Scuola universitaria professionale
della Svizzera italiana
SUPSI

CELLMAT 2010

Si-SiC Reticulated Foams for High Temperature Applications

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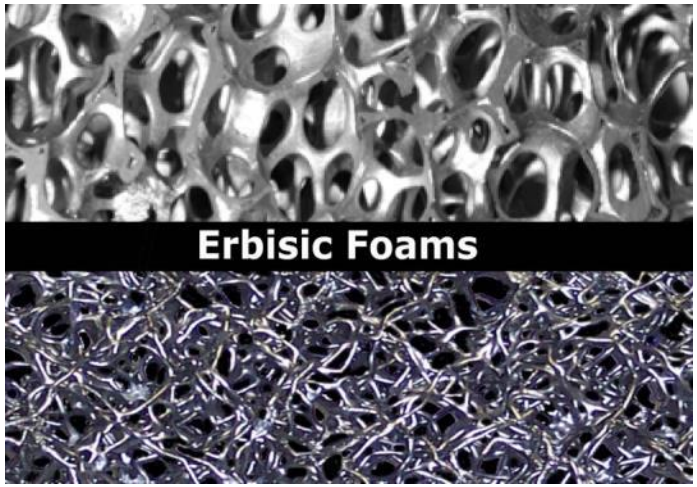
Erbicol SA - ***Porous Ceramics Department***

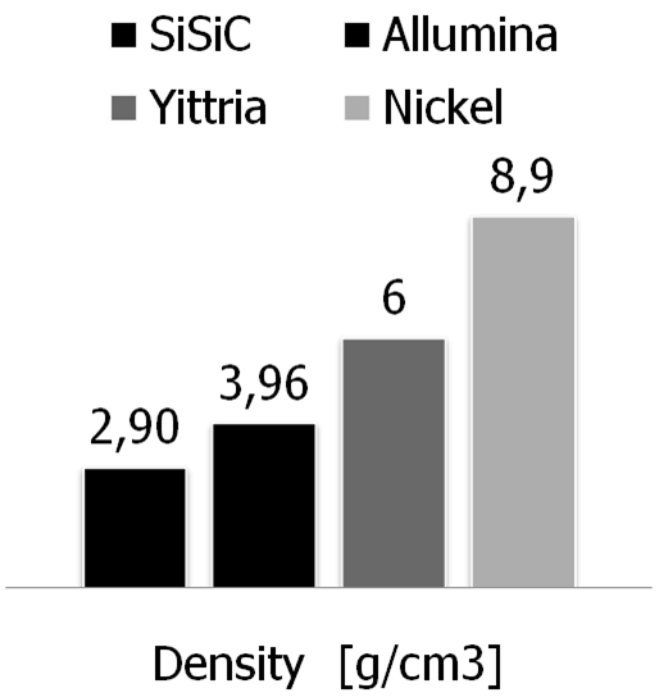


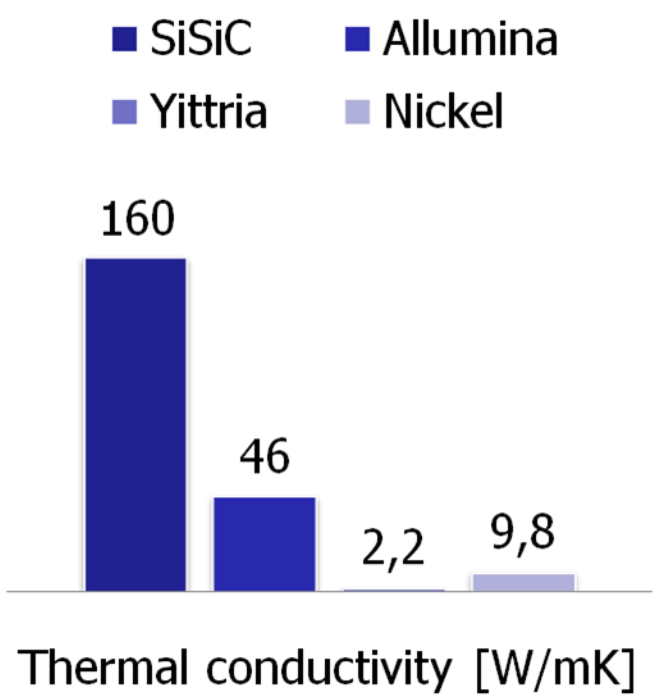
- Foam architecture (pore size and shape)
- Foam geometry for different applications

- Material properties at elevetad temperature
- Foam emissivity at high temperature

Properties

Properties - *Material*

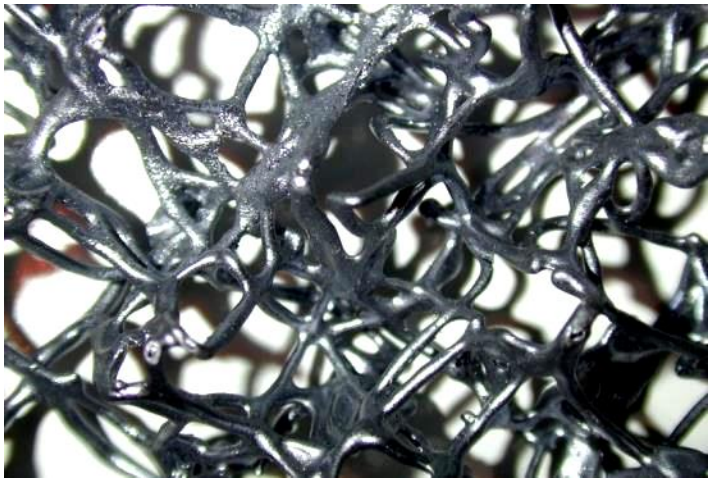




Properties – *Foam architecture*

Reticulated Foam (ErbiSiC R)

- Macroporosity: 87%
- Pore per inch (PPI) range: 10-30 ppi
- Low pressure drop

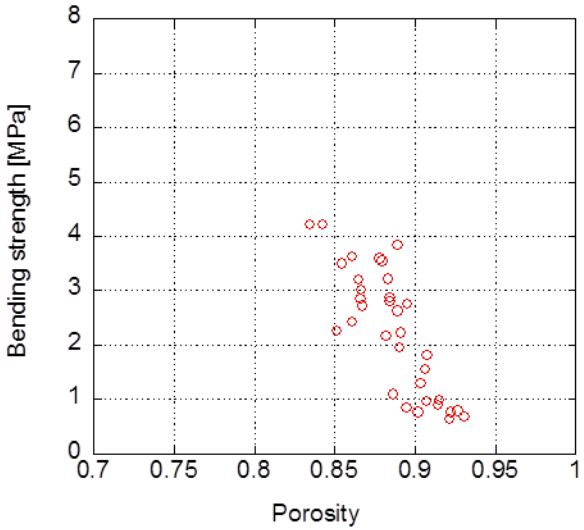


Filamentous structure (ErbiSiC F)

- Macroporosity: 60-95%
- Custum made structure
- Low pressure drop

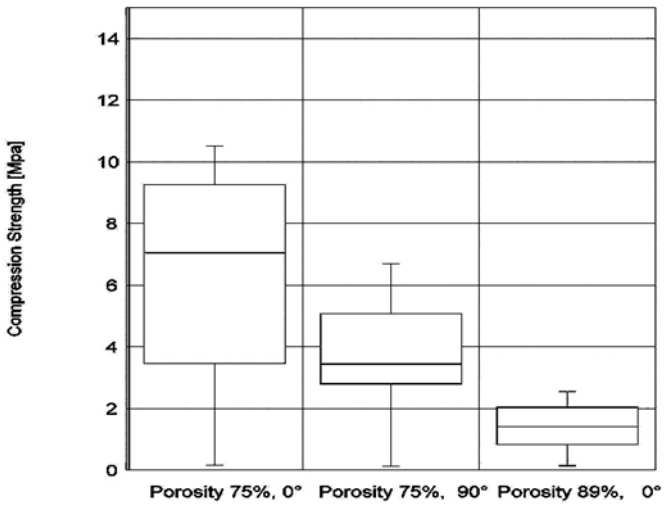
Properties - *Mechanical*

Bending strength



- ~ 3 MPa for a standard 10 ppi foam

Compression strength

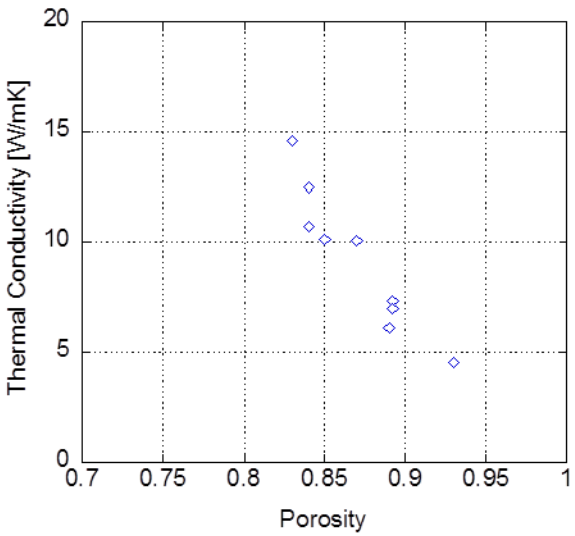


- ~ 2 MPa for a standard 10 ppi foam

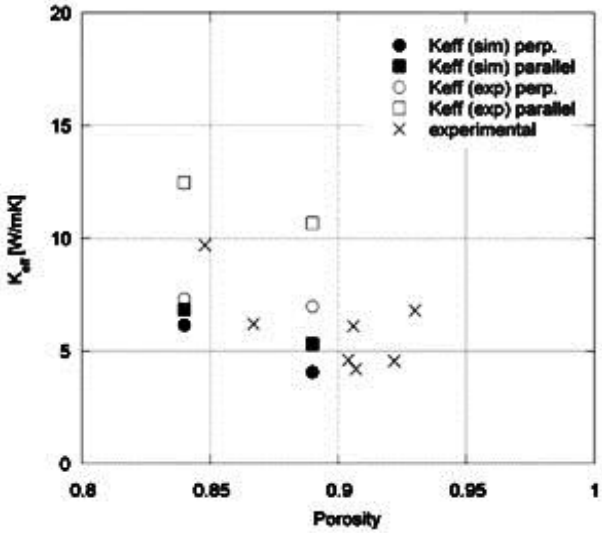
ASTM C1674 - 08 Standard Test Method for Flexural Strength of Advanced Ceramics with Engineered Porosity (Honeycomb Cellular Channels) at Ambient Temperatures

Properties – *Thermal*

Thermal conductivity



Thermal conductivity

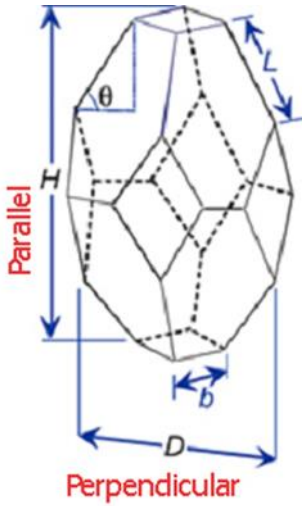


- ~ 10 W/mK for a standard 10 ppi foam

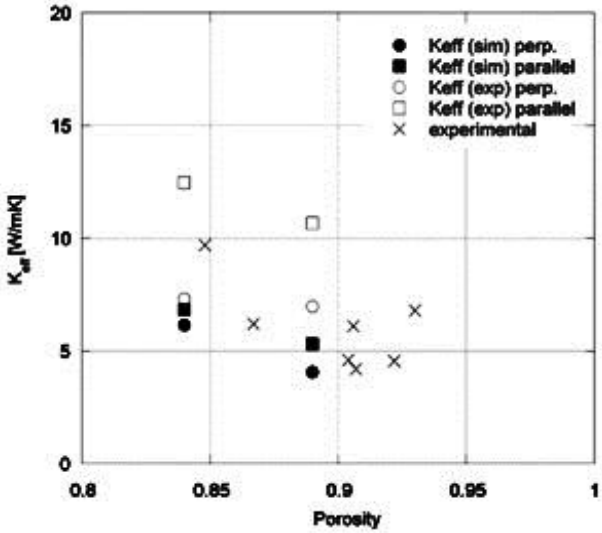
- Anisotropy of thermal conductivity

A. Ortona, S. Pusterla, S. Valton" Reticulated SiC foam X-ray CT, meshing, and simulation" Advances in Bioceramics and Porous Ceramics III, Ceramic Engineering and Science Proceedings, Roger Narayan and Paolo Colombo, Editors, Wiley, 2011.

Properties – *Thermal*



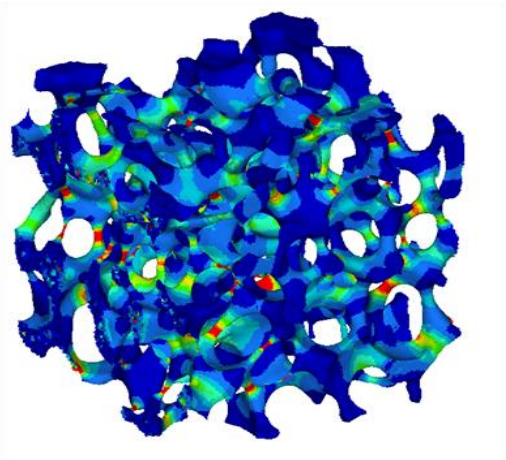
Thermal conductivity



Material → **Porosity** → **Cell orientation** → **Strut geometry**

A. Ortona, S. Pusterla, S. Valton" Reticulated SiC foam X-ray CT, meshing, and simulation" Advances in Bioceramics and Porous Ceramics III, Ceramic Engineering and Science Proceedings, Roger Narayan and Paolo Colombo, Editors, Wiley, 2011.

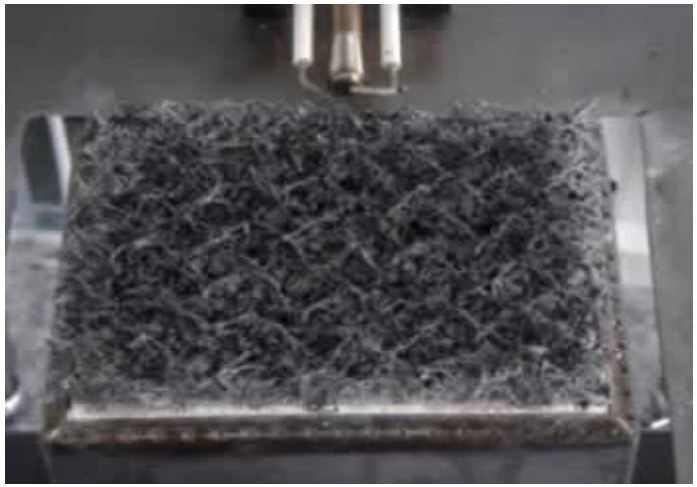
Properties – *Simulations*



X-ray micro-CT ⇨ Image processing ⇨ Meshing ⇨ Mesh conditioning ➡ **Simulations**

Porous burners

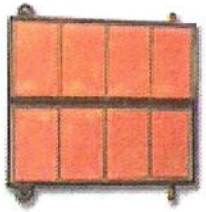
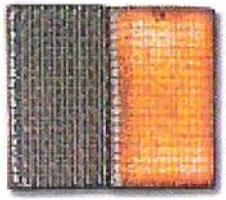
Porous burners



- Material operating temperature 1400°C
- IR-emissivity at high temperature
- Thermal shock resistance

- Lower gas consumption
- Low NO_x – Emission
- Low CO_2 - Emission

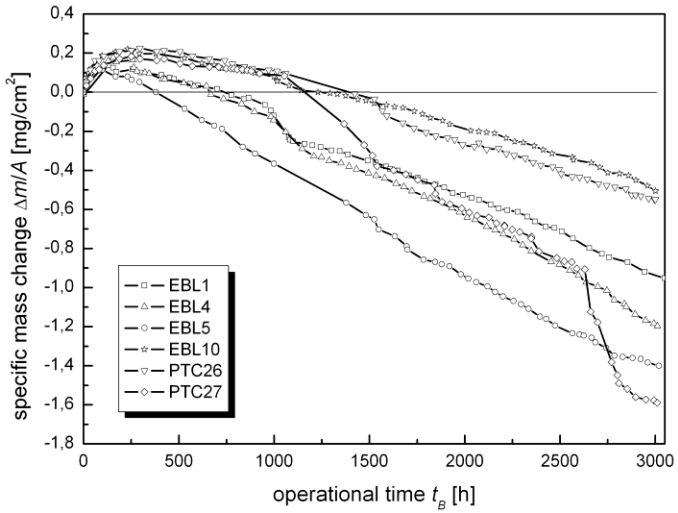
Porous burners

					
Typ	**Katalytstrahler**	**Keramikstrahler**	**Metallfaserstrahler** gestrickte Oberfläche	**Metallfaserstrahler** gesinterte Oberfläche	**Porenstrahler**
Art	Langwelliger Strahler	Mittelwelliger Strahler	Mittelwelliger Strahler	Mittelwelliger Strahler	Kurzwelliger Strahler
Wellenlänge	3,3 - 5 µm	2,4 µm	2,2 µm	2,2 µm	1,7 µm
Max. Strahlertemperatur	600 °C	950 °C	1050 °C	1050 °C	1450 °C
Max. thermische Flächenbelastung	30 kW/m²	120 kW/m²	200 kW/m²	250 kW/m²	1000 kW/m²

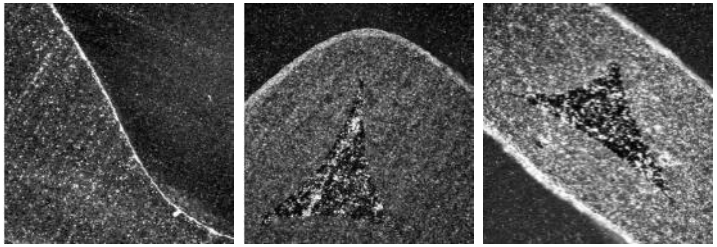
Life span ?

Porous burners

Mass evolution



Passive oxidation layer



As produced | After 100h | After 1000h

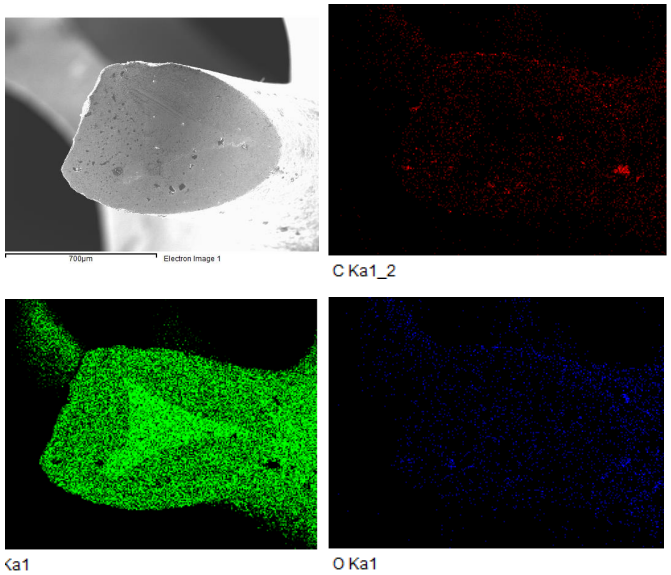
Mass gain ⇒ passive oxidation

Mass loss ⇒ active oxidation and spalling

R. A. Mach, F. v. Issendorff, A. Delgado A. Ortona, Experimental investigation of the oxidation behavior of Si-SiC-foams Advances in Bioceramics and Porous Ceramics: Ceramic Engineering and Science Proceedings, Volume 29, Issue 7, 299-311, 2009, WILEY

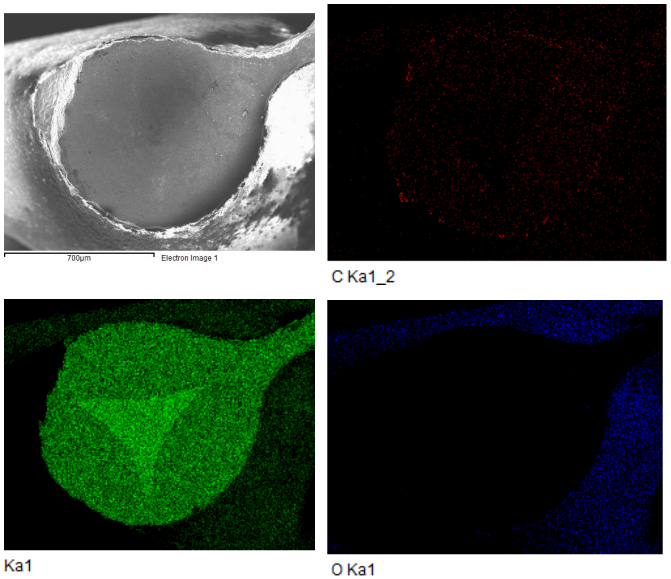
Porous burners

SEM – EDS Analysis



- Untreated sample

SEM – EDS Analysis

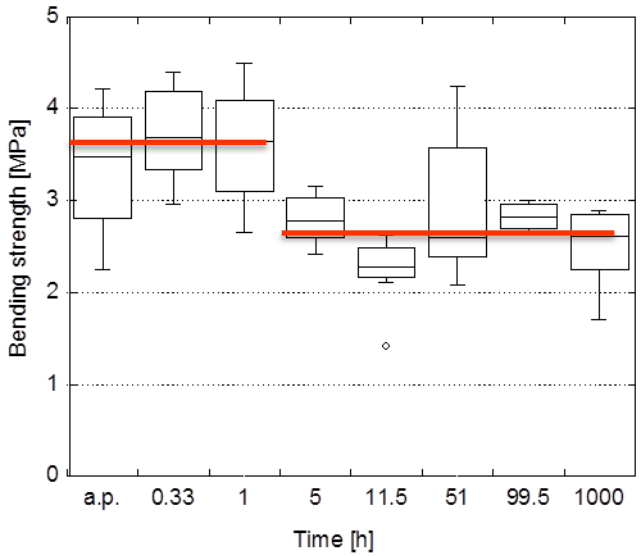


- Sample after 1000 hours

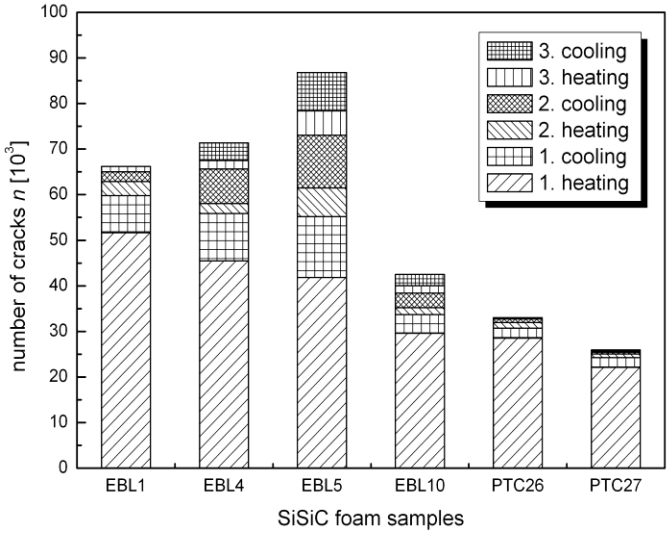
R. A. Mach, F. v. Issendorff, A. Delgado A. Ortona, Experimental investigation of the oxidation behavior of Si-SiC-foams Advances in Bioceramics and Porous Ceramics: Ceramic Engineering and Science Proceedings, Volume 29, Issue 7, 299-311, 2009, WILEY

Porous burners

Bending strength



Number of cracks



- Decrease in first hours
- Almost constant thereafter

- First three ON/OFF cycles
- Crack formation decreases drastically

R. A. Mach, F. v. Issendorff, A. Delgado A. Ortona, Experimental investigation of the oxidation behavior of Si-SiC-foams Advances in Bioceramics and Porous Ceramics: Ceramic Engineering and Science Proceedings, Volume 29, Issue 7, 299-311, 2009, WILEY

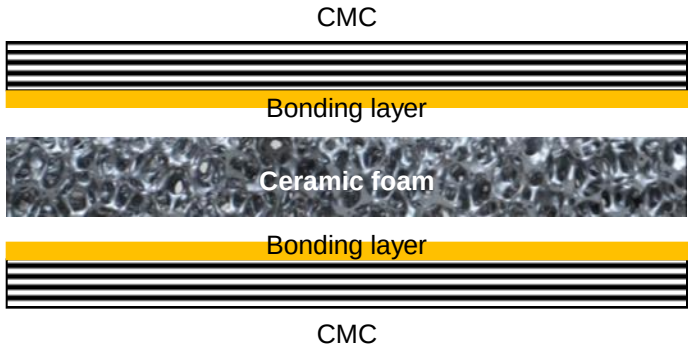
Porous burners

Long time behaviour → **Look at first hours**

- Silica layer formation
- Maximal crack formation during first operation hours
- Mechanical strength decreases 30% during the very first hours of operation

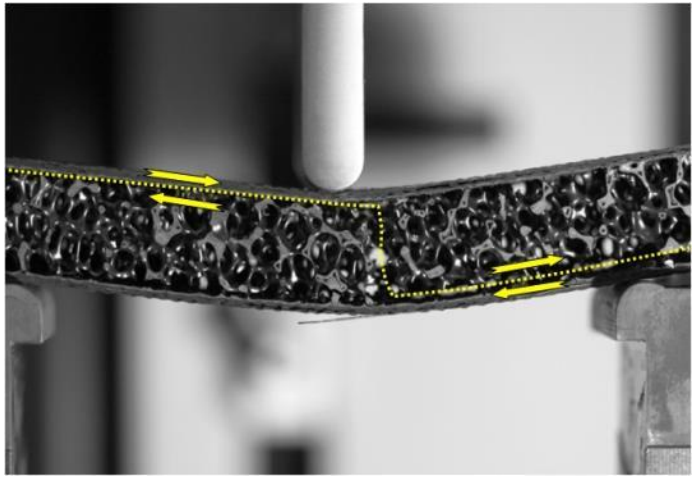
Structural applications

Structural applications



Alberto Ortona, Simone Pusterla, Sandro Gianella "Cf/SiCm CMC - SiC foam sandwich preparation and characterization"
Conference proceedings HTCMC7, Sept. 20-22 Bayreuth (D), 2010

Structural applications



- After foam failure, the sandwich was still bearing loads
- SiC skins

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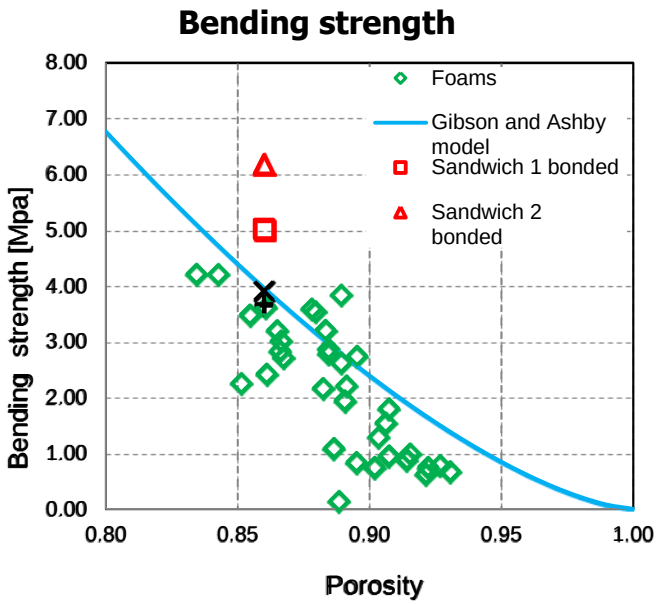
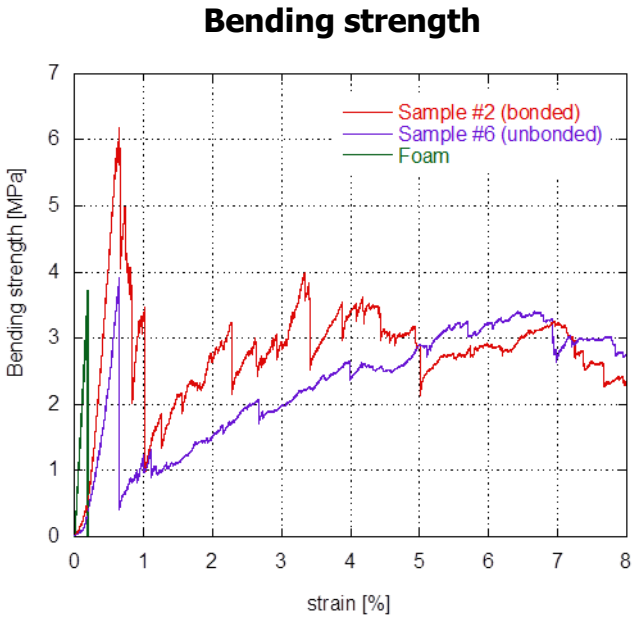
Structural applications





Bonded foam sandwich show a bending strength increase (36-67%)

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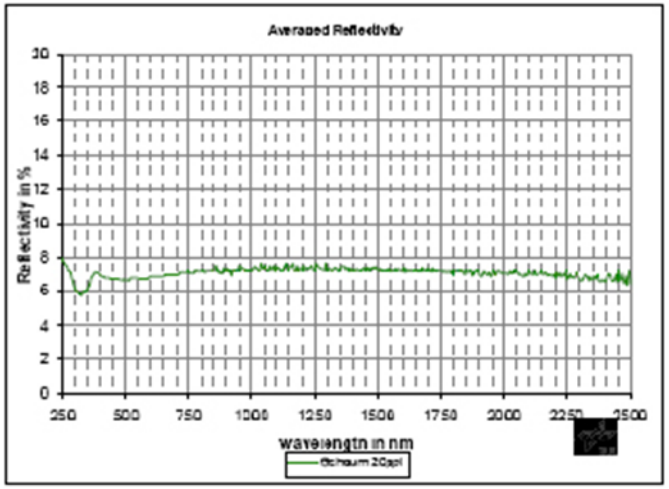
Solar radiation absorbers

Solar radiation absorbers

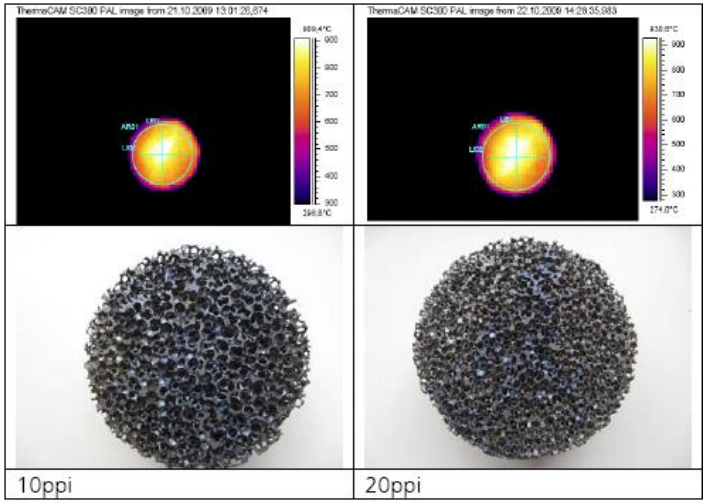
- Solar radiation absorbers
- Hydrogen production - H_2SO_4 cycle
- Solar steam reforming

Solar radiation absorbers

Reflectivity



IR-Camera analysis



- ~ 93% absorption

- High temperature stability
- 3-D flow characteristics

Avizo

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