

## *Program*

# Thermal Barrier Coatings III

August 7-12, 2011

**Kloster Irsee  
Irsee, Germany**

**Conference Chair:**

**Dr. Michael J. Maloney**  
Pratt & Whitney, USA

**Conference Co-Chairs:**

**Dr. Uwe Schulz**, German Aerospace Center, Germany

**Dr. David Rickerby**, Rolls-Royce UK

**Dr. Ram Darolia**, GE Aviation (Retired), USA

**Dr. Odile Lavigne**, ONERA DMSM/MAT, France

**Dr. Hideyuki Murakami**, National Institute for Materials Science, Japan

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



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**The organizers would like to thank the following for their support of this conference:**

**The Office of Naval Research**

**Pratt & Whitney**

## **Sunday, August 7, 2011**

- 16:00 - 18:00 Registration (Hospitality Desk in Kloster Irsee Lobby)
- 18:15 - 19:30 Organ Concert:  
Roland Götz, Organist, will play on the historic organ of the monastery Church
- 19:30 - 20:30 Reception (Kloster Irsee Restaurant)
- 20:30 - 22:00 Dinner (Kloster Irsee Restaurant)
- 22:00 – 23:00 Social Hour (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 3-5 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 any corrections to your name/contact information on the Master Participant List or confirm (by your initials) that the listing is correct. A corrected 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, August 8, 2011**

07:00 - 08:00 Breakfast

08:00 - 08:15 Welcome and Conference Overview  
Michael Maloney, Pratt & Whitney  
Ram Darolia, ECI Technical Liaison

**SESSION 1: OVERVIEWS**

Chair: David Shifler, Office of Naval Research, USA

08:15 - 09:00 H.-P. Bossmann  
Alstom, Switzerland  
RELIABLE THERMAL BARRIER COATINGS FOR HIGH-LOADED  
TURBINE AND COMBUSTOR PARTS

09:00 - 09:45 Huibin Xu  
Beihang University, China  
RESEARCH PROGRESS ON TBCS MATERIALS FOR ULTRA-HIGH  
TEMPERATURE APPLICATIONS

09:45 - 10:15 Coffee Break

10:15 - 11:00 David Rickerby  
Rolls Royce, UK  
LIFING AND DEGRADATION OF EB-PVD THERMAL BARRIER COATINGS

**SESSION 2: BONDCOAT DEVELOPMENT AND BEHAVIOR**

Chair: Brian Gleeson, University of Pittsburgh, USA

11:00 - 11:40 Teresa Pollock  
University of California, Santa Barbara, USA  
COMBINATORIAL STUDIES OF NIAL-BASED OVERLAY BOND  
COATINGS

11:40 - 12:20 Shengkai Gong,  
Beihang University, China  
NEW BOND COAT MATERIALS IN TBC SYSTEM FOR ADVANCED SINGLE  
CRYSTAL SUPERALLOY

12:20 - 13:30 Lunch

13:30 - 14:10 Akihiro Sato  
Research Laboratory, IHI Corporation, Japan  
DEVELOPMENT OF NEW PT- $\gamma$ + $\gamma'$  TYPE BOND COATINGS FOR  
ADVANCED NI-BASE SINGLE CRYSTAL SUPERALLOYS

14:10 - 14:40 Discussion

**Monday, August 8, 2011 (continued)**

**SESSION 3: FUNDAMENTALS OF OXIDATION**

Chair: Gerald Meier, University of Pittsburgh, USA

- 14:40 - 15:20 Brian Gleeson  
University of Pittsburgh, USA  
COMPOSITIONAL FACTORS AFFECTING THE OXIDATION BEHAVIOR  
OF CURRENT AND DEVELOPMENTAL BOND COATING SYSTEMS
- 15:20 - 15:50 Afternoon Coffee Break
- 15:50 - 16:30 Dimitry Naumenko  
Juelich, Germany  
OXIDATION OF MCRAZY-BOND COATS AND ITS INFLUENCE ON  
THE THERMAL CYCLIC LIFETIME OF YSZ TBC SYSTEMS
- 16:30 – 16:50 Roger Reed (presented by Rudder Wu)  
University of Birmingham, UK  
FACTORS CONTROLLING ADHESION OF TBC SYSTEMS TO NICKEL-  
BASED SUPERALLOYS
- 16:50 – 17:10 Rudder Wu  
ICYS, National Institute for Materials Science, Japan  
TOWARDS A DETAILED UNDERSTANDING OF THE FUNDAMENTAL  
MECHANISMS UNDERLYING THE BENEFICIAL EFFECTS OF PLATINUM  
MODIFICATION
- 17:10 – 17:50 Vladimir Tolpygo  
Honeywell, USA  
ON THE ORIGIN OF STRESSES IN ALUMINIDE BOND COATS DURING  
SERVICE AT HIGH TEMPERATURES
- 17:50 - 18:10 Discussion
- 19:00 - 20:30 Dinner
- 20:30 - 22:00 Social Hour

**Tuesday, August 9, 2011**

07:00 - 08:00 Breakfast

**SESSION 4-1: TOP COAT DEVELOPMENT AND CHARACTERISTICS**

Chairs: Uwe Schulz, DLR, German Aerospace Center, Germany  
Richard Wellman, Cranfield University, UK

08:00 - 08:40 Konstantyn Yakovchuk  
ICEBT, Ukraine

ELECTRON BEAM TECHNOLOGY AND EQUIPMENT FOR  
DEPOSITION OF GRADED TBC

08:40 - 09:20 Frederic Rousseau

LGPPTS Ecole Nationale Supérieure de Chimie de Paris, France  
DEVELOPMENT OF A LOW PRESSURE PLASMA DEPOSITION  
TECHNIQUE TO IMPROVE THE PROPERTIES AND THE  
RESISTANCE OF THERMAL BARRIER COATINGS

09:20 - 10:00 Robert Vassen

Juelich, Germany

SUSPENSION PLASMA SPRAYING FOR THE MANUFACTURE OF  
ADVANCED THERMAL BARRIER COATINGS

10:00 - 10:30 Coffee Break

10:30 - 11:10 Derek Hass

DVTI, USA

PROCESSING OF ADVANCED THERMAL BARRIER COATINGS  
VIA DIRECTED VAPOR DEPOSITION

11:10 - 11:40 Roman Kubrin

Hamburg University of Technology, Germany

MULTILAYER 3D PHOTONIC CRYSTALS FOR APPLICATION AS  
HIGHLY REFLECTIVE THERMAL BARRIER COATINGS

11:40 - 12:10 Lucy Y. Liu

Chromalloy Gas Turbine LLC, USA

A NEW APS MULTILAYER TBC WITH LOW K AND HIGH DURABILITY

12:10 - 12:30 Discussion

12:30 -

Boxed Lunch

Optional Excursion

18:00 - 19:00 Dinner

**Tuesday, August 9, 2011 (continued)**

**SESSION 4-2: TOP COAT DEVELOPMENT AND CHARACTERISTICS**

Chair: Robert Vassen, Forschungszentrum Jülich GmbH, Germany

- 19:00 - 19:40 Sanjay Sampath  
State University of New York, USA  
CONTROLLED INTRODUCTION ON ANELASTICITY IN PLASMA  
SPRAYED TBCS: IMPLICATIONS FOR PERFORMANCE AND  
RELIABILITY
- 19:40 - 20:20 Konstantin Von Niessen  
Sulzer, Switzerland  
VAPOR PHASE DEPOSITION USING A PLASMA SPRAY PROCESS
- 20:20 - 21:00 Ping Xiao  
University of Manchester, UK  
MICROSTRUCTURE, RESIDUAL STRESSES AND MECHANICAL  
PROPERTIES OF TBCS
- 21:00 – 21:30 Discussion
- 21:30 - 23:00 Social Hour

**Wednesday, August 10, 2011**

07:00 - 08:00 Breakfast

**SESSION 4-3: TOP COAT DEVELOPMENT AND CHARACTERISTICS**

Chairs: Odile Lavigne, ONERA, DMSM/MAT, France  
Kevin Hemker, Johns Hopkins University, USA

08:00 - 08:40 Gerry Meier  
University of Pittsburgh, USA  
THE EFFECT OF PROCESSING VARIABLES ON THE DURABILITY  
OF HIGH-PURITY YSZ-TBCS PREPARED BY APS

08:40 - 09:20 Dongming Zhu  
NASA, USA  
ENVIRONMENTAL BARRIER COATINGS FOR SIC/SIC CERAMIC MATRIX  
COMPOSITE TURBINE ENGINE HOT-SECTION COMPONENTS: ADVANCES,  
APPLICATIONS AND DIRECTIONS

09:20 - 10:00 Kang Lee  
Rolls Royce, USA  
RECESSION OF ENVIRONMENTAL BARRIER COATINGS FOR CERAMIC  
MATRIX COMPOSITES

10:00 - 10:30 Coffee Break

10:30 - 11:00 Maria Ophelia Jarligo  
Julich GmbH, Germany  
NEW THERMAL BARRIER COATINGS FROM COMPLEX PEROVSKITES

11:00 - 11:30 Ming Fu  
GE Aviation, USA  
IMPACT AND EROSION PERFORMANCE OF THERMAL BARRIER COATINGS

11:30 - 12:00 Federico Cernuschi  
RSE, Italy  
THERMAL DIFFUSIVITY MEASUREMENT BY THERMOGRAPHIC  
TECHNIQUE FOR THE NON DESTRUCTIVE INTEGRITY ASSESSMENT OF  
TBCS COUPONS

12:00 - 12:30 Discussion

12:30 - 13:30 Lunch

**SESSION 5: CMAS MECHANISMS AND MITIGATION**

Chairs: David Litton, Pratt & Whitney, USA  
David Clarke, Harvard University, USA

13:30 - 14:10 Carlos Levi  
University of California, Santa Barbara, USA  
CMAS: LESSONS LEARNED AND PERSPECTIVES

**Wednesday, August 10, 2011 (continued)**

- 14:10 - 14:50 Peter Mechnich  
DLR, Germany  
THERMOCHEMICAL ATTACK OF ARTIFICIAL AND NATURAL  
VOLCANIC ASHES ON 7 YSZ AND PYROCHLORE TBCS
- 14:50 - 15:20 Wolfgang Braue  
DLR, Germany  
GARNET-TYPE REACTIVE INTERFACES FROM FE-TI-CMAS HOT  
CORROSION OF YSZ COATED ENGINE HARDWARE
- 15:20 - 15:50 Coffee Break
- 15:50 - 16:20 M.H. Vidal-Setif  
ONERA, France  
CMAS DEGRADATION OF EB-PVD THERMAL BARRIER COATINGS:  
FROM EX SERVICE EXAMINATIONS TO LABORATORY TESTS
- 16:20 - 17:00 Nitin Padture  
The Ohio State University, USA  
PLASMA-SPRAYED THERMAL BARRIER COATINGS THAT ARE  
RESISTANT TO DAMAGE BY MOLTEN DEPOSITS: CMAS SAND,  
VOLCANIC ASH, AND COAL FLY ASH
- 17:00 - 17:30 M. Shinozaki  
University of Cambridge, UK  
THE EFFECT OF CMAS- ASSISTED SINTERING ON THE  
THERMOMECHANICAL STABILITY OF PLASMA- SPRAYED TBCS
- 17:30 - 18:00 Discussion
- 18:30 - 19:45 Dinner
- 20:00 - 22:00 **SESSION 6: POSTER SESSION** and Social Hour  
Chair: Sanjay Sampath, SUNY Stonybrook, USA

**Thursday, August 11, 2011**

07:00 - 08:00 Breakfast

**SESSION 7: FAILURE MECHANISMS**

Chairs: David Rickerby, Rolls Royce, UK

Ram Darolia, General Electric (retired), USA

Teresa Pollack, University of California Santa Barbara, USA

08:00 - 08:40 Ramesh Subramanian  
Siemens, USA

ADVANCED MULTI-FUNCTIONAL COATINGS FOR LAND-BASED  
INDUSTRIAL GAS TURBINES

08:40 - 09:20 David Clarke  
Harvard University, USA

PROPERTY AND DAMAGE EVOLUTION IN THERMAL BARRIER COATINGS

09:20 - 10:00 Wim G. Sloof  
Technical University of Delft, Netherlands

DAMAGE GROWTH TRIGGERED BY INTERFACE IRREGULARITIES IN  
THERMAL BARRIER COATINGS

10:00 - 10:30 Coffee Break

10:30 - 11:10 Yutaka Kagawa  
University of Tokyo, Japan

EFFECT OF EXTRINSIC FACTORS FOR DEFORMATION OF EB-  
PVD THERMAL BARRIER COATINGS: SOME RESULTS OF  
THERMO-MECHANICAL FATIGUE TESTS

11:10 - 11:50 Kevin Hemker  
John Hopkins University, USA

EXPERIMENTAL INVESTIGATIONS OF DELAMINATION TOUGHNESS  
IN LAYERED PROTECTION SYSTEMS

11:50 - 12:20 Mario Schweda  
Forschungszentrum Jülich, Germany

INFLUENCE OF BONDCOAT CREEP AND ROUGHNESS ON TBC-DAMAGE

12:20 - 13:30 Lunch

13:30 - 14:10 Eric Jordan  
University of Connecticut, USA

UNDERSTANDING APS TBC FAILURE BY SUFFICIENTLY REALISTIC  
MODELING AND SUPPORTING EXPERIMENTS

14:10 - 14:50 Richard Wellman, University of Cranfield, UK

ARE EB PVD TBCS MORE EROSION RESISTANT THAN PS TBCS?

14:50 - 15:20 M. Rudolphi  
Karl-Winnacker-Institut der DECHEMA, Germany

FAILURE PREDICTION OF THERMAL BARRIER COATINGS USING A  
FRACTURE MECHANICS APPROACH

15:20 - 15:50 Afternoon Coffee

**Thursday, August 11, 2011 (continued)**

- 15:50 - 16:30 Matthias Oechsner  
University of Darmstadt, Germany  
PROPERTY VARIATIONS IN TBC SYSTEMS AND THEIR IMPACT ON  
TURBINE DESIGN
- 16:30 - 17:30 Discussion
- 18:30 - Conference dinner and social hour

**Friday, August 12, 2011**

07:00 - 08:00 Breakfast

**SESSION 8: LIFE MODELING AND CHARACTERIZATION TECHNIQUES**

Chairs: Matthias Oechsner, Technische Universität Darmstadt, Germany  
Yukata Kagawa, The University of Tokyo, Japan

- 08:00 - 08:40 Tilmann Beck  
FZ Juelich, Germany  
TBC'S FOR GAS TURBINES UNDER THERMO-MECHANICAL  
LOADINGS: FAILURE BEHAVIOUR AND LIFE PREDICTION
- 08:40 - 09:20 Kyoko Kawagishi (presented by Hiroshi Harada)  
National Institute for Materials Science, Japan  
THERMAL CYCLIC LIFE OF EB-PVD TBC SYSTEM
- 09:20 - 10:00 Jeffery Eldridge  
NASA, USA  
OBSERVING DAMAGE EVOLUTION IN THERMAL BARRIER COATINGS  
BY LUMINESCENCE IMAGING
- 10:00 - 10:30 Coffee Break
- 10:30 - 11:00 Pascale Kanoute,  
ONERA, France  
LIFE TIME ANALYSIS FOR TBC SPALLATION
- 11:00 - 11:30 Bauke. Heeg  
Lumium, The Netherlands  
OPTICAL DIAGNOSTICS ON THERMAL BARRIER COATING STRUCTURES
- 11:30 - 12:00 Hua Wei  
Institute of Metals, Academy of Science, China  
A NUMERICAL MODEL FOR FAILURE MECHANISMS OF THERMAL  
BARRIER COATINGS
- 12:00 – 12:30 Wrap-up discussions
- 12:30 Lunch and Departures

## Poster Presentations

1. Ashutosh S. Gandhi  
Indian Institute of Technology Madras, India  
FRACTURE TOUGHNESS OF RARE-EARTH STABILISED ZIRCONIA THERMAL BARRIER MATERIALS: EFFECT OF PHASE TRANSFORMATIONS
2. Gopal Dwivedi  
Stony Brook University, USA  
EFFECT OF MOISTURE ON THE COMPLIANCE OF THERMAL BARRIER COATINGS
3. Hui Peng  
Beihang University, China  
IMPROVED OXIDATION RESISTANCE OF A NOVEL NICOCRALY COATING FABRICATED BY PLASMA-ACTIVATED EB-PVD
4. Fanny Riallant  
Institut Prime CNRS-ENSMA, Snecma - SAFRAN Group, France  
STRESS INFLUENCE ON HIGH TEMPERATURE OXIDE SCALE GROWTH: EXPERIMENTAL INVESTIGATION ON THE AM1/NIALPT/EBPVD YSZ SYSTEM
5. Olena Trunova  
Research Centre Jülich, Germany  
MICROSTRUCTURAL AND ACOUSTIC DAMAGE ANALYSIS OF AIR PLASMA-SPRAYED THERMAL BARRIER COATINGS UNDER THERMAL CYCLING
6. Qing He  
Chinese Academy of Agricultural Mechanization Science, China  
SEGMENTED TBCS PRODUCED BY ATMOSPHERIC PLASMA SPRAYING 7YSZ POWDER WITH LOW IMPURITY CONTENT
7. Fan Yang  
University of Manchester, UK  
THERMAL CONDUCTIVITIES OF ZIRCONIA-CERIA-YTTRIA SOLID SOLUTIONS
8. Julie M. Drexler  
The Ohio State University, USA  
THERMAL GRADIENT CYCLING WITH SIMULTANEOUS SILICATE PARTICLE DEPOSITION ONTO ADVANCED AIR PLASMA SPRAYED THERMAL BARRIER COATINGS
9. Andrzej Nowotnik  
Rzeszow University of Technology, Poland  
TECHNOLOGY AND THE DEVELOPMENT OF ADVANCED THERMAL BARRIER COATINGS
10. Andrew D Gledhill  
The Ohio State University, USA  
LIFETIME MODELING OF COAL FLY ASH INFILTRATED THERMAL BARRIER COATINGS IN CYCLIC THERMAL GRADIENT TESTING
11. Ying Zhu  
School of Fundamental Research, China  
PREPARATION AND PROPERTIES OF HOLLOW YSZ NANO-POWDERS

12. J.-R. Vaunois  
ONERA, France  
EXPERIMENTAL TESTS FOR MEASURING INTERFACE FRACTURE TOUGHNESS OF THERMAL BARRIER COATINGS
13. Jessica A. Krogstad  
University of California Santa Barbara, USA  
REVISITING PHASE STABILITY IN T'-ZIRCONIA BASED TBCS: A COMPARISON OF APS AND EBPVD TBCS
14. Erin M. Donohue  
University of California Santa Barbara, USA  
MODE I DELAMINATION TOUGHNESS OF AIR PLASMA SPRAY ZIRCONIA COATINGS: EXPERIMENTAL MEASUREMENTS AND FINITE ELEMENT ANALYSIS
15. Peter Wittig  
Technische Universität Darmstadt, Germany  
FRACTURE MECHANICAL CHARACTERIZATION OF PLASMA-SPRAYED THERMAL BARRIER COATINGS
16. Gregoire Witz  
Alstom Switzerland AG, Switzerland  
ANALYTICAL TOOLS FOR INVESTIGATION OF EX-SERVICE THERMAL BARRIER COATINGS
17. Daniel E. Mack  
IEK-1, Forschungszentrum Jülich GmbH, Germany  
MICROSTRUCTURE EVOLUTION AND THERMAL CYCLING PERFORMANCE OF PLASMA SPRAYED ALUMINATES FOR USE AS THERMAL BARRIER COATINGS
18. Daniel E. Mack  
IEK-1, Forschungszentrum Jülich GmbH, Germany  
THERMOGRAPHIC ONLINE MONITORING OF FAILURE EVOLUTION OF THERMAL BARRIER COATINGS IN GAS BURNER THERMAL CYCLING RIG ENVIRONMENT
19. Ralf Webler  
Institute I: General Materials Properties, University of Erlangen-Nürnberg, Germany  
NANOINDENTATION AND MICROSTRUCTURAL CHARACTERIZATION OF THERMALLY CYCLED NI-AL-CR BOND COATS ON NI-BASE SUPERALLOYS
20. Markus Krottenthaler  
Institute I: General Materials Properties, University of Erlangen-Nürnberg, Germany  
IN-SITU TENSILE TESTING AND RESIDUAL STRESS CHARACTERIZATION OF NIAL BOND COATS USED ON NICKEL BASED SUPERALLOYS
21. Christoph Metzner  
Fraunhofer Institute for Electron Beam and Plasma Technology, Germany  
(FEP) PLASMA-ACTIVATED ELECTRON BEAM VAPOR DEPOSITION - TECHNOLOGIES AND TECHNIQUES
22. Wesley Jackson  
University of California, Santa Barbara, USA  
OXIDATION AND RUMPLING BEHAVIOR OF  $\beta$ -PHASE BOND COATS
23. Wesley Jackson  
University of California, Santa Barbara, USA  
DELAMINATION OF CMAS INFILTRATED TBCS UNDER A THERMAL GRADIENT