

HELM – FINAL REPORT – Figures and Tables

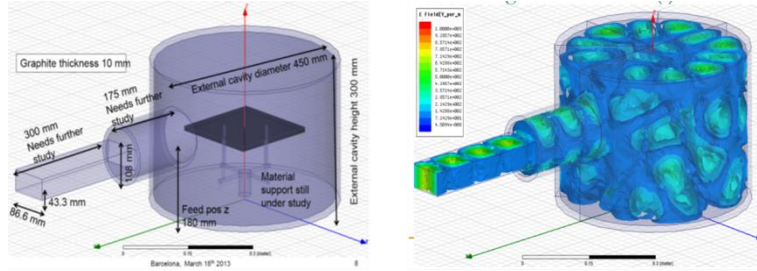


Fig. 1: design of MW-CVI plant: dimension of MW and CVI parts(a) and field homogeneity (b)



Fig. 2: assembly in ATL facilities (UK)

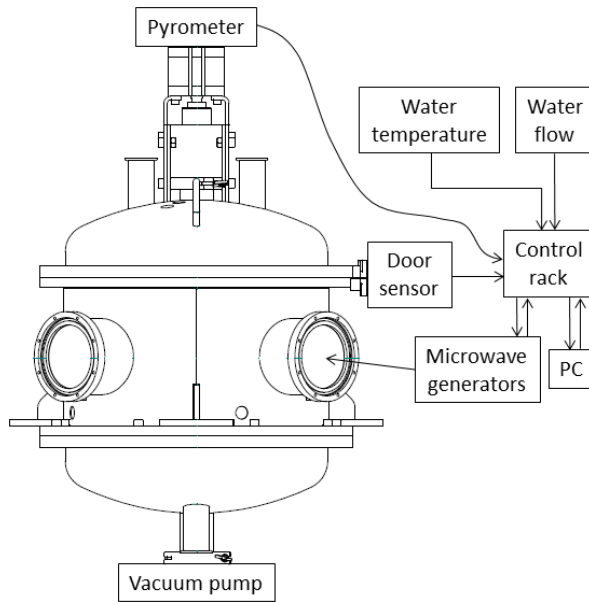


Fig. 3: Scheme of the microwave furnace

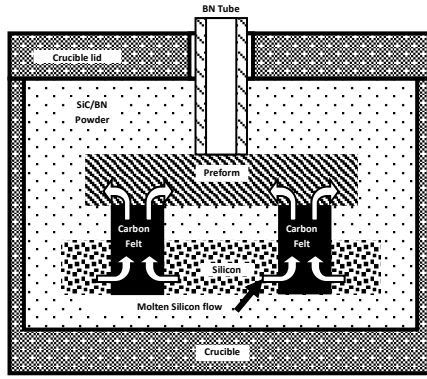


Fig. 4: Infiltration set-up representation.

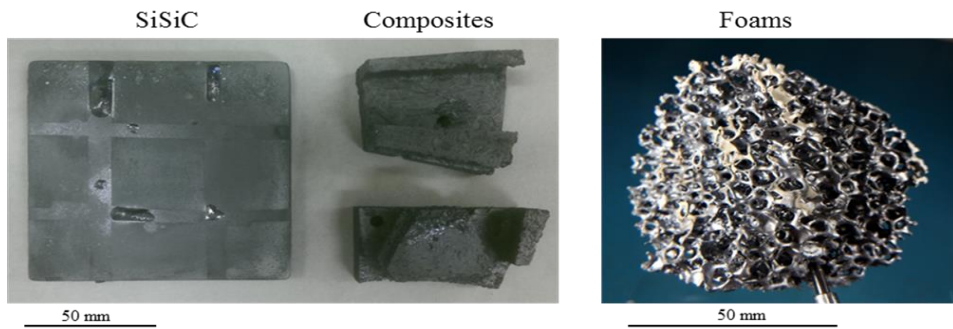


Fig. 5: Samples produced by MW RSI. A Si SiC ceramic antiballistic plate (Petroceramics), Parts of a Si SiC composite for brake disks (BSCCB) and a Si SiC foam (Erbicol).

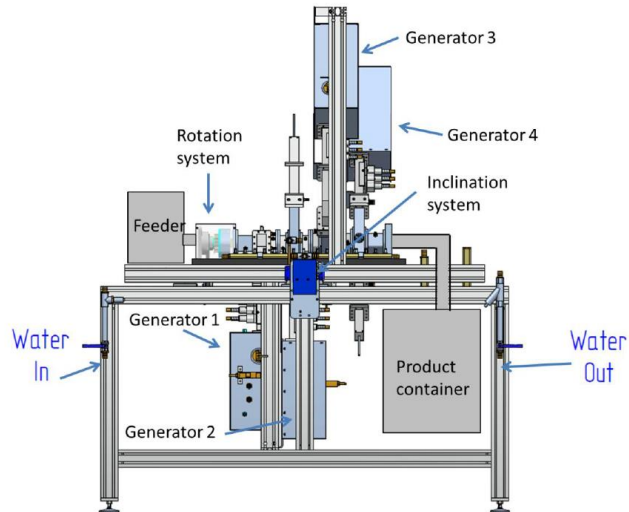


Fig. 6: 3D and lateral view of the MW furnace including the main components



Fig. 7: MW-CVI plant assembled and tested in Pisa



Fig. 8: SiC Nicalon fabric (left), hand-made preform (center) and infiltrated preform (right)



Fig. 9. Assembled MW-furnace for LSI of SiC foams.

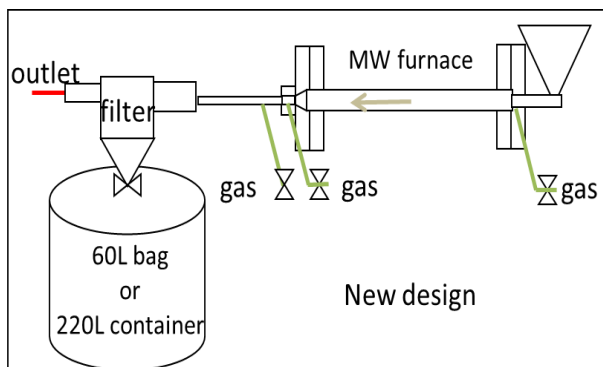


Fig. 10: Scheme of the new design of the MW furnace for GE and picture of the final set-up

	Overall Carbon footprint	Relative Carbon footprint	LCC (energy included)
	kg CO2	kg CO2/kg	€/kg
MW ind CVI	4.169	2,20	104,70 €
MW ind LSI	5.730	0,76	42,04 €
MW ind GE	3.804	0,30	19,09 €
MW ind PIP	975	0,11	15,20 €

Table 1: MW industrial Furnace absolute and relative carbon footprint and LCC results.

kg CO2 eq / kg	Conventional	MW Lab scale	MW Industrial scale	Improved scenarios	% vs conventional
CVI process	1161		2226	687	41%
LSI BSCCB process	82	78,2	61,8	42,7	48%
LSI Erbicol process	74		50		32%
GE process	0,7	3,2	1,7	1,1	-57%
PIP process	4,5	6,4	5,5	4,2	7%

Table 2: Carbon footprint assessment for every pillar at every stage of the project.

	Exergy yield			Unit exergy consumption			Unit exergy cost		
	Conv. furnace	MW furnace	Variation	Conv. furnace	MW furnace	Variation	Conv. furnace	MW furnace	Variation
CVI process	0.92%	2.13%	+131.52%	97.3	45.79	-52.94%	114.08	82.19	-27.95%
LSI process (foams)	12.68%	54.40%	+329.02%	6.39	1.73	-72.93%	7.88	1.84	-76.65%
LSI process (antiball.)	14.70%	33.90%	+130.61%	5.21	2.48	-52.40%	5.58	2.97	-46.77%
GE process	83.39%	88.03%	+5.56%	1.16	1.11	-4.31%	1.16	1.11	-4.31%
PIP process	60.22%	63.37%	+5.23%	1.57	1.49	-5.10%	1.66	1.57	-5.42%

Table 3: exergy balances related to the different techniques

Industrial scenarios materials

		Aerospace C/SiC, SiC/SiC	Refractories for steel foundry C/C-SiC, C/SiC, SiC/SiC	Brake disks C/SiC	Antiballistic plates C/SiC	Energy generation SiC foams	Energy storage, etc. Expanded Graphite
Thermal treatments	CVI	HERAKLES	SKT	HERAKLES	PETRO-CERAMICS		
		CVT (r-CVI)					
		AGI					
	high heating rates (LSI like)	AGI	SKT	BSCCB	PETRO-CERAMICS	ERBICOL SKT	IMERYS
	Pyrolysis	AGI	SKT	BSCCB	PETRO-CERAMICS		

Fig. 11: Pillars and industrial applications considered in HELM project

Plants	CVI	LSI and GE	PIP
laboratory	-	1 LSI (new), 1 GE (refurb)	1 PIP (refurb)
pilot	1	2	1
Total per pillar	1	4	2
Total in HELM project	7 (4 pilot plants)		

Table 4: number of plants developed in HELM project

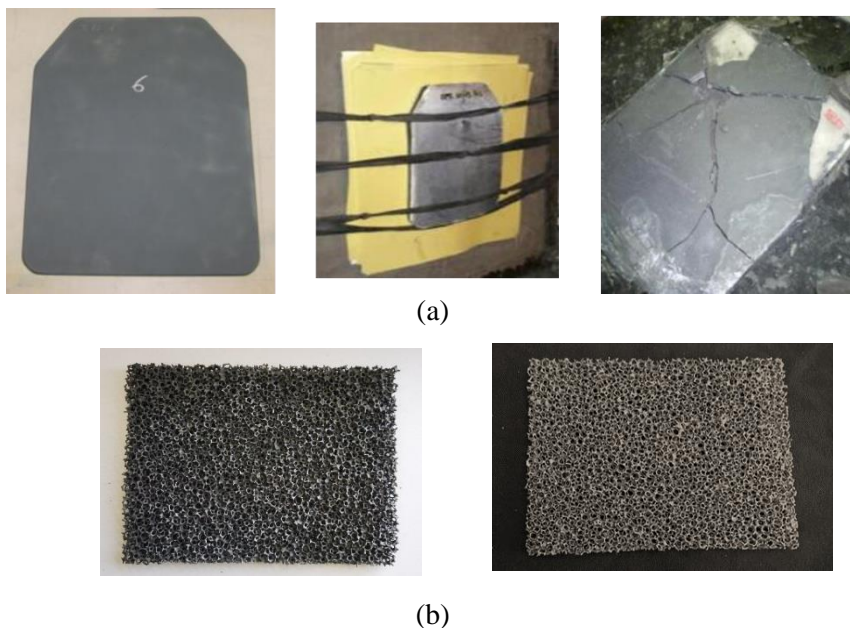


Fig. 12: Demonstration samples of HELM project products : (a) antiballistic plates; (b) SiSiC foams

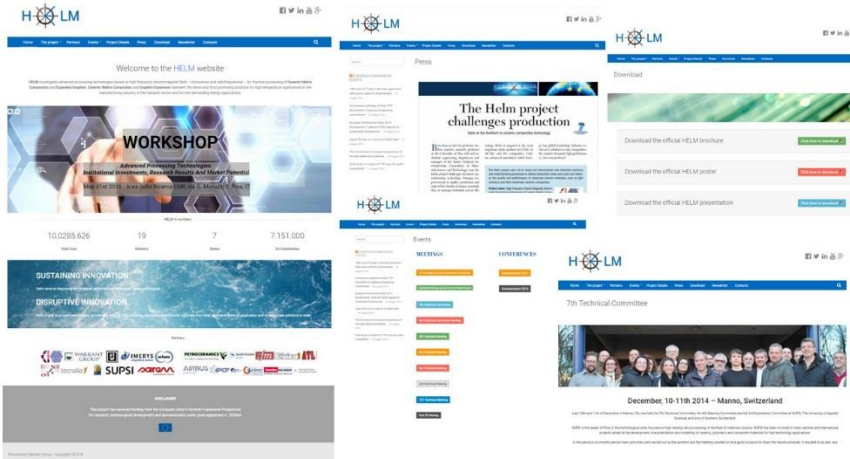


Fig. 13: HELM Website



Fig. 14: HELM Social Media



Fig. 15: HELM Newsletters



Fig. 16: HELM Brochure



Fig. 17: HELM Posters



Fig. 18: HELM Events and Conferences participation



Fig. 19: HELM Final Workshop