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High temperature oxidation of a 2D SiC/C_f coated by SiC deposited by CVD: effect on mechanical properties

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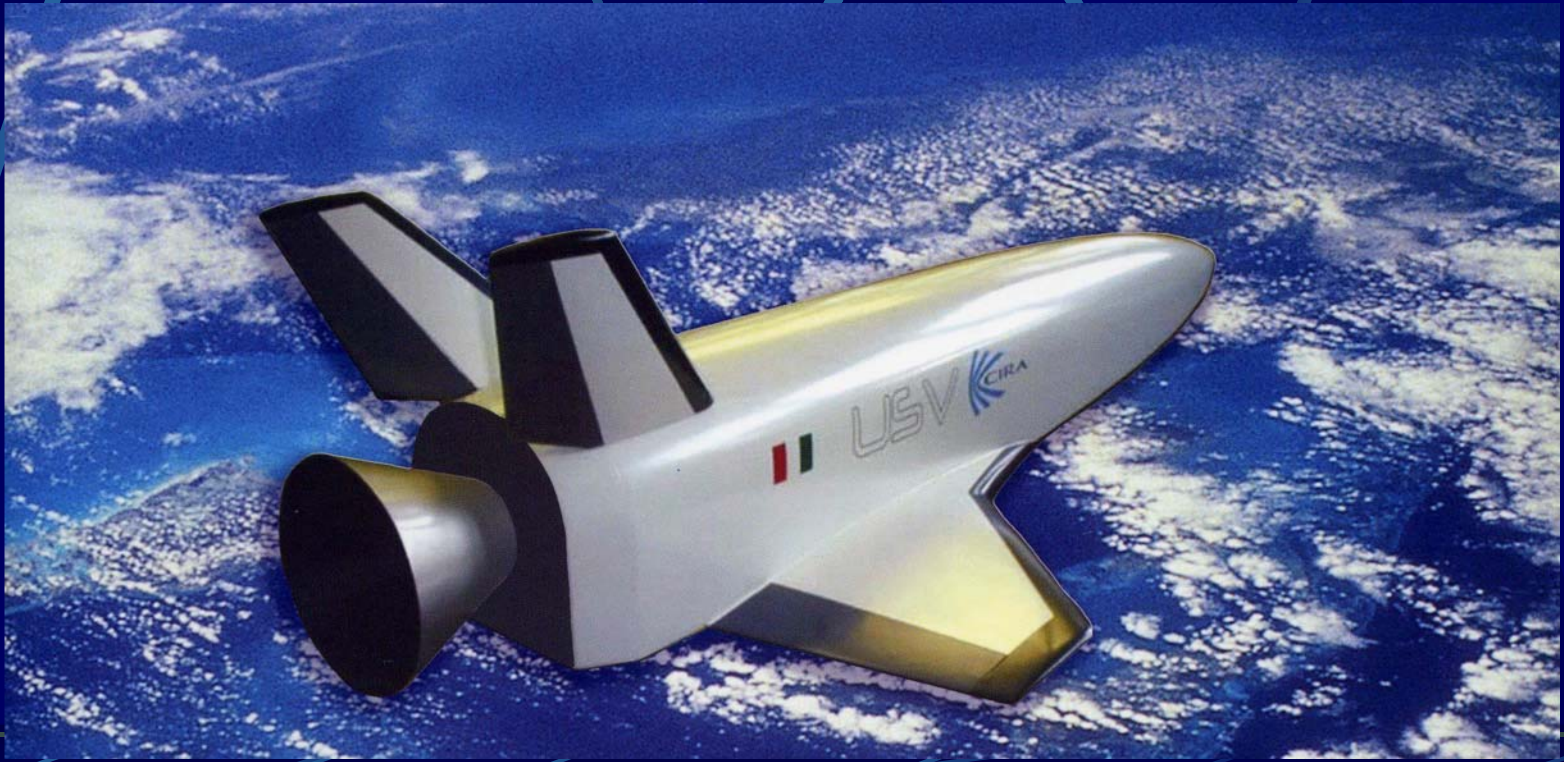
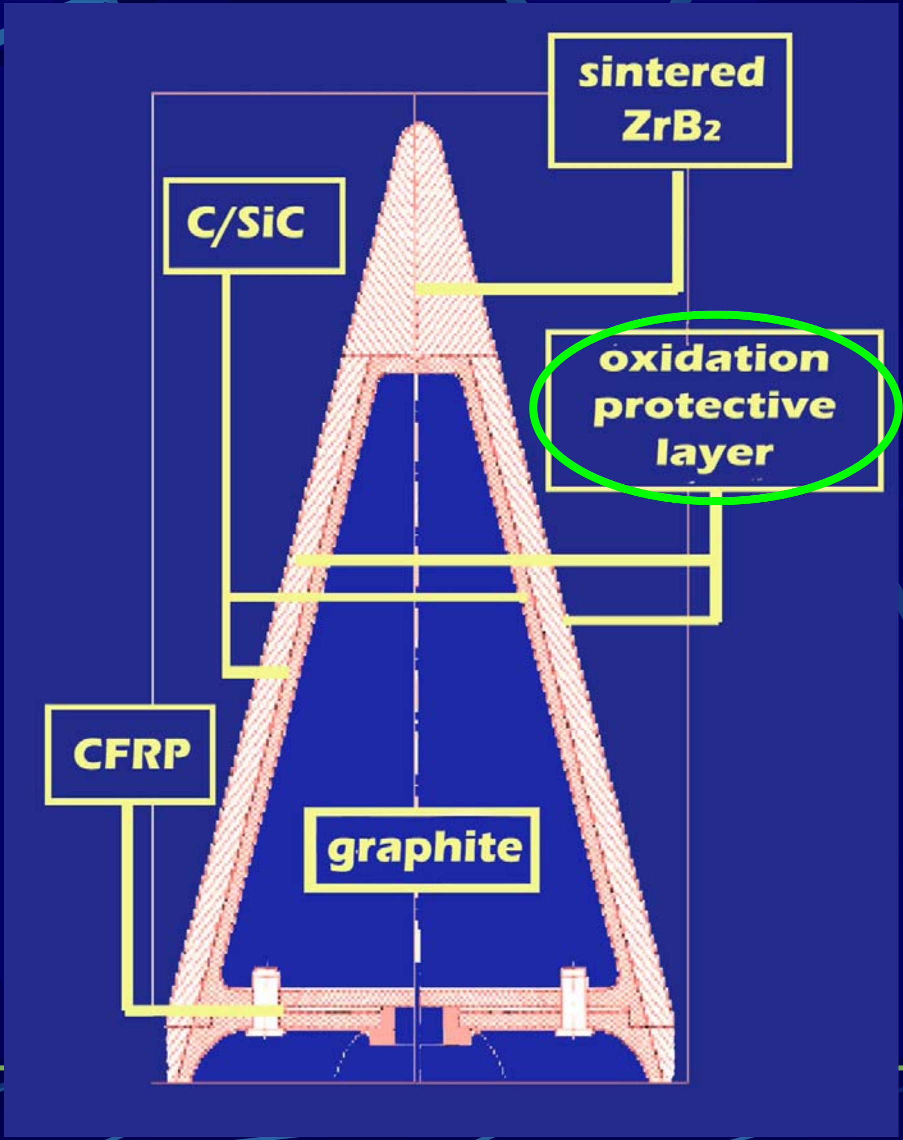
Introduction

Application → **Nose for USV** (Unmanned Space Vehicle)



Nose scheme


sintered
ZrB_2
C/SiC
oxidation
protective
layer
CFRP
graphite

Outline of the presentation

Preparation of C/SiC composite (by PIP)

Composite characterization

Oxidation behaviour

Effect of coating on oxidation behaviour

Composite preparation

Produced by FN S.p.A. Nuove Tecnologie e Servizi Avanzati with the **PIP (Polymer Infiltration Pyrolysis)** technique

main phases:

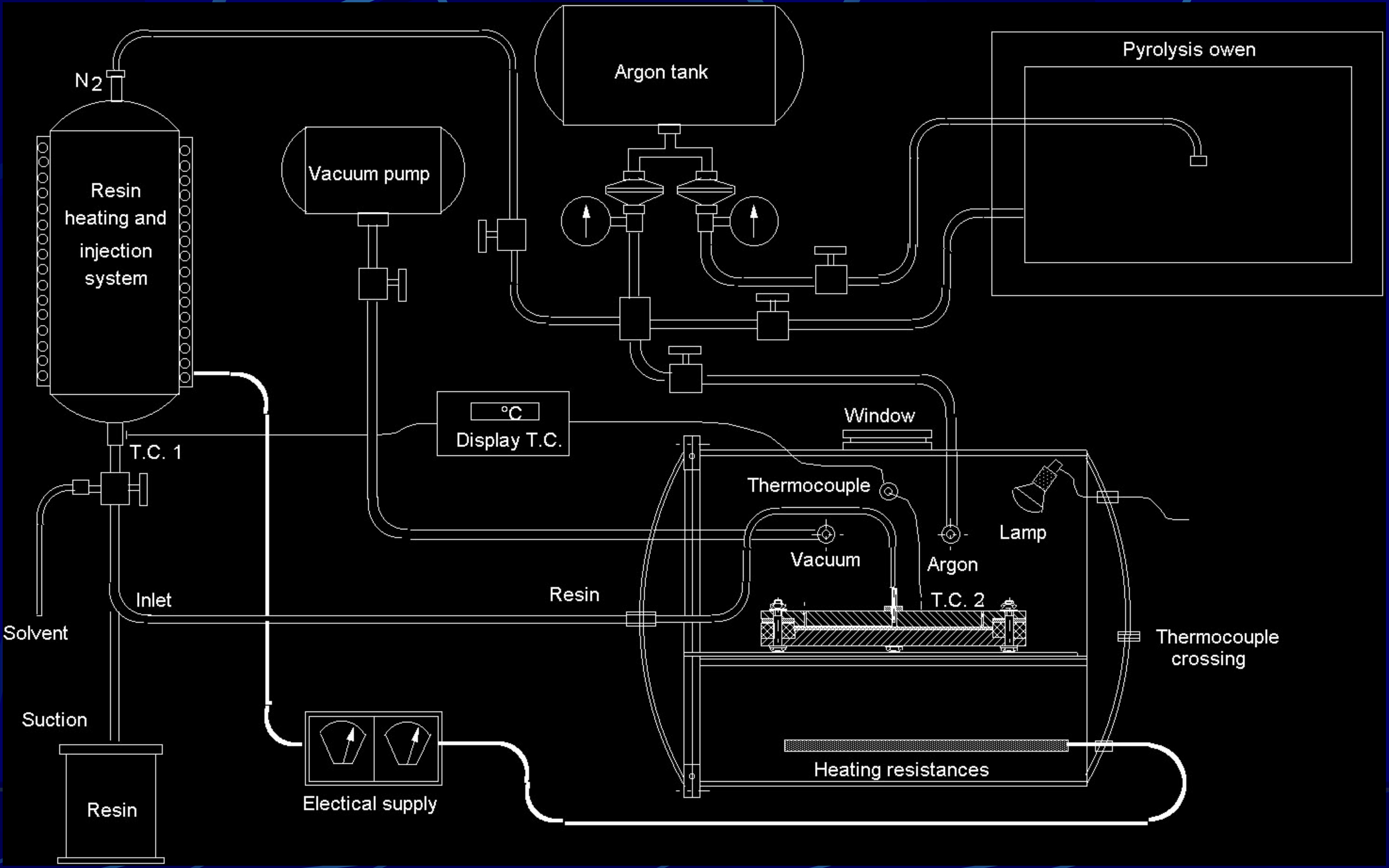
Stacking of carbon fibres (modulus 230 GPa, strength 3.5 GPa)

Deposition of a carbon layer by CVD

Cycles of infiltration with SiC precursor and pyrolysis up to 1000 °C

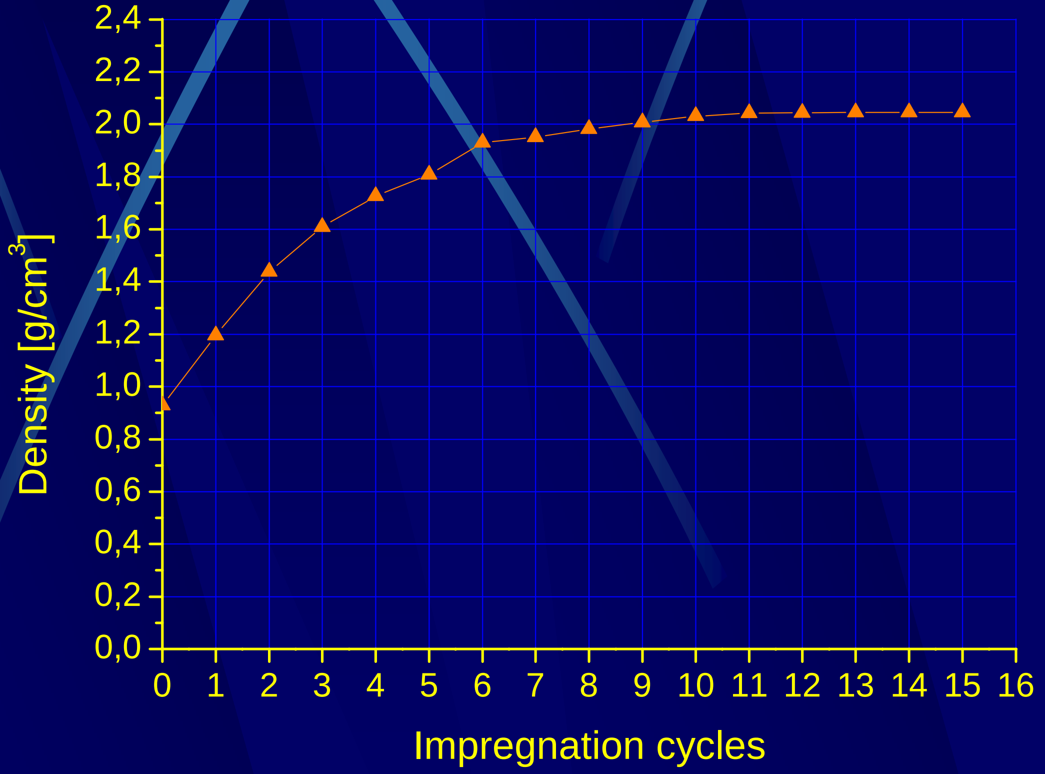
Deposition of SiC protective layer by CVD (on coated samples)

Polymer Infiltration Pyrolysis



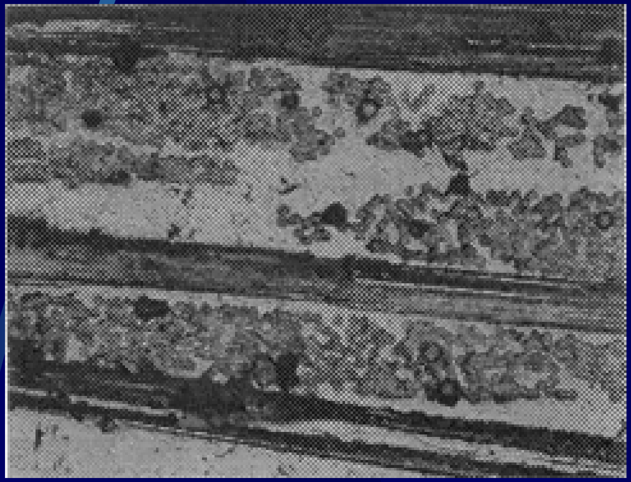
Impregnation cycles

After 11-12 impregnation cycles the density has reached its maximum value.



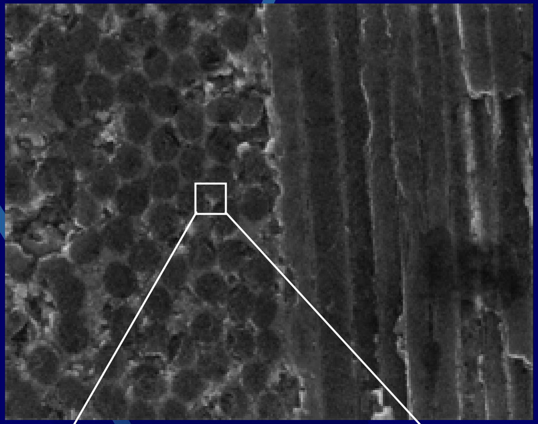
Composite aspect

Some images of the C/SiC composite



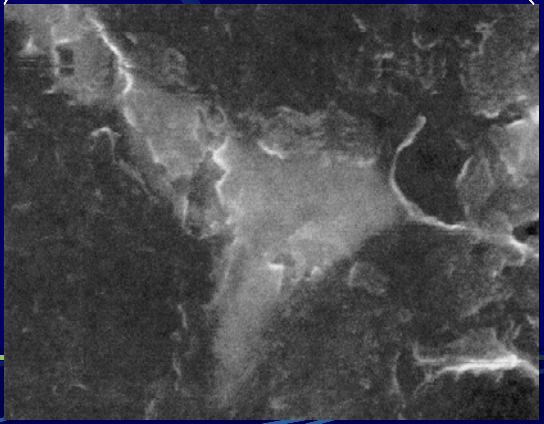
100 x

Optical microscope



400 x

SEM



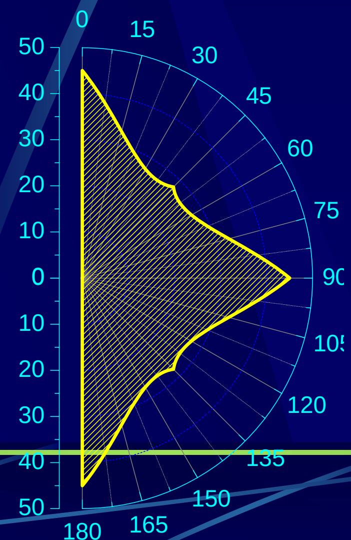
20000 x

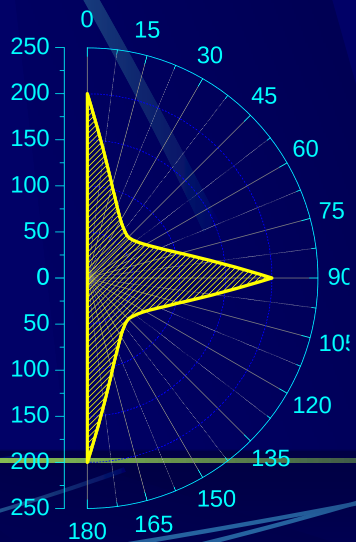
Composite mechanical characterization

Temperature [°C]	E (tensile) [GPa]	E (GrindoSonic) [GPa]	Tensile strength [MPa]	Bending strength [MPa]
25	45	57	200	315
800	50		170	
1200	39		158	

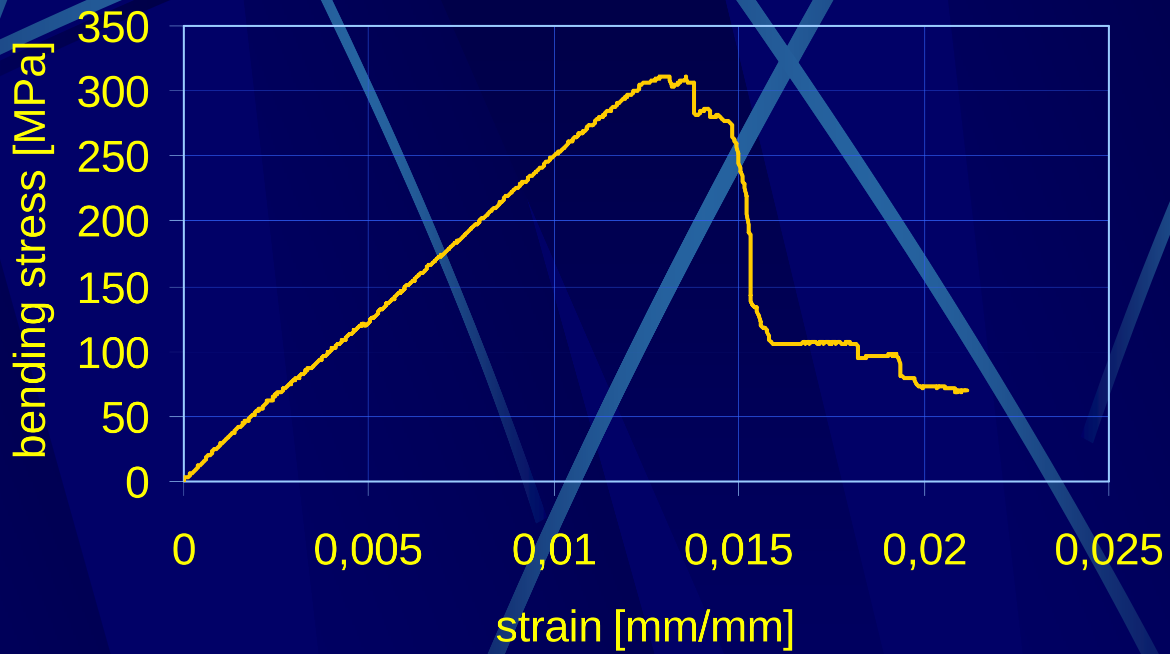
Composite characterization

orientation [°]	Tensile modulus [GPa]	Tensile strength [MPa]
0 / 90	45	200
15 / 75	35	112
30 / 60	24	66
45	28	63





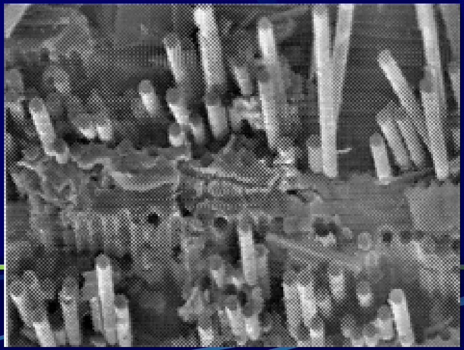
Composite characterization



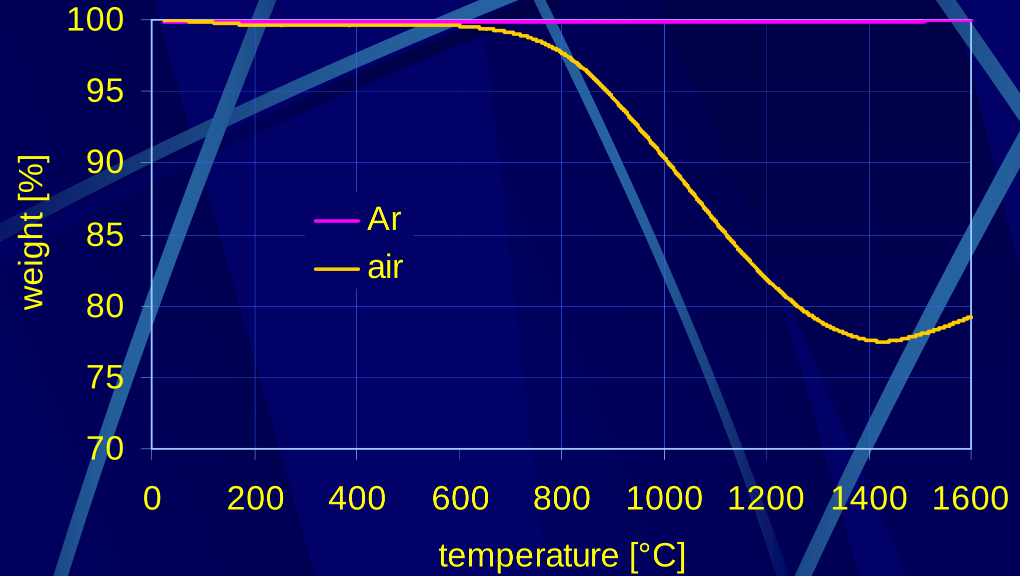
fracture surfaces

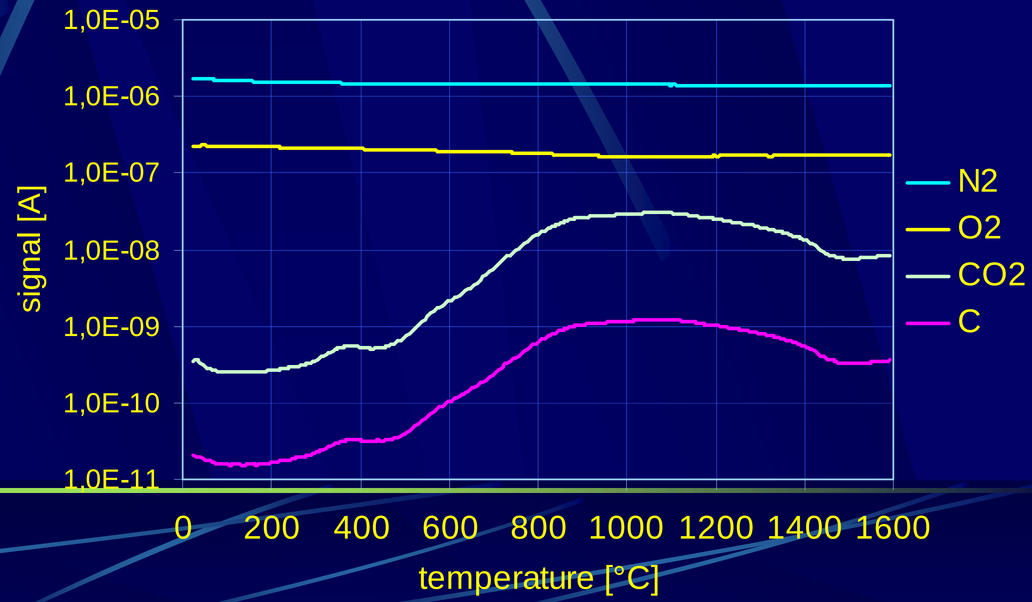
100 x

400 x



Oxidation: TGA/MS on uncoated composite





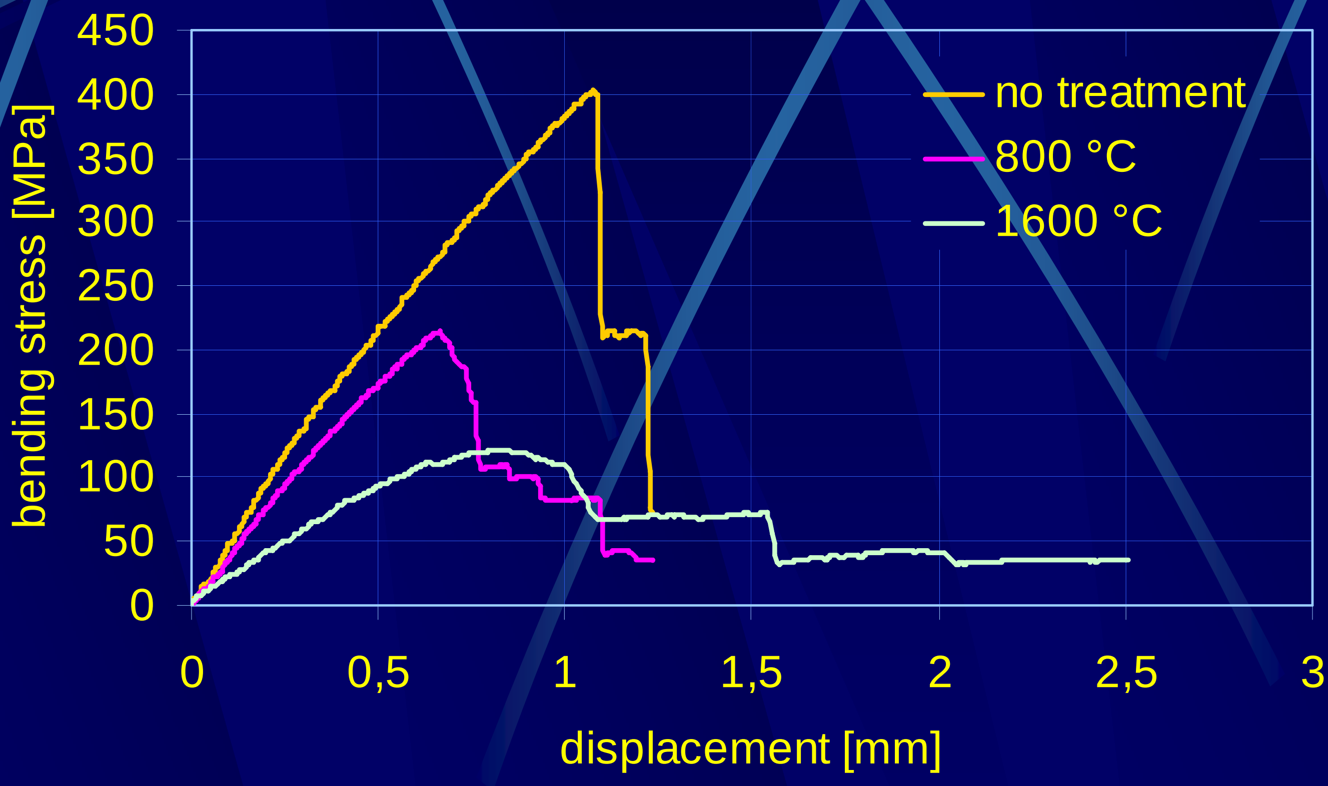
Oxidation treatment: modalities

Heat treatment at: **800** °C for 15 min
1600 °C for 15 min

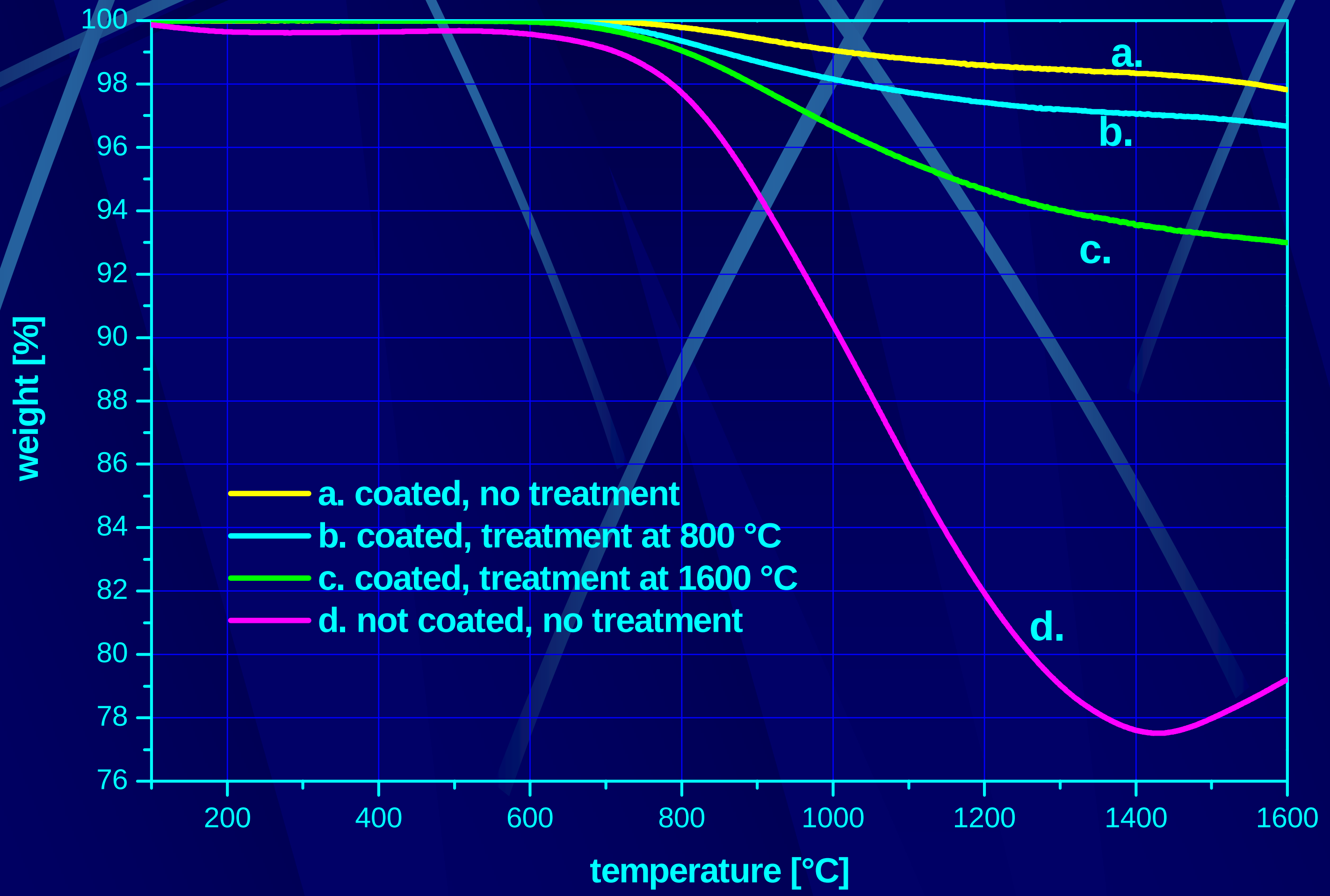
Atmosphere: **air**

Very **fast heating** and **cooling** rate

Oxidation: effect on mechanical properties for uncoated composite



Effect of Coating: TGA



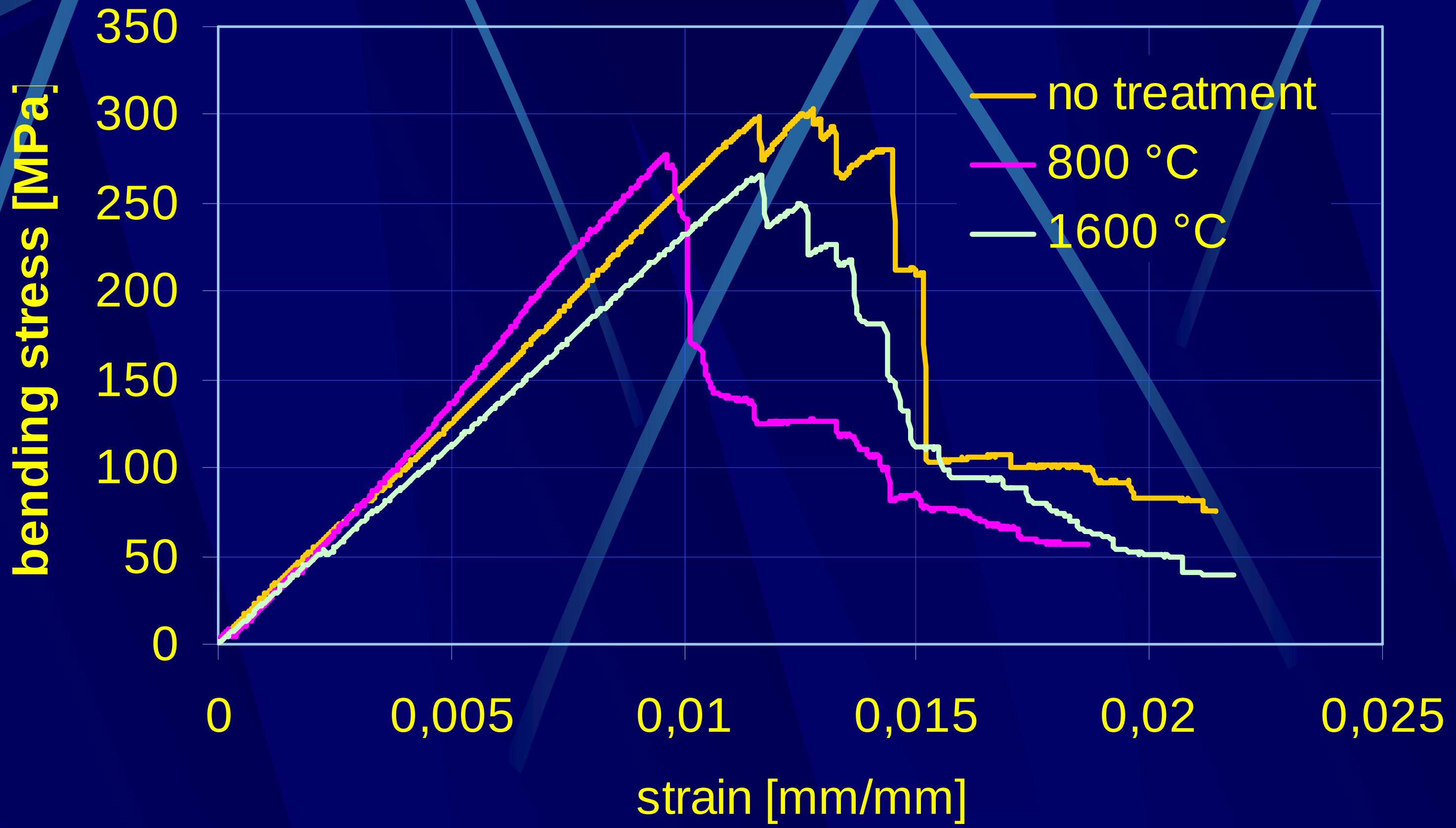
Effect of Coating: physical properties

Property	Change [%] upon oxidation UNCOATED		Change [%] upon oxidation COATED	
	800 °C	1600 °C	800 °C	1600 °C
Density	-0.5	-5.9	-0.2	-1.7
Hydrostatic density	+5.3	+7.8	+1.9	+1.4
CTE 200-1100 °C (parallel)	-11	-29	-11	-5.3

Effect of Coating: mechanical properties

Property	Change [%] upon oxidation UNCOATED		Change [%] upon oxidation COATED	
	800 °C	1600 °C	800 °C	1600 °C
Tensile strength	-	-	-20.8	-19.2
Young's modulus	-1.9	-49.3	-3.3	-8.0
Bending strength	-32.3	-61.3	-20.2	-26.1

Oxidation: effect on mechanical properties for coated composite



Conclusions

- Application: Nose of the USV (Unmanned Space Vehicle)
- Material: C/SiC composite
- Preparation technique: PIP (Polymer Impregnation Pyrolysis)
- SiC coating deposited by CVD
- Without coating the properties loss on heating is very high, due to oxidation of SiC and burning of carbon
- The SiC coating reduces properties loss, however after a heat cycle there is some damage → not fully satisfactory

Future investigations

- Other types of coating for the C/SiC composite
- Characterization after repeated thermal cycles
- Analysis of materials after prototype flights
- Scaling up of the structure
- Fly…

Prototypal Nose