Summer 6-22-2014

Program

Franco Berruti
Western University

Program

Thermal Barrier Coatings IV

June 22-27, 2014

Kloster Irsee
Irsee, Germany

Conference Chairs:

Dr. Uwe Schulz
German Aerospace Center, Germany

Dr. Michael J. Maloney
Pratt & Whitney, USA

Dr. Ram Darolia
GE Aviation (Retired), USA

Engineering Conferences International
32 Broadway, Suite 314 - New York, NY 10004, USA
Phone: 1 - 212 - 514 - 6760, Fax: 1 - 212 - 514 - 6030
www.engconfintl.org – info@engconfintl.org

Monastery Irsee
Conference & Education Centre
Klosterring 4
D - 87660 Irsee, Germany
Phone +49 (0)8341 906-00

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ONERA DMSM/MAT, France

Professor Robert Vassen
Research Center Jūlich, Germany

Dr. David Rickerby
Rolls-Royce, UK

Dr. Seiji Kuroda
National Institute for Materials Science, Japan

Prof. Hongbo Guo
School of Materials Science and Engineering, Beihang University, China

Prof. Carlos Levi
University of California – Santa Barbara, USA

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Sunday, June 22, 2014

16:00 - 18:00 Registration

18:15 - 19:30 Organ Concert:
Roland Götz, Organist, will play on the historic organ of the monastery Church

19:30 - 21:00 Dinner (Kloster Irsee Restaurant)

21:00 - 22:00 Reception (Bierstube/Stiftskeller)

Notes

- *Technical sessions will be in "Vortragsaal" (Room 128)*
- *Lunches and dinners will typically be in the Kloster Irsee Restaurant.*
- *The conference banquet will be in the Festsaal.*
- *Audiotaping, videotaping and photography of presentations are prohibited.*
- *Speakers – Please have your presentation loaded onto the conference computer prior to the session start (preferably the day before).*
- *Speakers – Please leave at least 5 minutes for questions and discussion.*
- *Please do not smoke at any conference functions.*
- *Turn your cellular telephones to vibrate or off during technical sessions.*
- *Be sure to make check your name/contact information on the Participant List. An updated copy will be sent to all participants after the conference.*
- *Participants staying at the Klosterbräu Hotel Irsee should have breakfast at the hotel. Those staying at Kloster Irsee will have breakfast at Kloster Irsee.*

Monday, June 23, 2014

07:00 - 08:15 Breakfast

08:15 - 08:30 Conference Overview
Uwe Schulz, German Aerospace Center, DLR, Köln, Germany

ECI Introduction:
Ram Darolia, ECI Technical Liaison

SESSION 1: OVERVIEWS
Chair: Odile Lavigne, ONERA

08:30 - 09:00 Brian Hazel, Pratt & Whitney, USA
A recent history of thermal barrier coatings for aero-propulsion applications

09:00 - 09:30 David Rickerby, Rolls Royce, United Kingdom
High-temperature ceramic coatings used in aero engine environments

09:30 – 10:00 TBA

10:00 - 10:30 Morning coffee break

SESSION 2: BONDCOAT DEVELOPMENT AND OXIDATION BEHAVIOR
Chairs: Tresa Pollock, Vladimir Tolpygo

10:30 - 11:00 Gerry Meier, University of Pittsburgh, USA
The effect of exposure variables on the development of alumina scales

11:00 - 11:30 Willem J. Quadakkers, Research Center Jülich, Germany
Effect of bondcoat roughness on lifetime of APS-TBC systems in dry and wet gases

11:30 - 12:00 Tresa Pollock, University of California, Santa Barbara, USA
Design constraints and higher temperature intermetallic bond coatings

12:00 - 13:30 Lunch

13:30 - 14:00 Daniel R. Mumm, University of California, Irvine, USA
Potential impacts of alternative fuels on the evolution and stability of turbine hot-section materials

14:00 - 14:30 Hongbo Guo, Beihang University, China
The role of reactive elements in improving the cyclic oxidation performance of B-NiAl coatings

14:30 - 15:00 Bruce A. Pint, , USA
The effect of environment and superalloy composition on TBC lifetime

15:00 - 15:30 Afternoon coffee break

15:30 - 16:00 Kazuhide Matsumoto, National Institute for Materials Science, Japan
Application of EQ bond coat to EB-PVD TBC systems

Monday, June 23, 2014 (continued)

16:00 - 16:20 Robbie J. Bennett, University of Cambridge, United Kingdom
On the behavior of titanium within thermal barrier coatings and its influence on residual stress within the TGO

16:20 – 16:50 Alexander Barth, Sulzer Metco AG, Switzerland
Cold spray bond coats structure and oxidation behavior

16:50 - 17:20 Discussion

19:00 - 20:30 Dinner

20:30 - 22:00 Social Hour

Tuesday, June 24, 2014

07:00 - 08:30 Breakfast

SESSION 3: TOP COAT DEVELOPMENT - MATERIALS AND PROCESSING
Chairs: Robert Vaßen, Sanjay Sampath

08:30 - 9:00 David Clarke, Harvard University, USA
Zirconia-doped yttrium tantalates as a potential next generation thermal barrier coating material

09:00 - 09:30 Wei Pan, Tsinghua University, China
New class of refractory ceramics for thermal barrier coatings

09:30 - 10:00 Christopher Petorak,, Praxair Surface Technologies, USA
Performance of columnar 7-8 wt% YSZ coatings on platinum aluminide bondcoats

10:00 - 10:30 Coffee break

10:30 - 11:00 Seiji Kuroda, NIMS, Japan
Stress and crack monitoring during plasma spraying of TBC

11:00 - 11:30 Sanjay Sampath, Stony Brook University, USA
Engineered multi-layered thermal barrier coatings for enhanced durability

11:30 – 12:00 Nicolaie Markocsan, University West, Sweden,
Suspension Plasma Sprayed Thermal Barrier Coatings

12:15 – 18:00 Boxed lunch
Depart for Optional Excursion

18:00 - 19:00 Dinner

19:00 - 19:30 Robert Vassen, Research Center Jülich GmbH, Germany
Columnar structured thermal barrier coatings by thermal spray methods

19:30 – 20:00 Xueqiang Cao, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences
Multilayered thermal barrier coatings

20:00 - 20:30 Federico Cernuschi, Robert Vassen, RSE Ricerca per il Sistema Energetico, Italy and Research Center Jülich, Germany
High temperature oxidation and burner rig testing of different TBCs in the frame of the European Project TOPPCOAT: A summary of results

20:30 - 21:00 Discussion

21:00 - 23:00 Social hour

Wednesday, June 25, 2014

SESSION 4: FAILURE MECHANISMS – CMAS AND MITIGRATION STRATEGIES
Chairs: David Shiffler, Carlos Levi

07:00 - 08:30 Breakfast

08:30 - 09:00 Carlos G. Levi University of California, Santa Barbara, USA
CMAS degradation and implications for coating design

09:00 - 09:30 Daniel E. Mack, Research Center Jülich GmbH, Germany
TBC lifetime under thermal gradient cyclic testing with simultaneous CMAS attack: Towards prediction of advanced TBC performance

09:30 - 10:00 Marie-Helene Vidal-Setif, Onera, France
Solubility of oxides from ZrO_2-Y_2O_3 and ZrO_2-Nd_2O_3 systems in a molten CAS. Selection of a thermal barrier composition resistant to CAS infiltration

10:00 - 10:30 Morning coffee break

10:30 - 11:00 Huahai Mao, Thermo-Calc Software AB, Sweden
A thermodynamic database for simulation of CMAS and TBC interactions

11:00 – 11:30 Nitin P. Padture, Brown University, USA
Attack of thermal barrier coatings by molten silicate deposits (sand, ash) and its mitigation

11:30 – 12:00 Bill Clyne, University of Cambridge, United Kingdom
CMAS deposition within the turbine of a small jet engine and effects on TBC spallation

12:00 – 13:30 Lunch

13:30 - 14:00 Vladimir Tolpygo, Honeywell Aerospace, USA
Examination of CMAS-induced EB-PVD TBC failure

14:00 - 14:30 Andrew W. Phelps, University of Dayton Research Institute, USA
Development of a naturalistic test media for dust ingestion CMAS testing of gas turbine engines

14:30 - 15:00 Peter Mechnich, Ravisankar Naraparaju, German Aerospace Center (DLR), Germany
Yttrium oxide a candidate material for environmental and thermal barrier coatings

15:00 - 15:30 Discussion

15:30 - 16:00 Afternoon coffee break

SESSION 5: FAILURE MECHANISMS – LIFE MODELING AND DEGRADATION
Chairs: Matt Begley, Stefan Lampenscherf

16:00 - 16:30 Stefan Lampenscherf, Siemens AG, Germany
APS TBC life prediction - Impact of manufacturing variations

Wednesday, June 25, 2014 (continued)

16:30 – 17:15 Hans-Peter Bossmann, Gregoire Witz, Alstom Power, Switzerland (combined talk)
Probabilistic lifetime prediction of TBC coated parts considering design, operation and manufacturing + Thermal barrier coatings ageing mechanisms in land-based gas turbines

18:30 - 19:45 Dinner

19:30 - 22:00 Poster Session and Social Hour
Chairs: David Rickerby, Seiji Kuroda, Doug Konitzer

Thursday, June 26, 2014

07:00 - 08:30 Breakfast

08:30 - 09:00 Masakazu Okazaki, Nagaoka University of Technology, Japan
Specific failure modes of Ni-base superalloys and TBCs under a simulated combustion gas atmosphere

09:00 - 09:30 Pascale Kanoute, ONERA, France
Lifetime assessment tools for thermal barrier systems

09:30 - 09:50 Peter Wittig, Matthias Oechsner, Technical University of Darmstadt, Germany
Reliable measurement of mechanical TBC properties for quality control and life prediction

10:00 - 10:30 Coffee break

10:30 - 11:00 Mario Rudolphi, DECHEMA-Research Institute, Germany
Mechanical stability limits of bi-layer thermal barrier coatings

11:00 – 11:30 Matthew R. Begley, University of California at Santa Barbara, USA
Simulations of fracture in coatings with complex microstructures

11:30 – 12:00 Discussion

12:00 – 13:30 Lunch

SESSION 6: ENVIRONMENTAL BARRIER COATINGS FOR BEYOND Ni-BASED MATERIALS
Chairs: Brian Hazel, Gerry Meier

13:30 - 14:00 John H. Perepezko, University of Wisconsin-Madison, USA
High temperature environmental resistance of Mo-Si-B alloys and coatings

14:00 - 14:30 Michel Vilasi, Stéphane Mathieu, Université de Lorraine, Université de Lorraine
Manufacture of silicide coatings for the protection of niobium alloys against high temperature oxidation

14:30 - 15:00 Reinhold Braun, DLR - German Aerospace Center, Germany
Lifetime of environmental/thermal barrier coatings deposited on an Nb/Nb_5Si_3-based alloy with FeB-Modified M_7Si_6-based bond coat

15:00 - 15:30 Afternoon coffee break

15:30 – 16:00 Haydn Wadley, University of Virginia, USA
Ceramic matrix composite environmental protection strategies

16:00 – 16:30 Dongning Zhu, NASA, USA
NASA's advanced environmental barrier coatings development for SiC/SiC Ceramic matrix composites: Understanding CMAS degradations and resistance

16:30 - 17:00 Discussion

Thursday, June 26, 2014 (continued)

	Introductory remarks: Dave Wortman, Consultant
17:00 – 17:30	Pre-dinner talk Ram Darolia, Consultant, USA Lessons learned during development and implementations of TBCs
18:00 – 19:45	Optional social event
19:45 - 20:15	Reception
20:15	Conference dinner, awards and prizes, and social hour

Friday, June 27, 2014

07:00 - 08:30 Breakfast

SESSION 7: PROPERTIES AND CHARARTERIZATION TECHNIQUES.
Chairs: Mike Maloney, Hongbo Guo

08:30 - 09:30 Marion Bartsch, German Aerospace Center, Germany
Evaluating deformation behavior of a TBC-System during thermal gradient mechanical fatigue by means of high energy X-ray diffraction

09:30 – 10:00 Thomas Cosack, MTU Aero Engines, Germany
Nondestructive thickness measurements on EBPVD thermal barrier coatings by using Terahertz technique

10:00 – 10:30 Morning coffee break

10:30 – 11:00 Eric Jordan, University of Connecticut
Prediction of the cyclic durability as a function of cycle duration and temperature of an air plasma sprayed coating using inelastic strain

11:00 - 11:30 Anton Van der Ven, University of California, USA
High temperature thermodynamic, mechanical and kinetic properties from first principles

11:30 – 11:50 Markus Krottenthaler, FAU Erlangen-Nuremberg, Germany
Demonstration of two novel methods for residual stress management on NiAl bond coats

11:50 – 12:15 Wrap-up discussions

12:15 Lunch and Departures

Thermal Barrier Coatings IV
Poster List

1. **Thermal barrier coatings by EB-PVD for the aviation industry**
   Stefan Kunkel, ALD Vacuum Technologies GmbH, Germany

2. **Development of thermal barrier coatings by laser cladding of TiAl intermetallic alloy on Ti_6Al_4V**
   Bernabe Carcel, Asociacion Industrial de Optica Color e Imagen AIDO, Spain

3. **Deposition of NiCoCrAlY coatings by plasma activated EB-PVD using dual crucible technology**
   Liu Zhu, Beihang University, China

4. **Studies of high-temperature interactions between CMAS and TBCs: In situ Raman, optical basicity considerations, and mitigation strategies**
   Hector F. Garces, Brown University, USA

5. **Degradation and delamination of TBCs exposed to fly-ash CMAS in gas-turbine engines and its mitigation**
   Amanda R. Krause, Brown University, USA

6. **The effects of microstructure and thin alumina layer on the thermal cycling life for 7YSZ TBCs with CMAS deposits**
   Qing He, Chinese Academy of Agricultural Mechanization Sciences, China

7. **Damage evolution of APS-TBC systems with laser structured and sand blasted fecralloy substrates**
   Mario Schweda, Forschungszentrum Jülich GmbH, Germany

8. **Interdiffusion between vacuum plasma-sprayed protective bond coats and γ`-strengthened cobalt-base superalloys during thermal treatment**
   Philipp J. Terberger, Forschungszentrum Jülich GmbH, Germany

9. **Plasma-based tools for activated EB-PVD of TBC systems**
   Burkhard Zimmermann, Fraunhofer Institute for Electron Beam and Plasma Technology, Germany

10. **Reactively co-sputtered alumina-stabilized zirconia – a base layer for EBPVD-TBC?**
    Heidrun Klostermann, Fraunhofer Institute for Electron Beam and Plasma Technology, Germany

11. **Understanding the presence of $CaSO_4$ within CMAS and its effect on the infiltration behaviour in EB-PVD 7YSZ**
    Ravisankar Naraparaju, German Aerospace Center (DLR), Germany

12. **The effect of zirconia concentration on the M' structure and the M'-M transformation in yttrium tantalate**
    Mary Gurak, Harvard University, USA

13. **Oxydation dynamics in APS and HVOF deposited AMDRY997 alloys**
    Aurel-Mihai Vlaicu, I. N. C. D. Fizica Materialelor, Romania

14. **Mechanism of molten salt attack on zirconia based thermal barrier materials**
    Ashutosh S. Gandhi, Indian Institute of Technology Madras, India

15. **Synthesis and thermophysical properties of $La_2Zr_2O_7/SrZrO_3$ composite as a new thermal barrier coating material**
    Wen Ma, Inner Mongolia University of Technology, China

16. **Microstructure control of new generation SOL-GEL thermal barrier coatings: Formulation and processing**
    Fabien Blas, Institut Carnot CIRIMAT, France

17. **Palladium and platinum modified aluminide bond coatings for EB-PVD TBCs**
    Radosław Swadźba, Institute for Ferrous Metallurgy, Poland

18. **Influence of TBC coating on fatigue performance in resonance bending**
    Radek Musalek, Institute of Plasma Physics AS CR, v.v.i., Czech Republic

19. **Oxidation and rumpling quantitative study on AM1/NiPtAl/7YPSZ EB-PVD TBC system**
    Martine Poulain, Onera, France

20. **Process property relationships for plasma sprayed gadolinium zirconate**
    Vaishak Viswanathan, Stony Brook University, USA

21. **Development of high entropy alloy bond coat compositions for thermal barrier coating systems**
    Todd M. Butler, The University of Alabama, USA

22. **Long term degradation behavior of $La_2Zr_2O_7$-$Yb_2Zr_2O_7$ thermal barrier coatings**
    Xiaorui Ren, Tsinghua University, China

23. **Thermophysical properties of simultaneous substituted pyrochlore solid solutions $(Gd_2Zr_2O_7)1-x(Ca_2Nb_2O_7)x$**
    Meng Zhao, Tsinghua University, China

24. **Influence of thin PVD inter-layers on the durability of high temperature coating systems**
    Ibrahim Ali, TU-Chemnitz, Germany

25. **Evolution of thermal barrier coating systems during isothermal oxidation at 1100°C: Kinetic and crystalline structure study**
    Luis Alberto Cáceres Díaz, Unidad Querétaro, Mexico

26. **Hot corrosion of shipboard turbine components in a low velocity burner rig using alternative fuels**
    Timothy Montalbano, University of California, Irvine, USA

27. **Elucidation of the yttria-tantala-zirconia phase diagram**
    Chandra A. Macauley, University of California, Santa Barbara, USA

28. **Explicit-DEM modeling of failure in thermal barrier coatings**
    John W. Pro, University of California, Santa Barbara, USA

29. **A new technique for measuring TGO interfacial toughness**
    David J. Jorgensen, University of California, Santa Barbara, USA

30. **Bond coat cavitation under CMAS-infiltrated thermal barrier coatings**
    Kaylan M. Wessels, University of California, Santa Barbara, USA

31. **Rare earth efficacy for CMAS mitigation in T/EBC systems**
    David L. Poerschke, University of California, Santa Barbara, USA

32. **The influence of the composition of single crystalline NiAl and bond coats on fracture toughness, hardness and Young's modulus**
    Ralf Webler, University of Erlangen-Nürnberg, Germany

33. **On the oxidation behaviour of Al-Cr-Si base bond-coat type alloys**
    Amir Nanpazi, University of Sheffield, United Kingdom

34. **Low thermal conductivity TBCs with large lamellar pores prepared by plasma-cospraying of soid powder and suspension**
    Guan-Jun Yang, Xi'an Jiaotong University, China

35. **Influence of particle size on composition and properties of La2Ce2O7 splats and coatings deposited by plasma spraying**
    Chang-Jiu Li, Xi'an Jiaotong University, China

36. **Evolution of microstructure and properties of plasma sprayed ysz coating attached to substrate during thermal cycling**
    Guang-Rong Li, Xi'an Jiaotong University, China

37. **Determination of interfacial adhesion energies of thermal barrier coatings by compression test and cohesive zone finite element method**
    Wang Zhu, Xiangtan University, China

38. **Sol-gel synthesis and characterisation of LaTi2Al9O19 thermal barrier material**
    Peng Zhang, University College London, United Kingdom

39. **The detection of failure process in thermal barrier coatings based on acoustic emission testing**
    Li Yang, Xiangtan University, China

40. **Oxidation analysis of thermal barrier coatings based on the large deformation theory**
    Qiang Shen, Xiangtan University, China

41. **Thermal cycling life of thermal barrier coatings prepared by plasma spraying with dry-ice blasting**
    Guan-Jun Yang, Xi'an Jiatong University, China