C^{3}HARME

Next Generation Ceramic Composites for Combustion Harsh Environments and Space

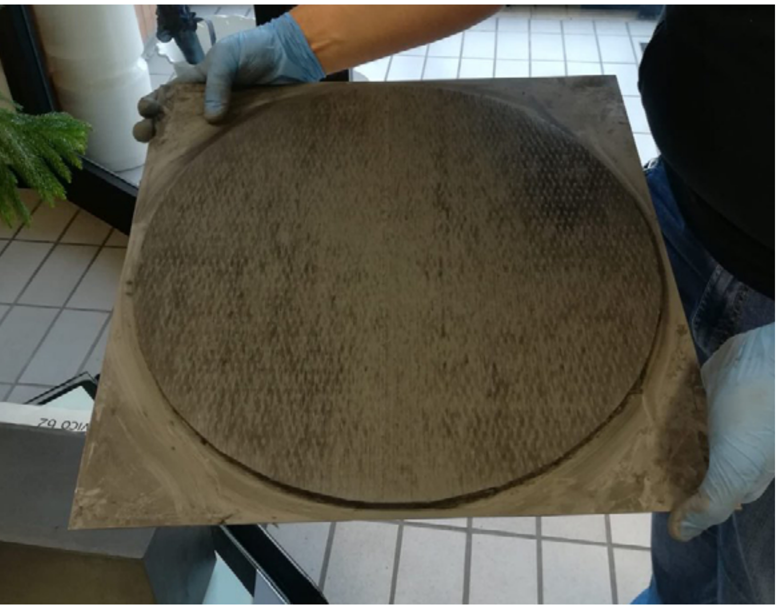
FEBRUARY 2019

EDITORIAL

C^{3}HARME is a research project funded under the EU's Horizon 2020 Framework Programme for Research and Innovation. Its main purpose is the design, testing and manufacturing of a new class of ceramic matrix composites based on ultra-high temperature ceramics.
The new UHTCMC materials should be suitable to operate in severe aerospace environments, with applications in rocket nozzles and vehicles for hypersonic re-entry. The 8M€ project, started in June 2016, will run for 4 years and involves 12 partners from 6 European countries. Every 6 months, our newsletter shares relevant news and a summary of our achievements. If you wish to be updated with C^{3}HARME's progresses, sign up on our website (www.c3harme.eu). In the meantime, enjoy reading!

Diletta Sciti
Project Coordinator

NEWSLETTER #2



A STEP CLOSER TO THE RIGHT SIZE

Half way to the project, C^{3}HARME is getting closer and closer to the prototype realization in relevant environments. After testing more than 500 samples at the lab scale (TRL 4), partners have produced samples with an increasing size in order to assess the scale–up of the processing routes.

Partners are currently setting up the ground systems in all the foreseen testing facilities and manufacturing prototypes for ground and qualification tests in the applications envisage by C^{3}HARME: propulsion and thermal protection system.

PARTNERS

ISTEC-CNR
UNIVERSITY OF NAPLES
UNIVERSITY OF BIRMINGHAM
AIRBUS
ARIANE GROUP
AVIO S.P.A
CRANN
DLR
HPS-PT
IN SRL
NANOKER RESEARCH
TECNALIA R&D

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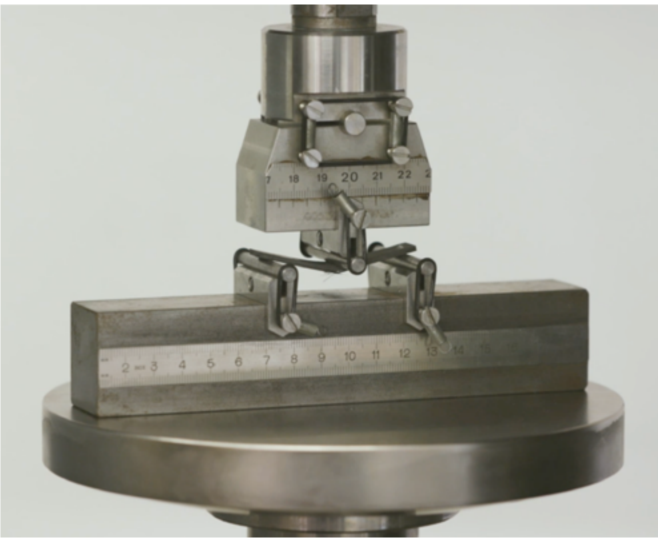
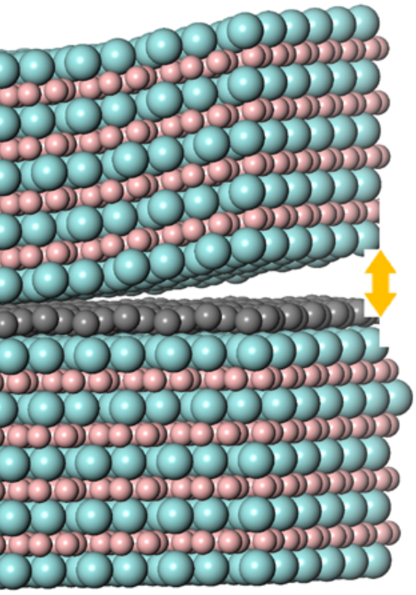
MEASURING THE SELF-HEALING

The new class of material in C³HARME should be able to self-repair damage without any external intervention, a feature called self-healing. The self-healing capability in UHTCMCs should arise from the tailored addition of nanosized substances that trigger a protection system when exposed to the temperatures and oxygen contents typical of launch or re-entry. The protection arises from the formation of external solid layers and internal fluid compounds that fix old and new defects. This feature vastly improves the reliability of the structural ceramic components and makes the material reusable, dramatically reducing costs of space missions.



In the last years, partners have investigated several techniques to incorporate self-healing phases and they have set-up reliable methodologies to test and quantify the self-healing capability. The developed methods (single edge notched beam and indentation) succeed in creating a known damage in a well-defined position, making it possible to quantify the affected key-property, e.g. strength. With this set-up, partners at ISTEC-CNR are evaluating the self-healing feature in several ceramic matrices in order to select the most responsive systems.

AT MATERIALS INTERFACES



The UHTCMCs developed in C³HARME are based on Ultra High Temperature Ceramic (UHTC) materials, like ZrB_2, infiltrated with carbon or SiC fibers. As composites they have a rich variety of interfaces, where the different materials get into contact. The interfacial characteristics dramatically affect the overall properties of the final compounds, including their mechanical behaviour, the thermal response and the resistance to the environment. Computational simulations at the atomic level are powerful tools to characterize the interfaces at the nano scale, especially when high temperatures are involved as in the applications relevant to C³HARME.

In the last years, the team lead by Prof. Sanvito of CRANN, AMBER and the School of Physics at Trinity College Dublin, has built a machine-learning interatomic potential (MLIP) for molecular dynamics (MD) simulations of the complicated deformation behaviour of UHTCMCs at ultra-high temperatures (T~ 2500 K). Applying this MLIP, they have calculated the thermal expansion coefficients and Young's Moduli of UHTC matrices at different temperatures. These properties serve as inputs to understand the stress states around the interfacial domains. The TCD team has also evaluated several possible conformations of the surfaces and interfaces of UHTCMCs using density functional theory method. Then, they analysed the interfaces strength and their response to the displacement modes of tensile and sliding. Currently, the team is working on the surface reaction of UHTCs with the most common chemical agents like O_2, H_2, H_2O, CO, HCl etc.