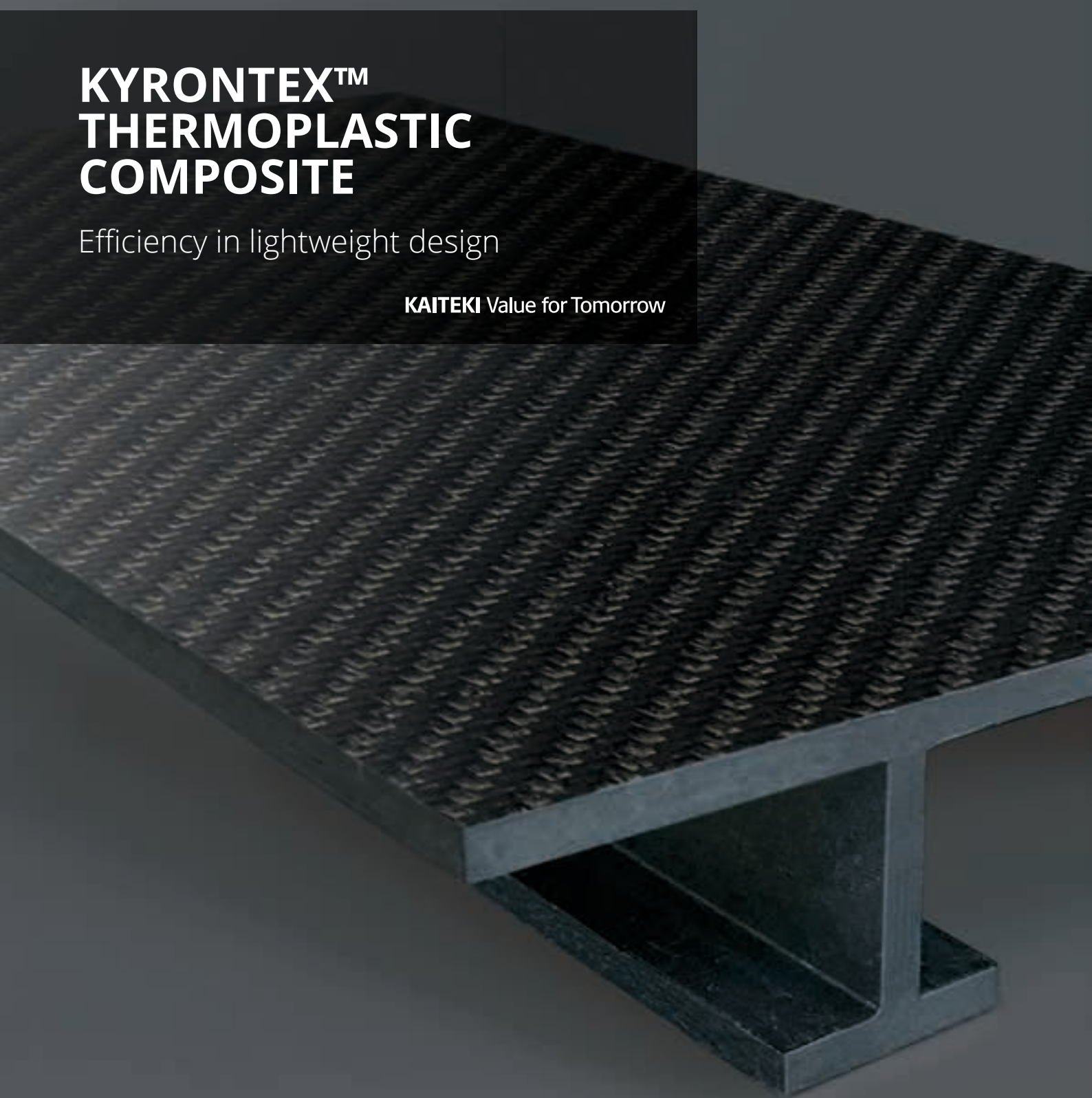
- Hybrid molding: QTex® Organo Sheet and standard thermoplastic technology (LFT)
- Good stiffness and dimensional stability
- Aerodynamic function
- High impact and crash performance



KYRONTEX™ THERMOPLASTIC COMPOSITE

Efficiency in lightweight design

KAITEKI Value for Tomorrow



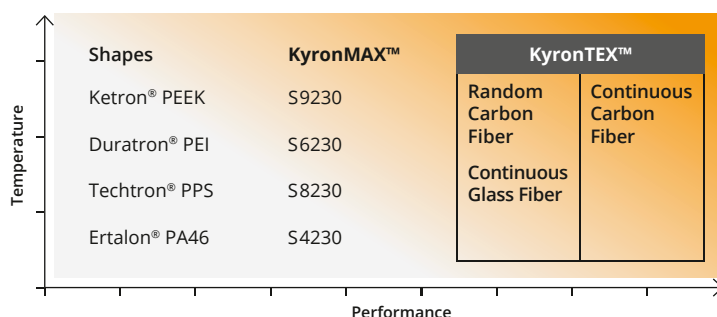
High Performance Thermoplastics

Our Legacy

Mitsubishi Chemical Advanced Material is the leading manufacturer of high-performance thermoplastic semi-finished goods and engineered solutions. Due to our experience in the processing of high performing thermoplastics and the requirements of our key customers to replace metal with solutions with higher mechanical integrity, we have continued to develop thermoplastic composite technology platforms for high mechanical requirements.

For the manufacturing of high strength and high stiffness parts based on injection molding a carbon fiber reinforced injection molding technology, KyronMAX™ technology has been developed and upscaled to commercial quantities. In addition, we have also developed the KyronTEX™ series of products based on compression molding processing of carbon fiber thermoplastic composites, for highest performance areas and larger parts.

Both KyronMAX™ and KyronTEX™ composite technology platforms are primarily based on compression molding processing following high performance thermoplastic polymers that are also still available as stock shapes.



KyronMAX™

KyronMAX™ is a thermoplastic compounding and molding technology that has been developed to replace metal and long fiber reinforced compounds. The unique combination of specialty carbon fiber technology, next generation injection molding and FEA based simulations allows metal replacement in areas that were previously exclusively available for lay up composites.



TECHNICAL PROPERTIES OF KyronMAX™ PRODUCTS

MECHANICAL	Test Method	Unit	Typical Value			
			S-4230	S-6230	S-8230	S-9230
Specific Density	ASTM D792	g/cm ³	1.31	1.4	1.43	1.41
Tensile Strength	ASTM D638	MPa	383	310	269	336
Tensile Modulus of Elasticity	ASTM D638	GPa	34	35	30	37
Tensile Elongation	ASTM D638	%	1.8	1.2	1.4	1.8
Flexural Strength	ASTM D790	MPa	517	407	379	503
Flexural Modulus of Elasticity	ASTM D790	GPa	29	25	27	33
Compressive Strength	ASTM D695	MPa	310	345	285	338
Compressive Modulus of Elasticity	ASTM D695	GPa	8	8	7	8
Notched Izod Impact	ASTM D256	J/m	68.9	68.9	69	106
Unnotched Izod Impact	ASTM D4812	J/m	901	583	534	954
THERMAL						
Glass Transition (Tg)	ASTM D3418	°C	118	215	99	153
Melting Point	ASTM D3418	°C	311	NA	282	345
ELECTRICAL						
Flammability	UL 941		HB	V-0	V-0	V-0
CHEMICAL						
Moisture, 24 hours	ASTM D570	% by wt	0.175	0.156	0.05	0.45

Thermoplastic Carbon Composites – KyronTEX™

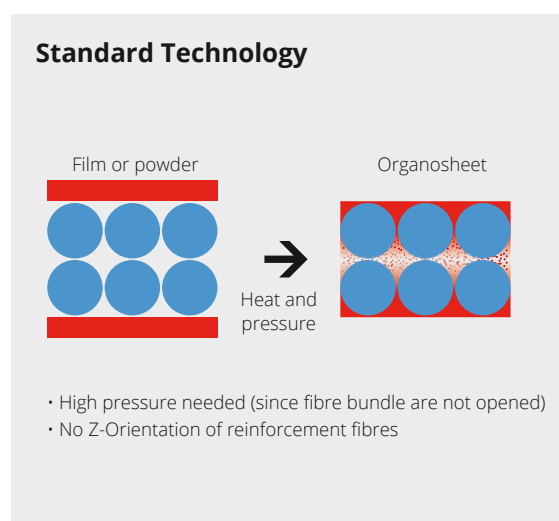
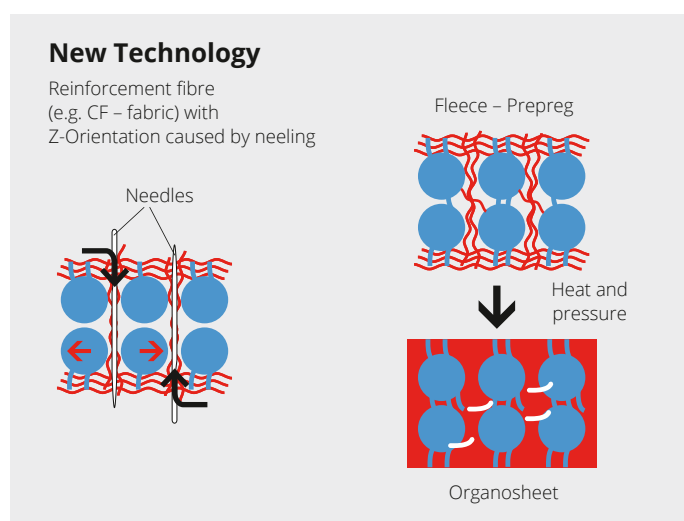
The KyronTEX™ technology platform is utilizing fast and scalable textile manufacturing processes. Polymer fibers are mechanically being positioned (dry impregnation) in between the reinforcement fibers to produce the prepregs. These prepregs can be manufactured with random fiber reinforcement, crimp fabrics and even UD fibers.

DRIVERS OF THE KyronTEX™ DEVELOPMENT



Combine the highest performance carbon fiber with Automotive thermoplastic processing efficiency and with the experience of Aerospace supply to develop the next generation Aerospace technologies.

DRY IMPREGNATION TECHNOLOGY





Random Fibers

KyronTEX™
C44MAT 500 PEI/PEEK/PPS

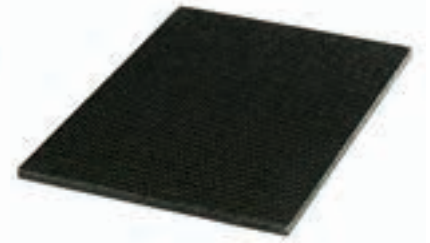
A composite with random carbon fiber reinforcement for applications with high impact requirements.



Continuous Fibers

KyronTEX™
C55FAB 440 PEI/PEEK/PPS

A composite with crimp fabric reinforcement for applications with highest strength requirements.



Sandwich

KyronTEX™
C44AIR 440 500 PEI/PEEK/PPS

A sandwich system with continuous fibers in the skin layers and random fibres in the core for applications that require a very high stiffness to weight ration.

EXAMPLE OF TECHNICAL PROPERTIES

of KyronTEX™ C44MAT 500 | KyronTEX™ C55FAB 440

	Standard	SI Unit	KyronTEX™ MAT	KyronTEX™ FAB
			Value	Value
Physical Properties				
Thickness of one Layer *	Internal	mm	0.34	0.29
Area Weight of one Layer *	Internal	g/m ²	500	440
Fiber Content (weight %)	ISO 1172	%	44	54.5
Fiber Content (volume %)		%	35.47	45.6
Density *	ISO 1183	g/cm ³	1.48	1.51

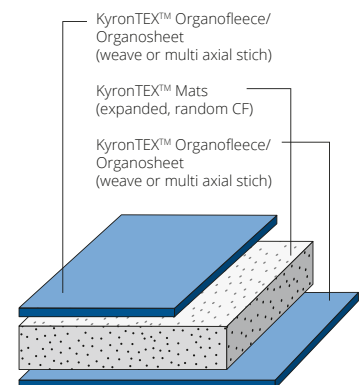
Material			PEI-rCF	PEI-CF
Mechanical Properties **				
Tensile Strength MD ¹⁾	ISO 527/EN 13677	MPa	180	770
Tensile Modulus MD	ISO 527/EN 13677	MPa	16400	60000
Elongation at Break MD	ISO 527/EN 13677	%	1.08	1.28
Flexural Strength MD	ISO 178	MPa	385	955
Flexural Strength CD	ISO 178	MPa	350	1010
Flexural Modulus MD	ISO 178	MPa	23170	44000
Flexural Modulus CD	ISO 178	MPa	29800	45000
Max. Force @ thickness (2.1 mm MAT; 1.8 mm FAB)	DIN ISO 6603-2/C	N	1320	3680
Energy at max. Force	DIN ISO 6603-2/C	J	2.28	7.10
Impact Force @ thickness (2.1 mm MAT; 1.8 mm FAB)	DIN ISO 6603-2/C	N	661	1840
Impact Energy	DIN ISO 6603-2/C	J	2.65	18

¹⁾ measured in longitudinal direction (MD: machine direction)

* Properties determined on laminate

** Properties determined on flat molded sheets

SANDWICH STRUCTURE



Exterior and Interior

Assembly | Masking | Transport Protection



STRONG AND RESIDUE-FREE REMOVABLE

The tape to protect composite parts

KAITEKI Value for Tomorrow

Nichigo G-Tape™

Mitsubishi Chemical's Nichigo G-Tape is a hand tearable, residue-free and highly weather resistant tape. These features offer many solutions to automotive industry and after markets.

- Innovative pressure-sensitive tape
- Hand-tearable, requiring no knives
- Leaves no residue on most surfaces
- Can easily be removed from itself and reused, unlike standard duct tapes
- Higher tensile strength and dimensional stability than conventional gaffer tapes or duct tapes



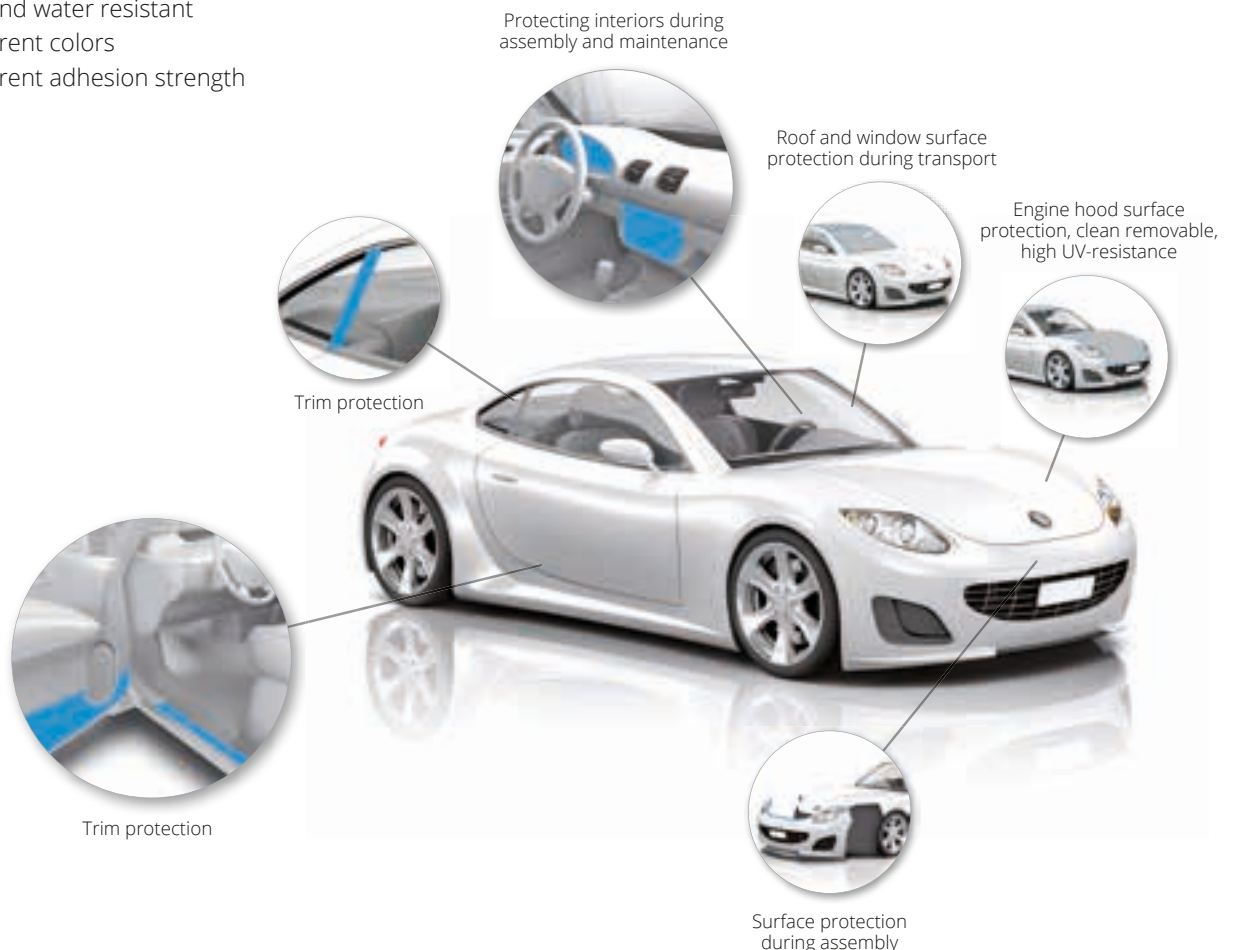
TECHNICAL DATA

Property	Unit	Masking and Protection			Waterproof and Airtight		Double Sided	
		1003	1008	1009	3030	3040	9206	9030
Thickness	mm	0.14	0.16	0.16	0.17	0.22	0.24	0.22
Adhesion Strength	N/25 mm	3	8	9	30	40	20/6	30/30
Holding Power*	mm	0.1	0.1	0.1	0.2	0.9	0.1/0.05	0.6/0.6
Tensile Strength	N/50 mm	230	350	280	380	400	400	400
Elongation	%	15	17	15	16	21	21	21

Note: Above figures are measured values based on test method of JIS Z-0237. The technical information and data are typical values for reference, not specifications. *The measure of slippage in one hour while holding a metal plate.

BENEFITS AND ADVANTAGES

- Easy to tear, no tools needed
- Clean removable, no residue after removing
- UV and water resistant
- Different colors
- Different adhesion strength



A fully integrated and independent supply chain
– for today's and future industry's needs.



CHEMICALS



MATERIALS



TECHNOLOGIES



SOLUTIONS



Mitsubishi Chemical Corporation
www.m-chemical.co.jp

KAITEKI Value for Tomorrow

Mitsubishi Chemical Holdings Group

For more information please contact:

Mitsubishi Chemical Europe GmbH | Willstätterstraße 30, D-40549 Düsseldorf | Kasteler Straße 45, D-65203 Wiesbaden
Phone +49 (0)211 520540 | carbon-fiber@mccfc.eu | advanced-composite-materials@mitsubishi-chemical.eu