

*Program*

# Thermal Barrier Coatings V

*An ECI Conference Series*

June 24 – 29, 2018

Irsee, Germany

Co-Chairs

**Robert Vaßen** (Forschungszentrum Jülich GmbH, Germany)

**Brian Hazel** (Pratt & Whitney, USA)

**Uwe Schulz** (German Aerospace Center, Germany)

**Michael J. Maloney** (Pratt & Whitney, USA)

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



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**Previous conferences in this series:**

***Thermal and Environmental Barrier Coatings***

**Aug 17-22, 2003**

**Irsee, Germany**

*Conference Chairs:*

David R. Clarke, University of California Santa Barbara, USA

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***Thermal Barrier Coatings II***

**August 12-17, 2007**

**Irsee, Germany**

*Conference Chairs:*

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Kevin Hemker, Johns Hopkins University, USA

Christoph Leyens, Technical University of Brandenburg at Cottbus, Germany

Yutaka Kagawa, University of Tokyo, Japan

***Thermal Barrier Coatings III***

**Aug. 7-12, 2011**

**Irsee, Germany**

*Conference Chairs:*

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Ram Darolia, GE Aviation, USA

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**

**Irsee, Germany**

*Conference Chairs:*

Uwe Schulz, German Aerospace Center, Germany

Ram Darolia, GE Aviation, USA

Michael J. Maloney, Pratt & Whitney, USA



**Dongming Zhu**

**December 2, 1962 - May 30, 2018**

The TBC community lost a very active researcher on high temperature ceramics materials and coatings.

Dongming Zhu was a very creative scientist who was full of energy and high throughput. He made lasting contributions in the area of high temperature ceramic coatings. His earlier research identified promising compositions for lower conductivity TBC systems. For the past 10 years, he was involved in identifying environmental barrier coating (EBC) compositions for ceramic metal composites. He made numerous conference presentations, published over 100 scientific papers, contributed to several conference proceedings, and organized conferences and sessions on TBC and EBC. He was very well liked and respected in the community.

He was an active participant in ECI sponsored conferences on TBC, CMC and EBC as evident from the following list:

- 2007 Thermal Barrier Coatings II - Speaker
- 2011 Thermal Barrier Coatings III - Speaker
- 2014 Thermal Barrier Coatings IV – Speaker and Poster Presenter
- 2017 Advanced Ceramic Matrix Composites – Co-Chair, Speaker, and Session Chair

**Conference Sponsors**

**ALD Vacuum Technologies GmbH**

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## **Sunday, June 24, 2018**

- 16:00 - 18:00 Conference Check-in
- 18:00 - 19:00 Organ Concert:  
Roland Götz (Organist) will play on the historic organ of the monastery church
- 19:00 - 21:00 Dinner (Kloster Irsee Restaurant)
- 21:00 - 22:00 Reception (Bierstube/Stiftskeller)

### **NOTES**

- *Audio, still photo and video recording by any device (e.g., cameras, cell phones, laptops, PDAs, watches) is strictly prohibited during the technical sessions, unless the author and ECI have granted prior permission.*
- *Speakers – Please have your presentation loaded onto the conference computer prior to the session start (preferably the day before).*
- *Speakers – Please leave discussion time as previously directed by your session chair.*
- *Please do not smoke at any conference functions.*
- *Turn your mobile telephones to vibrate or off during technical sessions.*
- *Please write your name on your program so that it can be returned to you if lost or misplaced.*
- *After the conference, ECI will send an updated participant list to all participants. Please check your listing now and if it needs updating, you may correct it at any time by logging into your ECI account.*

### ***Additional hotels housing conference participants***

*Klosterbrau - Klosterring 1-3, 87660 Irsee, Germany*

*Ibis hotel Kaufbeuren – Ganghoferstrasse 8, 87600 Kaufbeuren, Germany*

*Hotel am Turm – Josef-Landes-Strasse 1, 87600 Kaufbeuren, Germany*



## **Monday, June 25, 2018**

07:00 - 08:15 Breakfast

08:15 - 08:30 Conference Overview:  
Robert Vaßen, Forschungszentrum Jülich GmbH, Jülich, Germany  
ECI Introduction: Ram Darolia, ECI Technical Liaison

### **Session 1: Overview on TBC/EBC Application, Industrial Perspective**

**Chairs: Philip Howell, Brian Hazel**

08:30 – 09:00 Dan Roth-Fagaraseanu Rolls Royce Deutschland, Germany  
Ceramic layers in aero-engines: Adding complexity to reach the thermal limits of materials

09:00 – 09:30 Francesco Bozza, Turbocoating S.p.A., Italy  
Suspension plasma spray TBC applied on gas turbine components

09:30 – 10:00 Taiji Torigoe, Mitsubishi Heavy Industries, Ltd., Japan  
Development and application of advanced thermal barrier coating for high efficiency gas turbine

10:00 – 10:30 Coffee Break

10:30 – 11:00 Jürgen Hotz, ALD Vacuum Coating Technologies GmbH, Germany  
Current market situation on aircraft engines and increasing requirements of EB-PVD equipment

11:00 – 11:30 Albert Feuerstein, Praxair Surface Technologies, USA  
Operational experience with EB-PVD commercial equipment and processes

11:30 – 13:00 Lunch

### **Session 2: Bondcoat Development and Oxidation Behavior**

**Chairs: Sanjay Sampath, Hideyuki Murakami**

13:00 – 13:30 Damien Texier, Institut Clément Ader-UMR CNRS 5312, France  
High temperature tensile properties of  $\beta$ - $\gamma$ - $\gamma'$ -MCrAlY and  $\beta$ -Ni(Al,Pt) bond-coatings and interdiffusion zone with Ni-based single crystal superalloys

13:30 – 14:00 Mohit Gupta, University West, Sweden  
Development of bondcoats for high lifetime suspension plasma sprayed thermal barrier coatings

14:00 – 14:30 Bruce A. Pint, Oak Ridge National Laboratory, USA  
Effect of specimen geometry and aps flash bond coating on TBC lifetime

14:30 – 15:00 Dmitry Naumenko, Forschungszentrum Jülich-IEK2, Germany  
Oxidation and interdiffusion in MCrAlY-type bondcoats and their correlation with TBC life

15:00 – 15:30 Coffee Break

15:30 – 16:00 Ping Xiao, University of Manchester, UK  
Development of bond coats for extending lifetime of TBCs

**Monday, June 25, 2018 (continued)**

- 16:00 – 16:30 Daniel Mumm, University of California Irvine, USA  
Hot corrosion degradation of marine gas turbine materials subject to mixed-mode thermal exposures and complex corrosion environments
- 16:30 – 17:00 Kazuhiro Ogawa, Gota Katayanagi, Yuji Ichikawa, Tohoku University, Japan  
Development of thermal barrier coatings with excellent delamination resistant property by extreme internal oxidation
- 17:00 - 17:30 Discussion
- 18:30 - 21:30 Dinner and social hour

## **Tuesday, June 26, 2018**

07:00 - 08:30 Breakfast

### **Session 3: TBC Development**

**Chairs: Daniel Mack, Michael Maloney**

- 08:30 – 09:00 Sanjay Sampath, State University of New York at Stony Brook, USA  
Multifunctional thermal barrier coatings enabled by layered manufacturing
- 09:00 – 09:30 Nicolaie Markocsan, University West, Sweden  
Axial suspension plasma spraying: Microstructure effect on coatings performance
- 09:30 – 10:00 Seongwon Kim, Korea Institute of Ceramics, Korea  
Fabrication of double-ceramic-layer TBCs by suspension plasma spray
- 10:00 – 10:30 Coffee Break
- 10:30 – 11:00 Yeon Woo Yoo, Korea Institute of Materials Science, Korea  
Microstructure and thermal conductivities of suspension vacuum plasma sprayed YSZ coatings
- 11:00 – 11:30 Xueqiang Cao, Wuhan University of Technology, China  
Thermal barrier coatings on polymer materials
- 11:30 – 12:00 Hui Peng, Beihang University, China  
PS-PVD thermal/environmental barrier coatings with novel microstructures
- 12:00 – 13:30 Lunch
- 13:30 – 14:00 Burkhard Zimmermann, Fraunhofer FEP, Germany  
Optical emission spectroscopy for rate and composition control of plasma-assisted EBPVD processes
- 14:00 – 14:30 Arnaud Fregeac, Florence Ansart, CIRIMAT, France  
Relationship between mechanical properties and microstructure of yttria stabilized zirconia ceramics densified by Spark Plasma Sintering
- 14:30 – 15:00 Federico Cernuschi, RSE, Italy  
Thermophysical, microstructural characterization and non-destructive control of TBCs by photothermal and thermographic techniques: some lessons learned
- 15:00 – 15:30 Coffee Break
- 15:30 – 16:00 Emma Barbareschi, Ansaldo Energia, Italy  
Effect of cooling rate on phase transformation in 6-8 wt % YSZ APS TBCs
- 16:00 – 16:30 Patrick E. Hopkins, University of Virginia, USA  
Phonon scattering mechanisms contributing to the low thermal conductivities of entropy stabilized oxides and high entropy carbides
- 16:30 – 17:00 Jeffrey I. Eldridge, NASA, USA  
Temperature mapping above and below air film-cooled thermal barrier coatings using phosphor thermometry
- 17:00 – 17:30 Christopher Pilgrim, Sensor Coating Systems, United Kingdom  
Progress on luminescence coatings for temperature mapping on turbine engines
- 17:30 – 18:00 Discussion
- 18:30 – 21:30 Dinner and social hour

**Wednesday, June 27, 2018**

07:00 - 08:30 Breakfast

**Session 4: CMAS – Failure and Mitigation Strategies**

**Chairs: Dan Roth-Fagaraseanu, Hayden Wadley**

08:30 – 09:00 Carlos Levi, University of California Santa Barbara, USA  
Fundamental challenges in CMAS mitigation

09:00 – 09:30 David Poerschke, University of Minnesota, USA  
Application of phase equilibrium modeling to understand and mitigate the CMAS threat in thermal and environmental barrier coatings

09:30 – 10:00 Ravishankar Naraparaju, DLR-German Aerospace Center, Germany  
Criteria for development of new CMAS / volcanic ashes resistant TBCs in thermal gradient and FCT

10:00 – 10:30 Coffee Break

10:30 – 11:00 Dana Frankel, QuesTek Innovations LLC, USA  
Computational tool to accelerate CMAS-resistant TBC design for aero-turbine applications

11:00 – 11:30 Wenjia Song, LMU, Munich, Germany  
Molten volcanic ash deposition in jet engines

11:30 – 12:00 Eric Jordan, University of Connecticut, USA  
Role of microstructure geometry and CMAS viscosity in CMAS Infiltration

12:15 – 18:00 Optional excursion

18:00 – 19:30 Dinner

19:30 - 21:30 **Poster session** and social hour

## **Thursday, June 28, 2018**

- 07:00 - 08:30 Breakfast
- 08:30 – 09:00 Sandrine Duluard, Université Paul Sabatier / CIRIMAT, France  
CMAS interaction with yttrium based systems: Towards a promising solution?
- 09:00 – 09:30 Siddharth Lokachari, Ludwig Maximilian University of Munich, Germany  
Novel thermal barrier coatings resistant to molten volcanic ash wetting
- 09:30 – 10:00 Lars Steinberg, Technical University Dresden, Germany  
Investigation of erosion behavior of EB-PVD-TBCs and sacrificial coatings after CMAS infiltration
- 10:00 – 10:30 Coffee Break
- Session 5: Failure Mechanisms**  
**Chairs: Federico Cernuschi, Carlos Levi**
- 10:30 – 11:00 Vincent Guipont, Vincent Maurel, Marion Bartsch, MINES ParisTech, PSL Research University, France  
Interfacial toughness evolution under thermal cycling by laser shock and mechanical testing of an EB-PVD coating system
- 11:00 – 11:30 Wesley Jackson, United Technologies Research Center, USA  
The influence of thermal transient rates on TBC spallation
- 11:30 – 12:00 Kevin Hemker, Johns Hopkins University, USA  
Experimental measurements of thermal barrier coating interfacial fracture toughness as a function of mode-mix
- 12:00 – 13:30 Lunch
- 13:30 – 14:00 Marcel Adam, Technical University Darmstadt, Germany  
Failure behavior of modern double-layer thermal barrier coatings subjected to compression tests
- 14:00 – 14:30 Philip Howell, Siemens AG, Germany  
The influence of heating and cooling rates on TBC failure in high heat flux tests
- 14:30 – 15:00 Daniel Emil Mack, Forschungszentrum Julich-IEK1, Germany  
Thermally sprayed protective coatings under demanding load conditions
- 15:00 – 15:30 Coffee Break
- 15:30 – 16:00 Matthew R. Begley, University of California Santa Barbara, USA  
Virtual testing and design of barrier coating systems
- 16:00 – 16:30 Uwe Schulz, DLR-German Aerospace Center, Germany  
Lifetime evaluation of various new EB-PVD and APS TBCs in thermal in thermal gradient and FCT
- 16:30 – 17:00 Discussion
- 17:00 – 17:30 **Pre-dinner talk**  
Brian Hazel, Pratt & Whitney, USA  
Real world drivers to the durability of coating & material systems in gas turbines
- 19:30 - 20:00 Reception
- 20:00 Conference dinner, awards and prizes, and social hour  
Introductory remarks: Ram Darolia

**Friday, June 29, 2018**

07:00 - 08:30 Breakfast

**Session 6: Environmental Barrier Coatings**

**Chairs: Matthew Begley, Uwe Schulz**

08:30 – 09:00 Hayden Wadley, University of Virginia, USA  
T-EBC coating system failure modes

09:00 – 09:30 Hideki Kakisawa, National Institute for Materials Science, Japan  
Interface toughness measurement of environmental barrier coatings for SiC/SiC composites

09:30 – 10:00 Gopal Dwivedi, Oerlikon Metco, USA  
Thermal spray processing routes for environmental barrier coatings

10:00 – 10:30 Coffee Break

10:30 – 11:00 Nitin Padture, Brown University, USA  
Towards multifunctional thermal-barrier and environmental-barrier coatings

11:00 – 11:30 Emine Bakan, Forschungszentrum Julich-IEK1, Germany  
Environmental barrier coatings for SiC/SiC and Ox/Ox CMCs

11:30 – 12:00 Elizabeth J. Opila, University of Virginia, USA  
Microstructural evolution of environmental barrier coatings in high-temperature steam

12:00 – 12:30 Final discussion and concluding remarks

12:30 – 14:00 Lunch and departures

## Poster Presentations

### Session 1: Overview on TBC/EBC application, industrial perspective

1. **Semiconductor process chamber coatings: Improving performance and uptime**  
David A. Britz, Applied Materials, USA

### Session 2: Bondcoat Development and Oxidation Behaviour

2. **Oxidation behavior of two-phase ( $\gamma'$ + $\beta$ ) Ni-Al coatings doped with Dy and Hf**  
Shixing wang, Qing He, Weiping Wang, Chinese Academy of Agriculture Mechanization Sciences, China; Hongbo Guo, Beihang University, China
3. **Multiple-scale modeling of Pt effect on durability of aluminide coatings**  
Kuiying Chen, National Research Council of Canada, Canada; Prakash C. Patnaik, Gas Turbine Laboratory, National Research Council, Canada
4. **Design of novel  $\gamma'$  bondcoats and interdiffusion with Re-rich superalloys**  
Thomas Gheno, Martine Poulain, Stéphane Landais, Catherine Rio, Odile Lavigne Onera, Onera - The French Aerospace Lab, France
5. **Sustained peak low-cycle fatigue: The role of oxidation resistant bond coatings**  
Marissa A. Lafata, Ming Y. He, Tresa M. Pollock, University of California, Santa Barbara, USA
6. **Superior performance of plasma sprayed YSZ thermal barrier coatings with oxide dispersion strengthened bond coats**  
Christoph Vorkötter, Daniel Emil Mack, Olivier Guillon, Robert Vaßen, Forschungszentrum Jülich GmbH, Germany
7. **Microstructural evaluation with type i hot corrosion degradation of gas turbine alloys during burner-rig testing**  
Maryam Zahiri Azar, University of California, Irvine, USA

### Session 3: TBC development

8. **The modification of rare earth Yb doped yttrium aluminum garnet ceramic thermal protective coating material**  
Yue Ma, Zhaolou Xue, Hong-Bo Guo, Xiaolan Zeng, Beihang University, China
9. **Mechanical and thermal properties of nanostructured Gd<sub>2</sub>O<sub>3</sub> doped YSZ coatings prepared by atmospheric plasma spraying**  
Lei Jin, Beijing Aeronautical Manufacturing Technology Research Institute, China
10. **Synthesis and phase stability of the ZrO<sub>2</sub>-Ln<sub>2</sub>O<sub>3</sub>-Ta<sub>2</sub>O<sub>5</sub> compositions for high tetragonality zirconia-based thermal barrier coatings**  
Ivan Mazilin, Eugeny Sazonov, Nikolay Zaitsev, Lev Baldaev, TSPC Ltd, Russia
11. **Phonon scattering mechanisms contributing to the low thermal conductivities of entropy stabilized oxides and high entropy carbides**  
Patrick E. Hopkins, Ashutosh Giri, Jeffrey Braun, Christina Rost, Lavina Backman, Elizabeth Opila, University of Virginia, USA; Mina Lim, Zsolt Rack, Samuel Daigle, Kevin Ferri, Trent Borman, Jon-Paul Maria, Donald Brenner, North Carolina State University; Joshua Gild, Tyler Harrington, Jian Luo, Kenneth Vecchio, University of California; Cormac Toher, Pranab Sarker, Stefano Curtarolo, Duke University

12. **Fibers and sol-gel matrix based thermal barrier coating systems for outstanding durability**  
Sandrine Duluard, Elodie Delon, Florence Ansart, Jean-Pierre Bonino, Daniel Monceau, Aurélie Rouaix-Vande Put, Ronan Mainguy, Carole Thouron, Université Paul Sabatier / CIRIMAT, France; Aurélien Joulia, SAFRAN Tech, Pôle Matériaux et Procédés, rue des Jeunes Bois, France; André Malié, Luc Bianchi, SAFRAN AIRCRAFT ENGINES Site de Chatellerault, France; Philippe Gomez, DGA Techniques aéronautiques, France
13. **Structure and properties of condensed gradient coatings with NiAl-bond coat doped with Y or Dy**  
A.V. Mykytchyk, K.Yu. Yakovchuk, Yu.E. Rudoy, E.V. Onoprienko, R.A.Tkach, State-Run Company "International Center for Electron Beam Technologies (ICEBT) of E.O. Paton Electric Welding of NASU", Ukraine
14. **Tailored thermal barrier coatings deposited by hybrid water-stabilized plasma torch**  
Radek Musalek, Jan Medricky, Tomas Tesar, Frantisek Lukac, Jan Cizek, Ksenia Illkova, IPP CAS, Prague, Czech Republic
15. **Dense ceramic coatings deposited by aerosol deposition for multilayered architecture towards thermal/environmental barrier coatings**  
Kentaro Shinoda, Jun Akedo, National Institute of Advanced Industrial Science and Technology (AIST), Japan
16. **2-layers TBC by EBPVD**  
Valerii Topal, Paton Turbine Technologies, Ukraine
17. **Thermal shock performance of PS-PVD YSZ coating through water quenching cycle test**  
Chunming Deng, Kesong Zhou, Changguang Deng, Jie Mao, Min Liu, Guangdong Institute of New Materials, China
18. **Laser Flash technique: A critical analysis of testing parameters and models for fitting experimental data**  
Federico Cernuschi, RSE, Italy; Paolo Bison, Stefano Boldrini, Consiglio Nazionale delle Ricerche, ITC
19. **The possibilities of using optical properties measurement methods for TBC research**  
Zdeněk Veselý, Milan Honner, Petra Honnerová, University of West Bohemia, Czech Republic
20. **Factors affecting ceramic abrasion coating damage accommodation**  
Kara J. Phillips Bridges, Daniel R. Mumm, University of California, Irvine, USA
21. **Segmentation cracks in plasma spray coatings: Formation dynamics and characterization**  
 Shalaka Shinde, Sanjay Sampath, Stony Brook, New York, USA

#### **Session 4: CMAS – Failure and Mitigation Strategies**

22. **CMAS-resistance of a yttria graded thermal barrier coating fabricated by plasma activated EB-PVD**  
Hui Peng, ShengKai Gong, Yanling Pei, Shusuo Li, Hongbo Guo, Beihang University, China
23. **Gradient damage spreading of molten volcanic ash on thermal barrier coatings**  
Shanjie Yang, Hongbo Guo, Beihang University, China; Wenjia Song, Siddharth Lokachari, Donald Bruce Dingwell, Ludwig Maximilian University of Munich, Germany



24. **High temperature interactions between environmental barrier coating (EBC) ceramics and calcia-magnesia-alumina-silicate (CMAS) glass**  
Laura R. Turcer, Amanda R. Krause, Hector Garces, Lin Zhang, Nitin P. Padture, Brown University, USA
25. **High temperature infiltration behavior of three volcanic ashes of YSZ APS-deposited thermal barrier coatings**  
Marco Antonio Rivera Gil, Juan Muñoz Saldaña, Centro de Investigación y de Estudios Avanzados del IPN, Mexico; Juan José Gómez Chávez, Chintalapalle Ramana, University of Texas at El Paso, USA; Ravisankar Naraparaju, Uwe Schulz, German Aerospace Center (DLR), Germany
26. **Molten volcanic ash deposition in jet engines**  
Wenjia Song, Donald B. Dingwell LMU Munich, LMU Munich, Germany; Masahiro Fukumoto, Toyohashi University of Technology, Japan; Uwe Schulz, Ravisankar Naraparaju, German Aerospace Center, Germany; Yan Lavallée, University of Liverpool, UK; Yanchen You, Xiamen University, China
27. **Volcanic ash versus thermal barrier coatings of jet engines – a holistic experimental approach**  
Dirk Müller, Kai-Uwe Hess, Donald B. Dingwell, LMU Munich, LMU Munich, Germany; Gerhard Wolf, Volodymyr Palchyk, Fraunhofer UMSICHT, Germany; Pawel Rokicki, Rzeszow University of Technology, Poland
28. **Material damage in TBCs by a synthetic CMAS and the non-destructive detection:-An exploration via a single crystal YSZ-**  
Masakazu Okazaki, Nagaoka University of Technology, Japan; Y. Hayashi, Mitsubishi-Hitach Power Systems. Co. USA, Satoshi Yamagishi, Niigata Institute of Technology, Japan
29. **RE2O3 dissolution kinetics and mechanisms in CAS silicate melt: Influence of the rare earth**  
François Perrudin, M-H. Vidal-Sétif, C. Rio, Onera, The French Aerospace Lab, France; C. Petitjean, P-J. Panteix, M. Vilasi, Institut Jean Lamour, Université de Lorraine, France
30. **Calcium–magnesium–alumina–silicate (CMAS) resistance of LaPO4 thermal barrier coatings**  
Lei Guo, Mingzhu Li, Chenglong Zhang, Zheng Yan, Fuxing Ye, Tianjin University, China
31. **An experimentally-validated computational framework for CMAS degradation of environmental barrier coatings**  
William D. Summers, Matthew R. Begley, Carlos G. Levi, Frank W. Zok, University of California, Santa Barbara, USA; David L. Poerschke, University of Minnesota, USA
32. **Kinetics of thermal barrier oxide interactions with molten silicates**  
Collin S. Holgate, Carlos Levi, University of California, Santa Barbara, USA; David Poerschke, University of Minnesota, USA
33. **Raman studies on EB-PVD 7%Ytria - Stabilized Zirconia coatings with CMAS deposits**  
Estefania Bohorquez, Chance Barrett, Ryan Hoover, Laurene Tetard, Seetha Raghavan, University of Central Florida, USA; Ravisankar Naraparaju, Uwe Schulz, Institute of Materials Research, German Aerospace Center, Germany

34. **Y2O3-ZrO2 ratio studies for CMAS resistant thermal barrier coatings prepared by EB-PVD**  
Juan J. Gomez Chavez, Ramana Chintalapalle, University of Texas at El Paso, USA;  
 Ravisankar Naraparaju, Peter Mechnich, Uwe Schulz, German Aerospace Center (DLR), Germany
35. **Calcium-magnesium-alumino-silicate induced degradation of La<sub>2</sub>(Zr<sub>0.7</sub>Ce<sub>0.3</sub>)<sub>2</sub>O<sub>7</sub>/YSZ double-ceramic-layer thermal barrier coatings prepared by electron beam-physical vapor deposition**  
Xin Zhou, Xueqiang Cao, Shujuan Dong, Wuhan University of Technology, China; Chao Wang, Xuyang Xie, Hongqi Zhang, Shanghai Electric Gas Turbine Co.,Ltd., China; Limin He, Beijing Institute of Aeronautical Materials, China
36. **Correlation between porosity, amorphous phase and CMAS corrosion behaviour of LaMgAl<sub>11</sub>O<sub>19</sub> thermal barrier coatings**  
Shujuan Dong, Jinyan Zeng, Junbin Sun, Jianing Jiang, Longhui Deng, Xin Zhou, Xueqiang Cao, Wuhan University of Technology, China
37. **Moved to Wednesday, June 27, 09:30 – 10:00**
38. **Investigation of CMAS resistance of SPS- and SHVOF-alumina topcoats on EB-PVD 7YSZ layers**  
Christoph Mikulla, Ravisankar Naraparaju, Uwe Schulz, German Aerospace Center (DLR), Germany; Filofteia-Laura Toma, Fraunhofer Institute for Material and Beam Technology (IWS), Germany; Lars Steinberg, Christoph Leyens, TU Dresden, Institute of Materials Science, Germany

#### **Session 5: Failure Mechanisms**

39. **On coatings delamination; some analytical solutions**  
Konstantin Ustinov, A.Yi. Ishlinsky Institute for Problems in Mechanics RAS, Russia
40. **Crack morphology in a columnar thermal barrier coating system**  
 Marion Bartsch, Deutsches Zentrum für Luft- und Raumfahrt, Germany; Vincent Guipont, Vincent Maurel, Fabrice Gaslain, Anne Dennstedt, MINES ParisTech, PSL Research University (both Vincents), France
41. **Experimental characterization of elastic stiffness and delamination toughness in commercial thermal barrier coating systems**  
 Jalil Alidoost, Kevin Hemker, Johns Hopkins University, USA
42. **Thermal stress analysis of double-ceramic-layered thermal barrier coatings based on rare earth element**  
Janggyun Lim, Moon Ki Kim, Sungkyunkwan University, South Korea

#### **Session 6: Environmental Barrier Coatings**

43. **Development of environmental barrier coatings for Al<sub>2</sub>O<sub>3</sub>/Al<sub>2</sub>O<sub>3</sub> CMCs with improved Adhesion by texturing with laser ablation**  
Caren Sophia Gatzert, Daniel Emil Mack, Olivier Guillon, Robert Vaßen, Forschungszentrum Jülich GmbH, Germany

44. **Advances in the deposition of ceramics by soft chemistry process : example of rare-earth silicate coatings**  
Manon Prioux, Aude Paillassa, Jessica Mollicone, Sandrine Duluard, Florence Ansart, Université Paul Sabatier / CIRIMAT, France; Guillaume Pujol, Philippe Gomez, DGA Aeronautical Systems, France; Lisa Pin, Safran Ceramics, rue de Touban, France
45. **Development of yttrium and ytterbium silicates from their oxides and an oligosilazane precursor for coating applications to protect Si<sub>3</sub>N<sub>4</sub> ceramics in hot gas environments**  
Mateus Lenz Leite, University of Bayreuth, Germany
46. **From the lab to the industrial scale: EBC thermal spray powders**  
Ursa Pirnat, Treibacher Ind. AG, Austria

#### **Session 5: Failure Mechanisms**

47. **Measurements of mechanical properties of an air plasma sprayed thermal barrier coating using micro-cantilever bending**  
Ying Chen, The University of Manchester, United Kingdom