MITSUBISHI CHEMICAL GROUP

Heat Resistant Composite Materials

Carbon/Carbon Composite, CMC Composite

・C/C（Carbon/Carbon） ：CF＋Carbon
・CMC（Ceramic Matrix Composite） ：CF＋SiC
・Phenolic CFRP , SMC ：CF＋phenolic resin

【Characters】

・Light weight：1/3-1/5 density of steel (7.9g/cm^3)
・High stiffness：Higher than Steel・Thin design possible by High strength
・High heat resistance：（C/C, C/SiC：800℃≦、phenolic CFRP：300℃≦）。
・High flame retardance：phenolic CFRP（shot CF）EN45545-2 R1/R6 HL3 passed

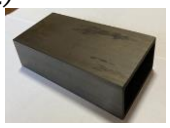
【Product example】

C/C brake (short CF)

C/SiC brake (development)

C/C, C/SiC hand (long CF ／development)

Phenolic CFRP hand & Molding（long CF・short CF／development）

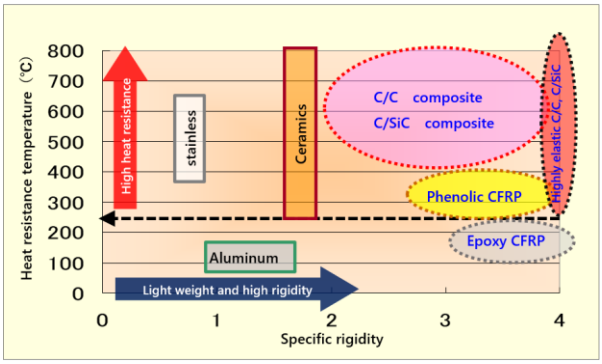


【Typical properties】

Materials	Direction	Bulk density g/cm^3	Bending strength (⊥) MPa	Bending modulus (⊥) GPa	Tensile strength (⊥) MPa	Compressive strength (⊥) MPa
C/C	Isotropic	1.9	180	70	110	170
	Unidirectional	1.7	440	290	300	300
C/SiC	Isotropic	2.4	150	100	100	500
	Unidirectional	2.1	410	310	300	450
Phenolic CFRP	Isotropic	1.6	100	20	50	170
	Unidirectional	1.7	630	390	1,710	300

The listed values are typical and can vary depending on the laminated structure and the amounts of substances contained.

【Comparison with other materials】



Mitsubishi Chemical Corporation
Composite Products Department
1-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8251, Japan

https://www.m-chemical.co.jp/carbon-fiber/en/

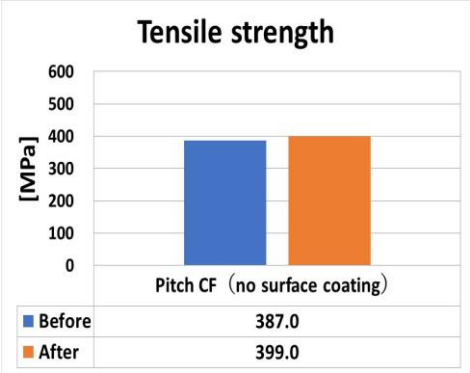
Printed in Japan February 1, 2024 (MCC)

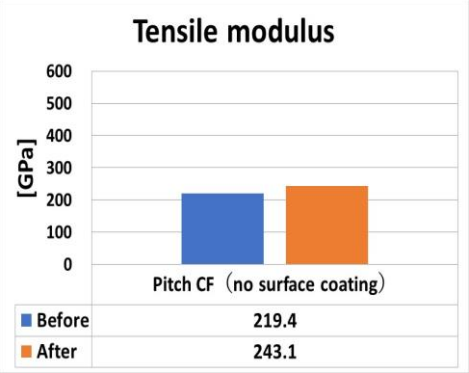
MITSUBISHI CHEMICAL GROUP

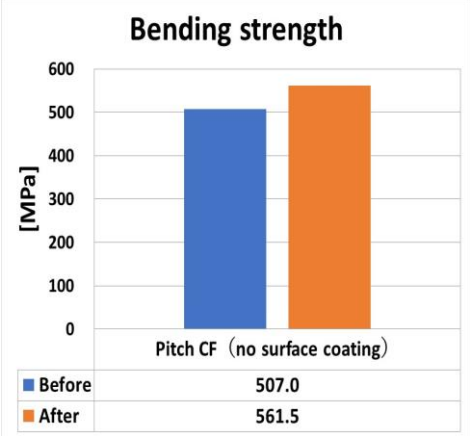
1500℃ Heat Resistant CMC (Pitch-based C/SiC Composite)

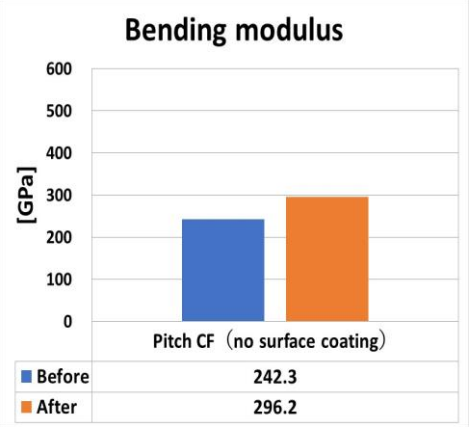
Application: Heat-resistant material for spacecraft heat shield tiles

Before vs after at 1,500℃×1 hour（in Air）

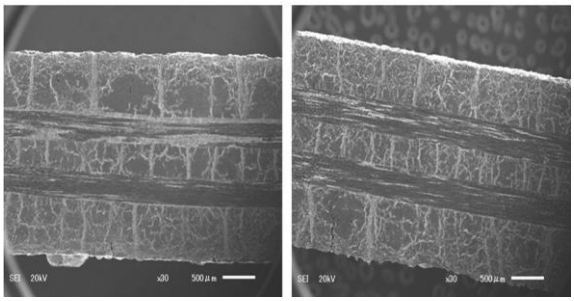








- No degradation of strength and modulus before and after heat treatment in air at 1,500°C for 1 hour,375MPa after exposure to 1500℃ for 1 hour
- JAXA innovative future space transportation system target: 1600℃-800 seconds resistance



- The cross-sectional observation photographs (SEM images) before and after heat treatment are shown below (left: before, right: after). No major changes in appearance (deterioration) were observed.
- **Plan to perform ～ 2000℃ heating test in future**

Mitsubishi Chemical Corporation
Composite Products Department
1-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8251, Japan

https://www.m-chemical.co.jp/carbon-fiber/en/

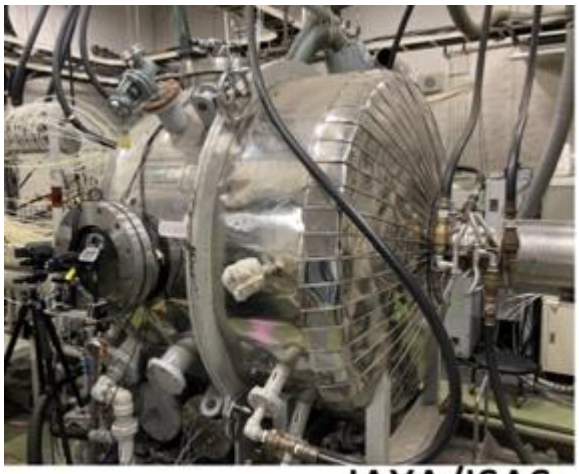
Printed in Japan February 1, 2024 (MCC)

MITSUBISHI CHEMICAL GROUP

2200℃ Heat Resistant Pitch-based C/C Composite

Application: Heat-resistant material for rocket nozzles and satellite attitude control thruster nozzles

JAXA arc heating wind tunnel test facility

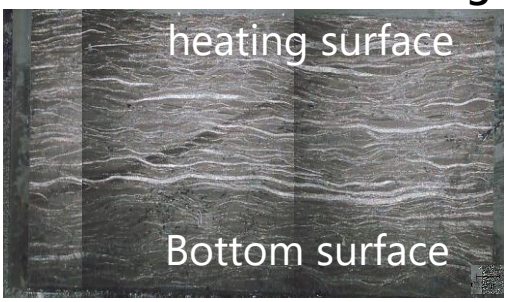


JAXA/ISAS

Surface after heating test

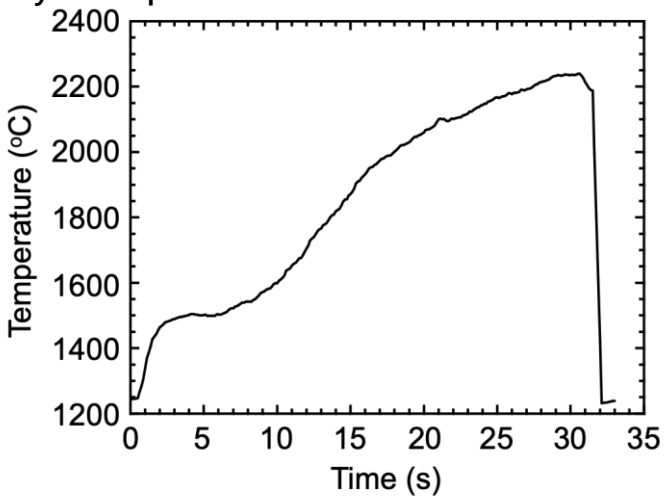
Thickness reduction rate: 10%

Cross section after heating test



Heating condition

Heating rate: 4.83 MW/m2
Dynamic pressure: 13~14 kPa



Surface during heating at 2200℃

Courtesy of Tokyo University of Science

- Joint development of CMC heat-resistant materials is underway with Tokyo University of Science.
- As a result of arc heating wind tunnel testing of the base material, the amount of wear was approximately 10% (0.8mm) for pitch-based C/C composite with a thickness of 8mm, .Plans for impregnating with alloys such as Zr-Ti to improve the heat resistance performance.

Mitsubishi Chemical Corporation
Composite Products Department
1-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8251, Japan

https://www.m-chemical.co.jp/carbon-fiber/en/

Printed in Japan February 1, 2024 (MCC)