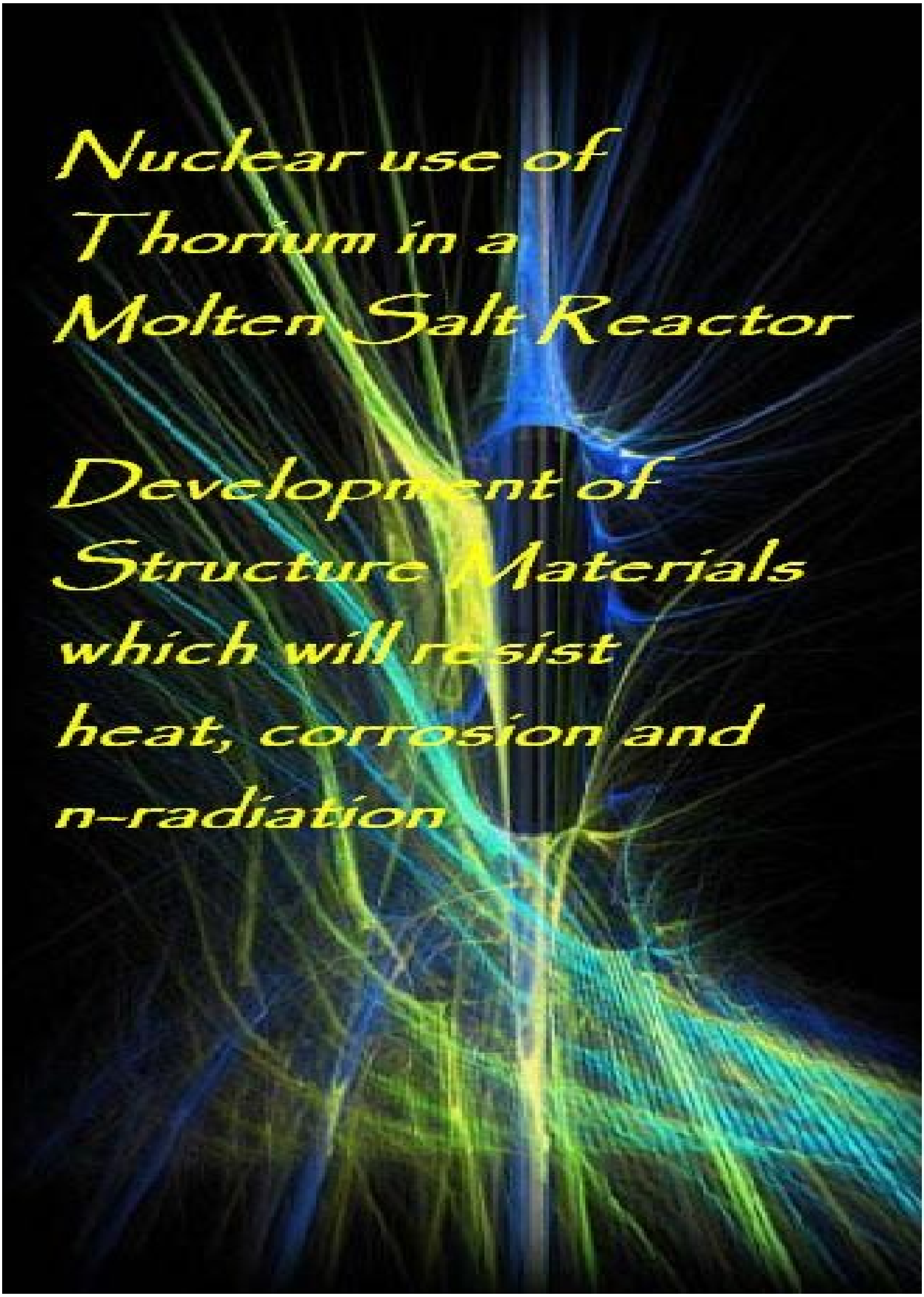
Dr. Rüdiger Klein,VDI
Tel.: 0179-7090393

Häuser Weg 5
D-63456 Hanau
Germany



1 Composition of the technical possibilities for the development and testing of new structure materials for a Molten Salt Reactor (MSR)

1.1 Research and Development of new Structure Materials for a Molten Salt Reactor

Researchers of the group of Alvin Weinberg at ORNL aready developed new alloys, which could resist heat, corrosion of fluorid-containing salts.

Also for the radiation damages in Hastelloy N, a new alloy had been developed and positively tested.
This however has never been published to the public.

Concerning the graphite pipes in the core, several new kinds of materials could be developed.

During the Sixties only nuclear graphite was pressed and sintered.

Today, nearly fifty years later, a lot of modern techniques are available to produce much better materials, which surely can resist the heat, corrosion and n-radiation for some decades.

1.2 Better structure materials by help of more efficient techniques in the future

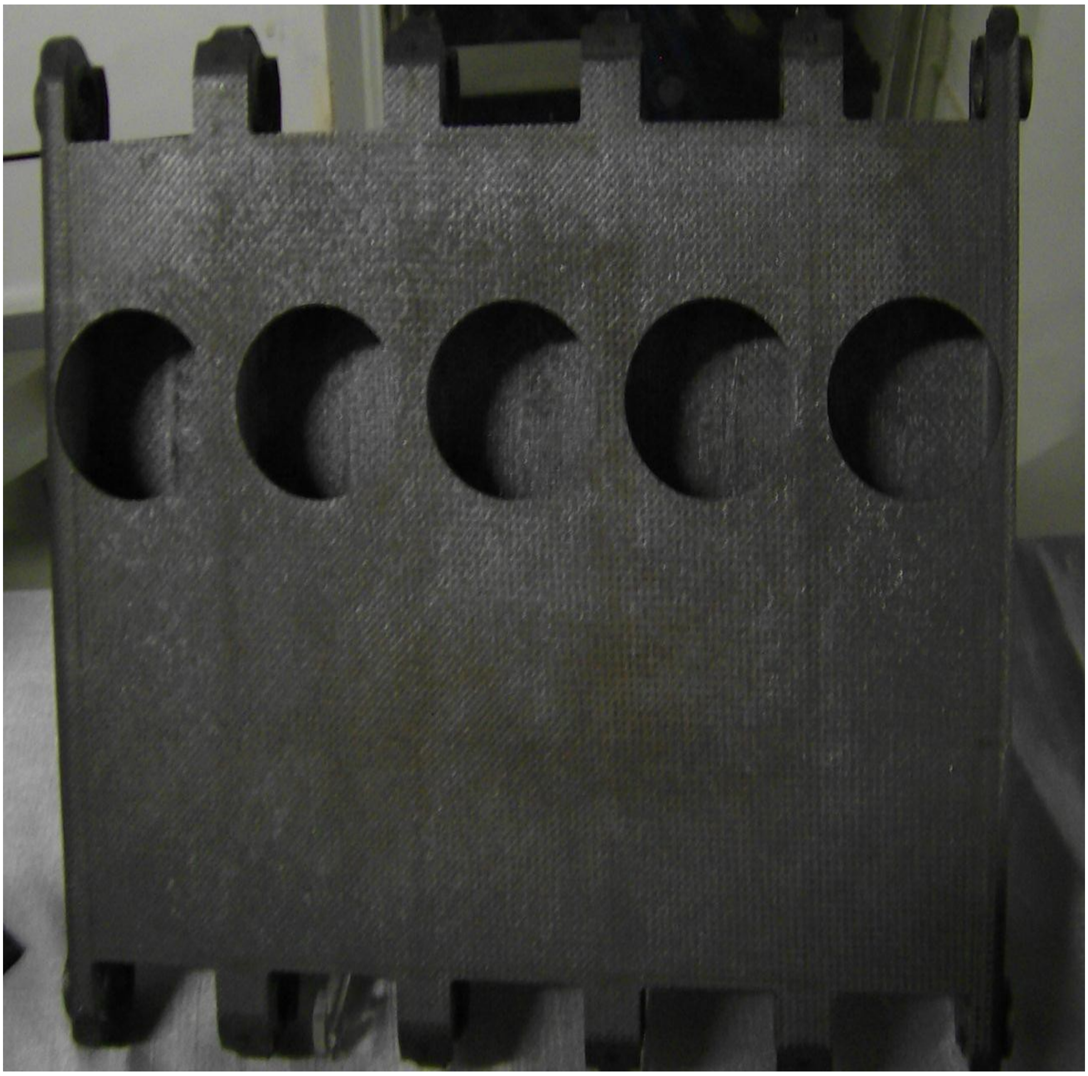
Sparc Plasma Sintering of

a) graphite which has been isostatically pressed at several thousand bars.
b) Siliconcarbide which has been treated by the same way,

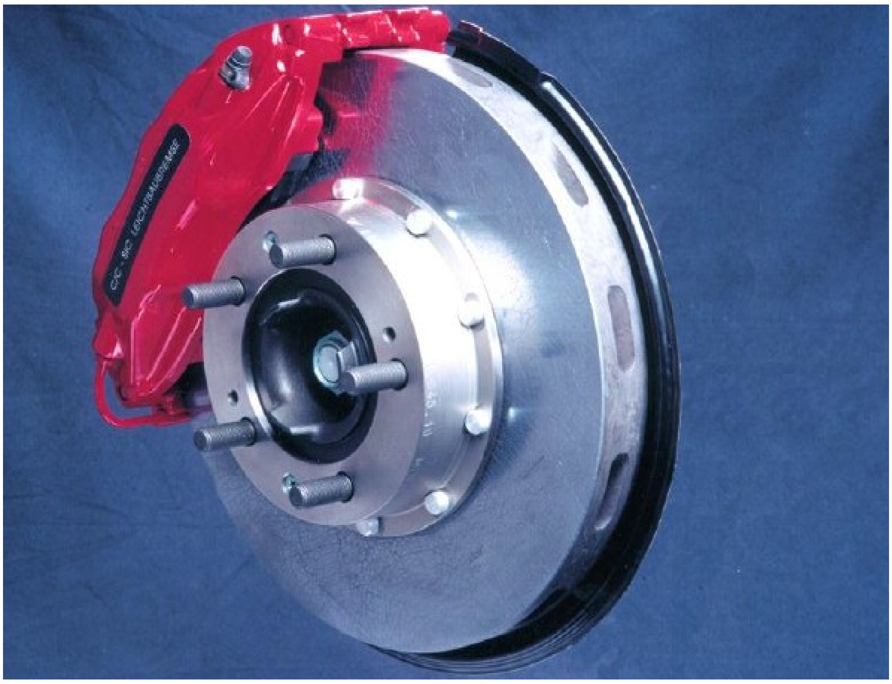
c) Zirconiumcarbide which has been also treated by the same way,
d) Mixtures of ZrC and other carbides, which have very high melting points.

Production of Ceramic Matrix Composites

which today are mainly used in air and space development. They are combining hardness, temperature-resistance and structural integrity against shock.



Nozzle component for aviation technique made of C/C SiC.



Brake-disk for racing cars (Brembo-SGL)

Telescope made of material, which has a very low thermal expansion.

Preparation Techniques of Fibers for a Ceramic Matrix

Chemical Vapor Infiltration (CVI)

Preparation of a model of fibers and resine

Pyrolysis of the resine

Deposition of a layer on the resine

filling of the fiberstructure with matrix-material out of the gas-phase (C + SiC)

grinding of the surface

Advantages of the CVI

good mechanical properties

well defined resine-matrix-binding is possible

Disadvantages of CVI

long processing-time
high costs
high porosity
preparation of complex geometries with thick walls is impossible

Liquid Polymer Infiltration (LPI)

Infiltration of a polymer by wrapping or cloth infiltration or pressure

hardening of the polymer

Production of a ceramic by pyrolysis

if the porosity is to high: reinfiltration with polymer and additional pyrolysis

advantages of LPI

preparation of large complex components

the desired porosity may be prepared

preparable fiber-matrix-connection
Disadvantages of the LPI

high cost by reinfiltration

infiltration of two- or threedimensional structures is difficult

relative low ceramic-output

Liquid Silicon Infiltration (LSI)

Preparation of a model

hardening of the resine

tempering (heat treatment)

Pyrolysis

Infiltration of liquid silicon

Advantages of Liquid Silicon Infiltration

the material is a short time in the furnace (one shot process)

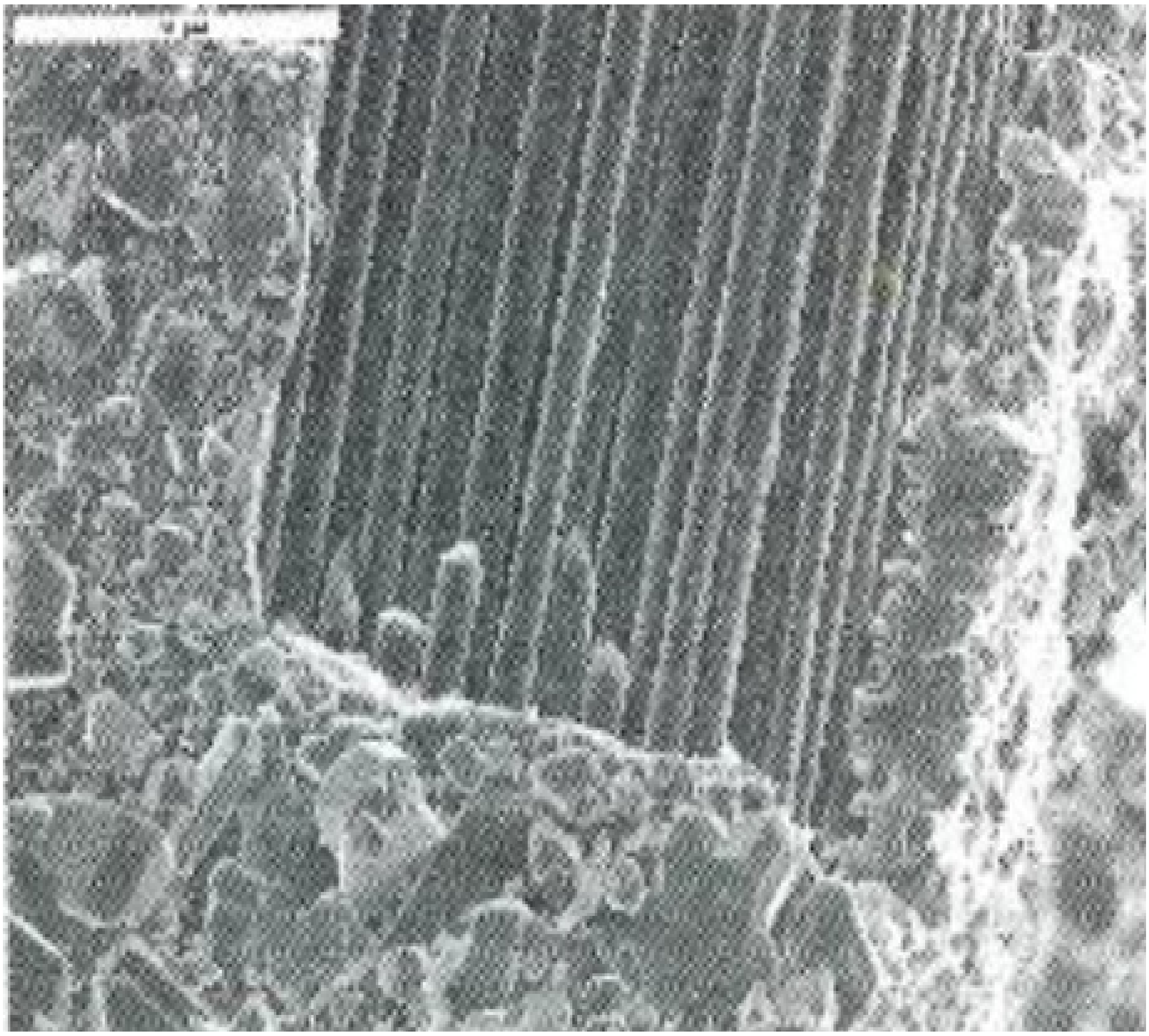
lower costs in comparison with LPI and CVI

the material will be received nearly in the same dimensions as it is prepared

Disadvantages of Liquid Silicon Infiltation

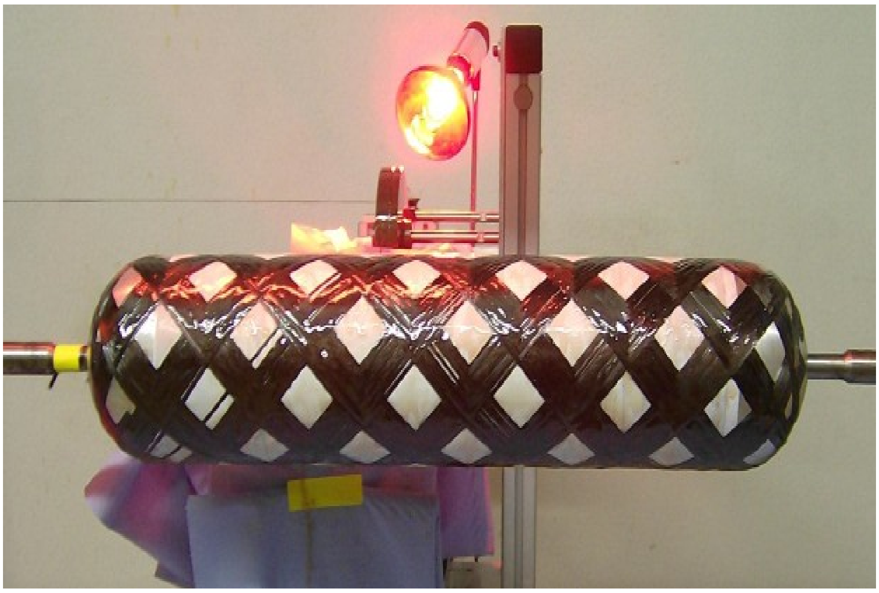
Reaction with silicon is depending on the porosity of the C/C-Material

Embedding of Fibers in Siliconcarbide



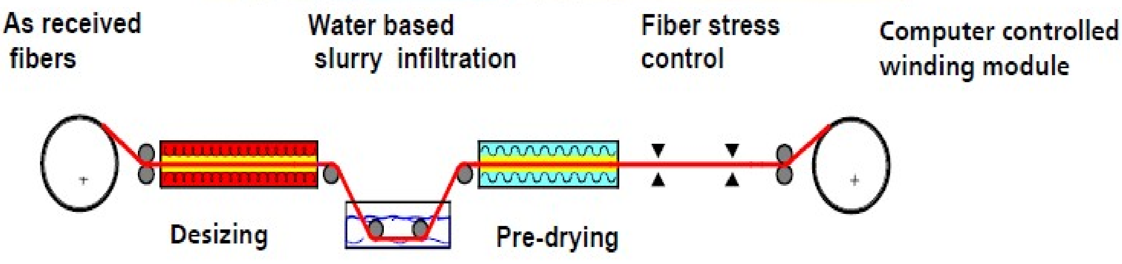
Fibers embedded in a SiC-Matrix

Using wrapping techniques for better mechanical stability of the material



Sample of wrapped fibers

Development of wrapping techniques for fibers



Comparison of heat and corrosion resistant materials
which are mainly used in aviation and space techniques

		RT	1000°C	
Inconel alloy 600	0,20%	~350MPa	~80MPa	
Ni-Co-Cr-Fe	UTS	~700MPa	~50MPa	
Inconel alloy 617	0,20%	~350MPa	~90MPa	
Ni-Cr-Co-Mo	UTS	~730MPa	~70MPa	
Inconel alloy HX	UTS	ca. 1200MPa	ca. 50MPa	
Ni-Cr-Fe-Mo				
Nimonic 75		UTS	ca. 100MPa	
Nimonic 86	0,20%	440MPa	45MPa	1050°C
Ni-Cr-Mo	UTS	875MPa	100MPa	
Nimonic 263	0,20%	585 MPa	70MPa	
Ni-Co-Cr-Mo	UTS	1004 MPa	108 MPa	
Haynes H188	0,20%	470 MPa	185MPa	980°C
Co-Ni-Cr-W	UTS	985 MPa	265 MPa	
	0,20%		88MPa	1095°C
	UTS		145 MPa	
Haynes H230	0,20%	375 MPa	125MPa	982°C
Ni-Cr-W-Mo	UTS	840 MPa	172 MPa	
	0,20%		69MPa	
	UTS		90 MPa	1093°C
C1023	0,20%	860 MPa	215 MPa	
	UTS	1010 MPa	400 MPa	

Zugfestigkeiten metallischer Brennkammerwerkstoffe

Zugfestigkeiten von WHIPOX CMCs

	0|90° MPa	+/-45° MPa
RT	110	70
1000°C	90	50

Dichte:

Hayens H188 = 8,9 g/cm^3
WHIPOX = 2,9 g/cm^3

Characteristics of WHIPOX

Material is not britteling. It is thermoshock-resistant

Characteristics of the material in dependance of the wrapping angel

Fiber Direction	0°/90°	± 45°
Tensile Strength [MPa]	110	70
Bending Strength [MPa] (60 mm Span)	200	190
In-Plane Strength [MPa] (un-notched)	220	200
In Plane Strength [MPa] (notched)	165	170
Elastic Modulus [GPa]	115	110
Inter-laminar Shear Strength [MPa]	12	12

This composition of ceramic matrix components and their characteristic will be compled in the future.