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Thermal and Environmental Barrier Coatings VI

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Conference Program

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Program

THERMAL AND ENVIRONMENTAL BARRIER COATINGS VI

June 19 - 24, 2022

Irsee, Germany
Kloster Irsee

Conference Co-Chairs

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Pratt & Whitney, USA

Uwe Schulz
German Aerospace Center, Germany

Mike Maloney (retired)
Pratt & Whitney, USA

Robert Vaßen
Research Center, Julich, Germany

Ram Darolia (retired)
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Previous conferences in this series:

Thermal and Environmental Barrier Coatings

Aug 17-22, 2003

Irsee, Germany

Conference Chairs:

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Thermal Barrier Coatings II

August 12-17, 2007

Irsee, Germany

Conference Chairs:

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Thermal Barrier Coatings III

Aug. 7-12, 2011

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Odile Lavigne, ONERA DMSM/MAT, France

Hideyuki Murakami, National Institute of Materials Science, Japan

Hongbo Guo, Beihang University, China

Thermal Barrier Coatings IV

June 22-27, 2014

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Thermal Barrier Coatings V

June 24 – 29, 2018

Irsee, Germany

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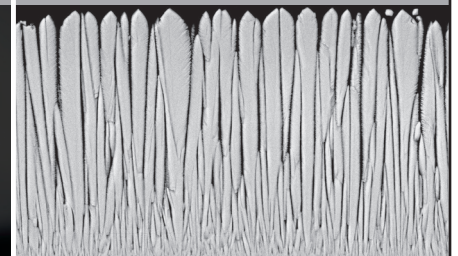
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Sunday, June 19, 2022

16:00 – 18:00	Conference Check-In (Room 102)
18:00 – 22:00	Garden Gathering including reception, BBQ dinner and music by BauernStreichwurst

Locations and Notes

- *Poster Sessions will be in the corridor near the meeting room.*
- *We will have as many meals outside as possible, weather permitting.*
- *Please wear your mask except when giving a presentation or actively eating or drinking. Please maintain physical distancing as much as possible.*
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Monday, June 20, 2022

- 07:00 – 08:15 Breakfast
- 08:15 – 08:30 **Conference Overview**
Brian Hazel, Pratt & Whitney, USA
- ECI welcome: Ram Darolia (GE Aviation, retired)
- Session: Overview of TBC/EBC Application**
Chairs: Gyn Brewster, Rolls-Royce plc., United Kingdom
- 08:30 – 09:00 **Requirements and Design Constraints for TBC's in Land Based Gas Turbines**
Grégoire Witz, Siemens Energy, Switzerland
- 09:00 – 09:30 **Successes, Challenges and Opportunities for Environmental Barrier Coatings**
Julie Kuhn, GE Aviation, USA
- 09:30 – 10:00 Coffee Break
- Session: EBCs for Novel Alloy Systems**
Chairs: Uwe Schulz, DLR - German Aerospace Center, Germany
- 10:00 – 10:30 **New Environmental-Thermal Barrier Coatings for Ultrahigh Temperature Alloys**
Ji-Cheng Zhao, University of Maryland, USA
- 10:30 – 11:00 **High Temperature Refractory Metal Alloys-advances and Challenges**
John Perepezko, University of Wisconsin-Madison, USA
- 11:00 – 11:30 **High Entropy Rare Earth Oxide (HERO) Environmental Barrier Coatings for Refractory Metal Alloys**
Elizabeth Opila, University of Virginia, USA
- 11:30 – 12:00 **Selective Thermal Emission Coatings for Improved Turbine Efficiency**
Pete McGrail, Pacific Northwest National Lab, USA
- 12:00 – 13:30 **Lunch**
- Session: EBCs for Novel Alloy Systems (continued)**
Chairs: Uwe Schulz, DLR - German Aerospace Center, Germany
- 13:30 – 14:00 **Assessing the High Temperature Performance of Refractory Metal Alloys**
Bruce Pint, Oak Ridge National Laboratory, USA
- Session: EBC**
Chairs: Sanjay Sampath, Stony Brook University, USA
- 14:00 – 14:30 **EBC Development and Behaviour Analysis for High Temperature CMC Components**
Lisa Pin, Safran Ceramics, France
- 14:30 – 15:00 **Concepts for Enhancing the Life of Environmental Coatings Systems**
Jeroen Deijkers, University of Virginia, USA

Monday, June 20, 2022 (continued)

- | | |
|---------------|---|
| 15:00 – 15:30 | Coffee Break |
| 15:30 – 16:00 | Processing and Characterization of Ytterbium Silicate Environmental Barrier Coatings
Ping Xiao, University of Manchester, United Kingdom |
| 16:00 – 16:30 | Damage Mechanism of an Environmental Barrier Coated Ceramic Matrix Composite Under Thermal and Mechanical Loadings
Thibaut Archer, ONERA, France |
| 16:30 – 17:00 | The Synthesis of EBC Layer Stacks by the Combination of PVD and CVD in a Continuous Vacuum Process
Jurgen Ramm, Oerlikon Surface Solutions AG ZN Balzers, Liechtenstein |
| 17:00 – 18:00 | Discussion
Leader: Matthew Begley, University of California, Santa Barbara, USA |
| 18:30 – 21:30 | Dinner & Social Hour |

Tuesday, June 21, 2022 (Summer Solstice)

- 07:00 – 08:30 Breakfast
- Session: EBC (continued)**
Chairs: Sanjay Sampath, Stony Brook University, USA
- 08:30 – 09:00 **Stabilization Mechanism and CMAS Corrosion Behavior of Rare Earth Oxides Based Environmental Barrier Coatings Prepared by Thermal Spray**
Naoki Yamazaki, IHI, Japan
- 09:00 – 09:30 **Cyclic oxidation of yttrium/ytterbium disilicate environmental barrier coatings**
Bruce Pint, Oak Ridge National Laboratory, USA
- Session: TBC**
Chairs: Grégoire Witz, Seimens Energy, Switzerland
- 09:30 – 10:00 **Factors influencing the performance of zirconia based thermal barrier coatings**
Robert Vaßen, Forschungszentrum Julich GmbH, Germany
- 10:00 – 10:30 Coffee Break
- 10:30 – 11:00 **A Coupled Thermal and Mechanical Analysis of Sintering in Thermal Barrier Coatings Under Gradient Exposure**
John Saputo, Stony Brook University, USA
- 11:00 – 11:30 **A mechanism-based approach for assessing the structural integrity of plasma-sprayed multilayer thermal barrier coatings**
Matthias Oechsner, University of Darmstadt, Germany
- 11:30 – 12:00 **Thermo-mechanical Analysis of Blister Damage in Eb-pvd Tbc System: Experiments and Modeling**
Vincent Maurel, Mines Paris PSL University – Centre des Materiaux UMR CNRS 7633, France
- 12:00 – 13:30 Lunch
- Session: TBC (continued)**
Chairs: Grégoire Witz, Seimens Energy, Switzerland
- 13:30 – 14:00 **Degradation of aluminide type bondcoats due to oxidation and interdiffusion: effect of base alloy composition**
Dmitry Naumenko, Forschungszentrum Juelich GmbH, Germany
- 14:00 – 14:30 **Novel multicomponent equiatomic pyrochlores for future thermal barrier coatings**
Maren Lepple, JLU Gießen, Germany
- Session: TBC/EBC Processing**
Chairs: Robert Vaßen, Research Center, Julich, Germany
- 14:30 – 15:00 **Microstructure, phase formation and cyclic behavior of PVD-based Y-silicate Environmental Barrier Coatings for SiC-SiC CMC**
Uwe Schulz, DLR – German Aerospace Center, Germany

Tuesday, June 21, 2022 (continued)

- | | |
|---------------|---|
| 15:00 – 15:30 | Coffee Break |
| 15:30 – 16:00 | Multilayer TBCs and EBCs: Integrating Design and Manufacturing Innovations for Multifunctional Performance
Sanjay Sampath, Stony Brook University, USA |
| 16:00 – 16:30 | Microstructure and Phase Composition Evolution of Thermal Sprayed Yb-Silicate Coatings during Post Heat Treatment and Burner Rig Test
Emine Bakan, Forschungszentrum Jülich GmbH, Germany |
| 16:30 – 17:00 | Comparative Study of Thermal Barrier Coatings by S-hvof and Eb-pvd Process
Yoshifumi Okajima, Mitsubishi Heavy Industries, Ltd., Japan |
| 17:00 – 18:00 | Discussion
Leader: Brian Stephens, GE Aviation, USA |
| 18:00 – 19:30 | Dinner |
| 19:30 – 21:30 | Poster Session & Social Hour |

Wednesday, June 22, 2022

- 07:00 – 08:30 Breakfast
- Session: TBC/EBC Processing (continued)**
Chairs: Molly O'Connor, Praxair Surface Technologies, USA
- 08:30 – 09:00 **Columnar Thermal Barrier Coatings Manufactured by Novel Laser Cladding Process**
Daniel Mack, Forschungszentrum Jülich, Germany
- 09:00 – 09:30 **Thermal Barrier Coatings on Additive Manufactured Superalloy Parts**
Nicolaie Markocsan, University West, Sweden
- 09:30 – 10:00 **Plasma-activated EB-PVD of protective coatings: tools and processes**
Burkhard Zimmerman, Fraunhofer FEP, Germany
- 10:00 – 10:30 Coffee Break
- 10:30 – 11:00 **Investigating the microstructure of as-sprayed high-crystalline Yb₂Si₂O₇ environmental barrier coating (EBC) deposited by atmospheric plasma spray (APS)**
Christian Moreau, Concordia University, Canada
- 11:00 – 11:30 **New Enhanced Technical Capabilities of the ALD SMARTcoater**
Ole Hinrichs, ALD Vacuum Technologies GmbH, Germany
- 11:30 – 12:00 **Cathodic Arc Evaporation of MCrALY Coatings**
Sebastien Guimond, Oerlikon Surface Solutions AG, Liechtenstein
- 12:00 – 13:30 Lunch
- Session: Properties and Testing**
Chairs: Bruce Pint, Oak Ridge National Laboratory, USA
- 13:30 – 14:00 **Simulations of Oxide Growth and Stress Evolution in Silicon-based Coatings and Composites**
Matt Begley, University of California, USA
- 14:00 – 14:30 **Micromechanical Testing of Thermal Barrier Coatings**
Ying Chen, The University of Manchester, United Kingdom
- 14:30 – 15:00 **Assessment of Mechanical TBC Failure in Complex Geometries**
Mario Rudolphi, DECHEMA-Forschungsinstitut, Germany
- 15:00 – 15:30 **Synthesis and characterization of compositionally complex zirconate and phosphates**
Daniel Mumm, University of California, Irvine, USA
- 15:30 – 16:00 Coffee Break
- 16:00 – 17:00 **Discussion**
Leader: David Poerschke, University of Minnesota, USA
- 17:00 – 17:30 **Future engine challenges for TBCs/EBCs**
Frank Preli, Pratt & Whitney, USA

Wednesday, June 22, 2022 (continued)

19:30 – 20:00 Reception

20:00 Conference Dinner with music by VoIXmucke

Thursday, June 23, 2022

07:00 – 08:30 Breakfast

Session: CMAS

Chairs: Elizabeth Opila, University of Virginia, USA

08:30 – 09:00 **E Understanding the Stability of Mixed-Anion Deposits and Effects on Reactions with Advanced Coating Materials**
David Poerschke, University of Minnesota, USA

09:00 – 09:30 **Reactions in Thermal Barrier Coatings and Multi-Mineral Dusts in a Gas Turbine Engine Dust Ingestion Test**
Gyn Brewster, Rolls Royce, USA

09:30 – 10:00 **A Geoscientific Perspective on Silicate Melt Interactions with TBCs**
Dirk Müller, LMU Munich, Germany

10:00 – 10:30 Coffee Break

Student Presentations

Chair: Brian Hazel, Pratt & Whitney, USA

10:30 – 10:45 **Understanding garnet phase stability in Gd/Y/Yb-CMAS systems and influences on multiphase T/EBC-CMAS interactions**
Eeshani Paresh Godbole, University of Minnesota, USA

10:45 – 11:00 **Microstructure modification of EB-pvd gadolinium zirconate thermal barrier coatings and the effect on their resistance against siliceous CMAS melts**
Christoph Mikulla, German Aerospace Center (DLR), Germany

11:00 – 11:15 **Mechanical properties of Yb₂Si₂O₇ coatings prepared using electrophoretic deposition**
Esma Yilmaz, University of Manchester, United Kingdom

11:15 – 11:30 **Simultaneous residual stress mapping of topcoat and TGO in APS TBC using combined micro-Raman-PL spectroscopy**
Srikanth Batna, Indian Institute of Technology Bombay, India

11:30 – 12:00 **Discussion**
Leader: Ravisankar Naraparaju, DLR – German Aerospace Center, Germany

12:00 – 13:30 Lunch

13:30 – 18:30 **Kaufbeuren Excursion**

18:30 – 21:30 Dinner & Social Hour

Friday, June 24, 2022

- 07:00 – 08:30 Breakfast
- Session: CMAS (continued)**
Chairs: Vincent Maurel, Mines Paris PSL University – Centre des Materiaux UMR CNRS 7633, France
- 08:30 – 09:00 **Understanding Silicate Deposit Variability and its Implications for Evaluating TBCs and EBCs**
Andrew Ericks, University of California, Santa Barbara, USA
- 09:00 – 09:30 **CMAS Reactive Coatings for TBCs**
Margeaux Wallace, General Electric Global Research, USA
- 09:30 – 10:00 **Development of CMAS Resistant Thermal Barrier Coatings: Challenges and Implications**
Ravisankar Naraparaju, DLR, Germany
- 10:00 – 10:30 Coffee Break
- 10:30 – 11:00 **Corrosion of E/TBCs: Chemical Interactions of Ceramic Materials with CMAS**
Pierre-Jean Panteix, University of Lorraine, France
- 11:00 – 12:00 **Discussion**
Leader: Mike Maloney, Pratt & Whitney, USA
- 12:00 – 13:30 Lunch
- 13:30 Departures

Poster Presentations

1. **Influence of alumina addition on steam corrosion behaviour of Ytterbium disilicates for EBC applications**
Ahmet Hilmi Paksoy, The University of Manchester, United Kingdom
2. **Reactions of rare earth hafnates and zirconates with silicate melts of different basicity**
Andrew R. Ericks, University of California, Santa Barbara, USA
3. **Debye-Larmor high enthalpy cascade plasma gun technology to apply ceramic coatings for the turbine industry**
Armando Salito, Gulhfi Consulting AG, Switzerland
4. **TUBA Nova - A novel industrial EB-PVD coater platform for state-of-the-art TBCs and multi-layer coatings**
Carsten Deus, VON ARDENNE GmbH, Germany
5. **Investigating the microstructure of as-sprayed high-crystalline Yb₂Si₂O₇ environmental barrier coating (EBC) deposited by atmospheric plasma spray (APS)**
Christian Moreau, Concordia University, Canada
6. **Microstructure modification of EB-pvd gadolinium zirconate thermal barrier coatings and the effect on their resistance against siliceous CMAS melts**
Christoph Mikulla, German Aerospace Center (DLR), Germany
7. **Thermal Environmental Barrier Coatings (TEBCs), and their deposits-induced degradation and its mitigation**
Christopher Louzon, Brown University, USA
8. **Synthesis of multi component rare-earth silicate systems for T/EBC application: Study of their high temperature interactions with CMAS**
Cynthia Yanel Guijosa Garcia, German Aerospace Center (DLR), Germany
9. **Environmental barrier coatings deposited by suspension plasma spraying**
Dapeng Zhou, Forschungszentrum Jülich GmbH, Germany
10. **Understanding garnet phase stability in Gd/Y/Yb-CMAS systems and influences on multiphase T/EBC-CMAS interactions**
Eeshani Paresh Godbole, University of Minnesota, USA
11. **Mechanical properties of Yb₂Si₂O₇ coatings prepared using electrophoretic deposition**
Esma Yilmaz, University of Manchester, United Kingdom
12. **Ytterbium silicate environmental barrier coatings prepared by a novel slurry spraying-reactive sintering technique**
Gauri Waghmare, Indian Institute of Technology Bombay, India
13. **Concepts for enhancing the life of environmental coatings systems**
Jeroen Deijkers, University of Virginia, USA
14. **Coatings for increased efficiency in compression ignition engines**
John Saputo, Stony Brook University, Center for Thermal Spray Research, USA

15. **A coupled thermal and mechanical analysis of sintering in thermal barrier coatings under gradient exposure**
John Saputo, Stony Brook University, Center for Thermal Spray Research, USA
16. **Effects of EB-PVD microstructural features on CMAS infiltration of Yttria-rich zirconia coatings**
Juan Gomez, Pratt & Whitney, USA
17. **Thermochemical stability of high entropy rare earth oxide (HERO) coatings for refractory alloys**
Kristyn Ardrey, University of Virginia, USA
18. **Spatially resolved characterization of thermally grown oxides using time-domain thermoreflectance**
Milena Milich, University of Virginia, USA
19. **Emerging coating materials for H₂ powered turbines**
Molly O'Connor, Praxair Surface Technologies, USA
20. **A study of the of ytterbium disilicates undergoing water vapour corrosion for environmental barrier coating applications**
Simon McCormack, University of Manchester, United Kingdom
21. **Simultaneous residual stress mapping of topcoat and TGO in APS TBC using combined micro-Raman-PL spectroscopy**
Srikanth Batna, Indian Institute of Technology Bombay, India
22. **Lessons learned in design and characterization of EBC spray powders**
Ursa Pirnat, Treibacher Ind. AG, Austria
23. **A comparative study of phase evolution in YSZ powders, pellets and free-standing air plasma sprayed thermal barrier coatings**
Vikram Hastak, Indian Institute of Technology Bombay, India
24. **SiC-based/EBC Coating systems investigated by LASAT (LAsER Shock Adhesion Test)**
Vincent Guipont, MINES Paris - PSL / Centre des Matériaux (CNRS 7633), France
25. **Non-destructively capturing CMAS degradation of EB-PVD thermal barrier coatings through 3D confocal Raman renderings**
Zachary Stein, University of Central Florida, USA
26. **The utilization of laser thermal testing with thermographic measurement for TBC lifetime performance evaluation**
Zdeněk Veselý, University of West Bohemia, Czech Republic