CERAMCOM NEWSLETTER (May 2020)

H2020-MSCA-IF-2017; Grant agreement No. 798651

The project "**New Generation Ultra High Temperature Ceramic Matrix Composites for Aerospace Industry**" with the acronym "**CeramCom**", led by Institute of Inorganic Chemistry, Slovak Academy of Sciences, was launched in June 2018 **to develop new generation Ultra High Temperature Ceramic Matrix Composites (UHTCMCs) with significantly improved ultra-high temperature properties and long-term thermo-chemical resistance**. The project has received funding (**153 381.60 €**) from the the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska - Curie grant agreement No. 798651. Duration of the project was 24 months.

Objectives of the project

- To develop Ultra-High Temperature Ceramics (UHTCs) with different contents and types of rare-earth (RE) elements.
- To understand the effect of various RE elements on sintering, microstructure and properties of new RE-reinforced UHTCs.
- To develop a coating technique for CMCs using the newly developed RE-reinforced UHTCs.
- To transfer knowledge to the industrial partner (**Airbus Defence and Space GmbH**) and verify the improved properties of C_f/SiC composites coated by the new system based on RE-UHTCs.

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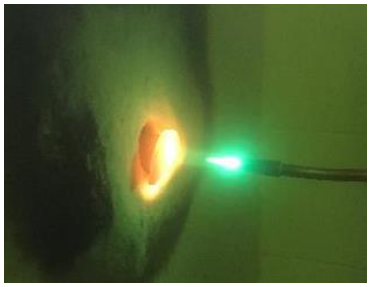
Ultra-High Temperature Ceramics with rare-earth oxide additives

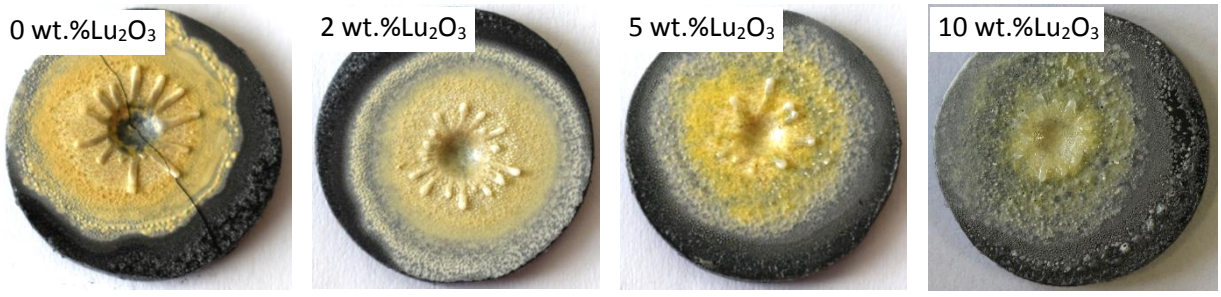
Fully dense ZrB_2 - 25vol.% SiC and HfB_2 – 25 vol.% SiC materials with the addition of various amounts (2, 5 and 10 wt.%) of rare-earth oxide additives (RE_2O_3) – Eu_2O_3, Yb_2O_3, Lu_2O_3 – were successfully prepared using electric field assisted sintering technology at the temperature of 2000°C and the uniaxial pressure of 70 MPa in argon.

Main achievements:

- Optimized ball milling process to obtain powders with the particle size below 1 µm, and a minimum contamination from ball milling media (< 1 wt.%).
- The addition of RE_2O_3 up to 5 wt.% did not lead to a deterioration of the room temperature mechanical properties, such as hardness, fracture toughness, Young's modulus, and strength of ZrB_2 – 25vol.% SiC. All room temperature properties even slightly increased for the addition of Lu_2O_3 and Yb_2O_3, when compared to the reference ZrB_2 – 25 vol.% SiC without RE_2O_3 additives.
- The ablation resistance of the samples was investigated up to ~ 2600°C using an oxyacetylene torch. A significantly improved ablation resistance of the materials was observed after the addition of Yb_2O_3 and Lu_2O_3. On the other hand, no significant improvement was observed for the materials with Eu_2O_3 additive.



Ablation resistance test using oxyacetylene torch



The surface of ZrB_2-SiC samples with different amounts of Lu_2O_3 after the ablation test at the temperature of 2600°C for 60 seconds.

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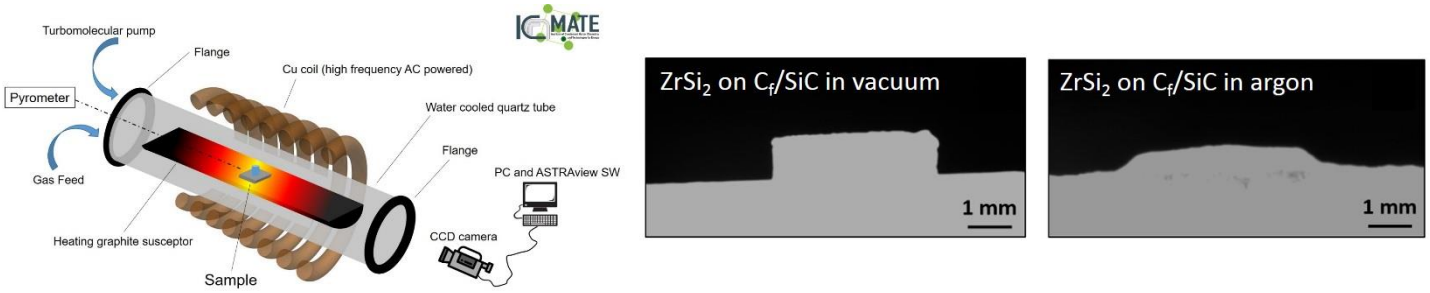
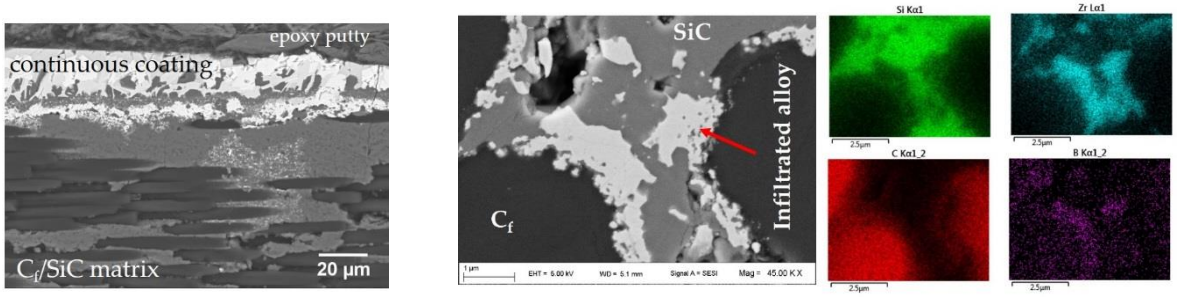
Ultra-High Temperature Ceramic Matrix Composites with RE oxide additives

- Development of new Ultra-High Temperature Ceramic Matrix Composites (UHTCMCs) by the incorporation of RE-reinforced UHTCs (ZrB_2/SiC or HfB_2/SiC) into the body of carbon fibres reinforced silicon carbide matrix (C_f/SiC).
- C_f/SiC with different porosities were obtained from **Airbus Defence & Space, Germany**.
- The coating process consists of two steps:
  - Infiltration of B_4C into a porous matrix of C_f/SiC
  - Melting and melt infiltration of $ZrSi_2$ (or $HfSi_2$) into the B_4C-infiltrated C_f/SiC
- In order to understand the high temperature interactions between molten alloys and the C_f/SiC matrix, **wetting studies** at temperatures above melting points of disilicides were performed in different environments with the help of **ICMATE CNR Genoa, Italy**.



Schematic illustration of wetting apparatus available at ICMATE CNR, Genoa; and the pictures of high temperature interactions between $ZrSi_2$ and C_f/SiC in vacuum or argon.



Back-scattered SEM image of the continuous external UHTC coating on the C_f/SiC matrix; and SEM/EDX analysis of the C_f/SiC matrix, showing the formation of ZrB_2 and SiC in SiC matrix near carbon fibres.

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Dissemination activities

Publications:

- P. Tatarko, F. Valenza, H. Ünsal, A. Kovalčíková, J. Sedláček, P. Šajgalík: Design of Lu_2O_3-reinforced C_f/SiC-ZrB_2-ZrC ultra-high temperature matrix composites: Wetting and interfacial reactivity by $ZrSi_2$ based alloys, Journal of the European Ceramic Society, 2020, in press, **open access**, https://doi.org/10.1016/j.jeurceramsoc.2020.05.055; repository: http://gofile.me/48WYH/JvWShMNVE
- Z. Fürdősová, H. Ünsal, A. Kovalčíková, I. Dlouhý, P. Tatarko: ZrB_2-SiC ceramics with rare-earth oxide additives, Processing and Properties of Advanced Ceramics and Glasses, online conference proceeding, Silikatnik 2019, p. 57 – 60, **open access**, http://www.sss.sav.sk/files/silikatnik19.pdf; repository: http://gofile.me/48WYH/vmxPVYVPS

Conferences:

- P. Tatarko, F. Valenza, H. Ünsal, A. Kovalčíková, R. Bystrický: Wetting and phase interaction between C_f/SiC and transition metal disilicides-based alloys, 10th International conference on high temperature ceramic matrix composites, HT-CMC10, September 22-26, 2019, Bordeaux, France.
- Z. Fürdősová, A. Kovalčíková, O. Hanzel, I. Dlouhý, P. Tatarko: Development of Ultra-High Temperature Ceramics by field assisted sintering technolgy, 5th Conference of The Serbian Society for Ceramic Materials, June 11-13, 2019, Belgrade, Serbia.
- P. Tatarko, F. Valenza, H. Ünsal, A. Kovalčíková, J. Sedláček, P. Šajgalík: Interactions of molten transition metal disilicides with C_f/SiC during the development of UHTCMC, Processing and Properties of Advanced Ceramics and Glasses, November 20-22, 2019, Ráztočno, Slovakia.

Outreach activities:

- **European Researchers' Night** 2018 and 2019; World of Inorganic Materials, Bratislava, Slovakia
- Annual **open day** at Institute of Inorganic Chemistry SAS, 07.11.2018, Bratislava, Slovakia
- **Marie Curie Ambassador**: MSCA individual fellowship (MSCA IF) seminar, 2018, 2019, 2020, Centrum vedecko-technickych informacii SR – CVTI SR, Bratislava, Slovakia
- **Lab tour** and **project presentation** for students from local Slovak Technical University in Bratislava, 04.04.2019
- **Presentation** at Slovak Technical University (FCHPT STU) about the project results and MSCA actions, 11.12.2019
- **Interviews** for **Slovak national television** (RTVS), which was shown in morning TV news (15.02.2018), main TV news (18.02.2018) and a special programme focused on science and technology (VAT – magazin, 31.03.2018; https://www.rtvs.sk/)
- **Interiews** for **local newspapers**, 2018: dennikn.sk; vedanadosah.cvtisr.sk; sav.sk

Peter Tatarko during interview for Slovak national television (RTVS)

Peter Tatarko during open day at IIC SAS

Peter Tatarko at MSCA IF seminar

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