Participant Profile

for the
Turkish-German Strategy Workshop 2006
TÜBITAK Marmara Research Center,
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International Bureau (IB)
of the Federal Ministry of
Education and Research
(BMBF)

1. Contact details and personal information

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[1] **Role/function** e.g. working group leader, managing director, postdoc, PhD etc.
[2] **Organisation type** e.g. university, research institution, small and medium enterprise (SME), industry etc.

Working Group:	X 1 Material Technologies ☐ 2 Biotechnology, Genomics and Food ☐ 3 Energy ☐ 4 Information and Communication Technologies X 5 Environmental Protection, Climate Change and Sustainable Development
Areas of activity:	X research ☐ training X technology development ☐ dissemination ☐ demonstration ☐ other:
Keywords characterising your area of research:	**Please choose the appropriate key words (max. 5) from the following list:** http://www.cordis.lu/fp6/keywords Aircraft materials application, materials engineering, solid-state physics, passive safety of vehicles, sensors
Expertise, technologies and infrastructures available in your institution:	**Research activities / expertise:** Ceramic materials and coatings **High-temperature ceramic matrix composites for propulsion and thermal protection systems** Für den zukünftigen Luftverkehr ist die Bereitstellung effizienter und umweltfreundlicher Antriebe von hoher ökonomischer und ökologischer Bedeutung, dies gilt sowohl für zivile als auch für militärische Flugzeuge. Ein herausragendes Ziel der Forschungs- und Entwicklungsarbeiten im DLR ist die Realisierung schadstoffarmer Gasturbinen mit verbessertem thermischem Wirkungsgrad. Dies kann durch die Auskleidung der Turbinen-Brennkammer mit Schindeln aus Hochtemperaturwerkstoffen erreicht werden. **High Temperature Coatings** Coatings are used to protect materials and components against harmful attack of the environment. In the Institute of Materials Research both metallic and ceramic coatings are developed that protect metallic, ceramic, and composite materials. **My own expertise areas are in TBCs and catalytic and sensoric coatings.** **Thermal Barrier Coatings (TBCs)** The surface temperature of turbine blades can be reduced in the order of 100 to 150°C by usage of only 0.2mm thick ceramic thermal barrier coatings of low thermal conductivity. This translates in modern aero engines in a reduction of the specific fuel consumption of about 2 to 3 % and a corresponding reduced emission. DLR's preferred manufacturing method, the electron beam physical vapour deposition (EB-PVD), creates very smooth and strain tolerant TBCs. They are the choice for highly loaded rotating aero engine blades due to the fact that the columnar microstructure provides excellent performance under rapid thermal cycling

and thermo-mechanical straining conditions. Blade cooling is maintained because cooling holes stay opened. DLR is one of the world's leading research organizations in the area of EB-PVD thermal barrier coatings. It develops in close cooperation with processing equipment manufacturers, coating companies, engine manufacturers, end users and other research cooperation partners new complex coatings

Catalytic Coatings and Gas Sensors

In the next few years, gaseous emissions related to the growing mobile transport (e.g. road and air traffic) as well as power generation systems will further increase. Due to the associated air pollution, the stringency of NOx- and other gas-emissions has been increased twice in the last decade and yet an additional increase has been recommended. Increases in engine efficiency and in engine operating temperatures have tended to offset the efforts to reduce NOx-emissions requiring the development of use of the best proven low-emission technologies. Current mobile catalytic converter systems which are based on three-way-catalysis (TWC), selective catalytic reduction with addition of ammonium (NH_3-SCR) and storage-reduction (SR) are either optimized for stochiometric A/F-ratio, significantly limited under net-oxidizing conditions or require application of special combustion-cycles, causing major disadvantageous for full-function of the system.
The principal aim of our team is to achieve effective reduction of NOx-emission in automotive engines and turbines of airliners which are today, compared to their predecessors, more fuel-efficient and cleaner by employing advanced technology post- and pre-combustion systems. Current low-emission turbine engines are based on in-furnace-control methods such as axially staged combustor with an LPP main module, dual annular combustor (DAC) as in CFM56 engine or those equipped with optimized injection systems and new diffuser design for lean-modules. As these technologies are still at low development levels to be considered for entry into service, there are some concerns about their applicability due to engine instabilities as well as a likelihood of a trade-off between NOx- and low power HC- and CO-emissions. When these and the issues such as impact of NOx at altitude, NOx-reduction during all phases of flight and difficulties in derivative engine design are merged, the importance of post-combustion NOx-reduction becomes significant. Considering the exhaust gas temperatures, pressure and velocity, use of ceramic coatings which can reduce toxic gases effectively under net-oxidizing conditions is unavoidable. Efficient emission reduction requires fast light-off sensors, proper catalyst conversion and accuracy of the control algorithm. Fuel efficiency, safety, reliability, economic and environmental friendly systems can be realized by installment of an "on-board-diagnosis" coupled catalyst monitoring system. Exhaust gas systems with closed-coupled catalysts and "upstream" sensors very close to the engine outlet or in narrow space between pre- and main catalyst require NOx-sensors with "increased temperature resistivity" and "small sizes". In order to achieve high NOx-sensitivity, it is necessary to employ suitable electrolytes as well as sensing electrodes stable at high-temperatures. In the case of NOx which contains many oxygen derivative species such as NO, NO_2, N_2O, etc., it is a crucial fact to use different sensing element arrays to increase the sensitivity of the sensor. Furthermore, if these sensors are integrated into a catalytic system, it may be necessary to replace the conventional electrolytes with those which perform more robust and incorporated. The research efforts in institute are therefore focused on finding better suitable electrolyte materials and concepts which are able to contribute more to the sensor characteristics through their microstructure as well as chemistry.

Oxidation Protection

Alloys used at elevated temperatures are mainly optimized with regard to their mechanical properties. In oxygen containing or corrosive atmosphere, however, they suffer from insufficient performance. In the institute oxidation protective coatings are developed for both Nickel-based superalloys (mainly as bond coats for thermal barrier coatings) and for titanium alloys. Application of titanium alloys and aluminides at high temperatures is restricted by insufficient lifetime in oxidizing atmosphere. Therefore, an effective protection of these materials is necessary for save operation under various conditions. The main focus of our work is on Magnetron sputtered coatings for application temperatures up to 900°C.

Environmental Barrier Coatings

Ceramic matrix composites such as WHIPOX show often substantial porosity, permeability for gases, and a rough surface caused by the manufacturing. For long term application e.g. as combustion chamber shingles these materials must be protected against the extreme attack due to temperature, hot gas erosion, and chemical reactions especially with water vapour. We develop for those ceramic matrix composites stable ETBCs (environmental and thermal barrier coatings).

Friction Stir Welding (FSW)

Friction Stir Welding (FSW) is a simple, clean and innovative joining technology for light metals invented by TWI, England. Due to the high strength of FSW joints, it allows considerable weight savings in lightweight construction compared to conventional joining technologies.

Light metal composites

Titanium alloys with a density of approx. 4.5 g/cm³ rank among the strongest and stiffest light metals. Due to their unique characteristic combinations titanium alloys are used in many areas of application such as air and space travel, the automobile industry, the dental and medical technology, offshore industry, sport and leisure products. Based on the manufacturing process developed and patented at the Institute of Materials Research not only specimens for material investigations but also prototypes in small series are manufactured to fulfil customer's needs. During the design phase of components, design, concepts, materials development and process technique are closely coupled with one another, as the potential of the titanium matrix composites can only be used to its full extent when specific load and material requirements are considered.

Thermoelectric sensors

Thermal sensors used at high temperature require the availability of an active material of high sensitivity, linearity and functional long- term stability, of high-temperature stable contacting between active sensor material and metallic signal leads, as well as thermomechanically stable joints between carrier structure, semiconductor and coatings. Suitable calibration or test apparatuses are required for system evaluation.
The team "Thermal Sensors" considers all of these partial aspects in the development of a layer-structured linear heat flow sensor based on semiconducting iron disilicide. System development for sensor applications of laboratory measuring techniques extends to fabrication of prototypes in industrial co-operation applying modern micro-structuring technologies, optimised semiconductor materials and numerical modelling tools.

Mechanics of Materials and microstructure

In aircraft and spacecraft structures and engines a multiplicity of different materials are used in order to optimally fulfil the requirements for technical safety and economic efficiency. In order to build the structures and construction units as light as possible without endangering their safety, the performance characteristics of the materials used must be determined as accurately as possible. Among these properties are strength and deformation behaviour, fatigue and fracture behaviour, corrosion characteristics etc. The investigation of fatigue under service conditions and fracture mechanics is one of the major tasks of material mechanics within DLR.

Methods:

Fabrication

Manufacturing of ceramic coatings by Magnetron-Sputtering, Sol- Gel Route und Electron-Beam Physical Vapor Deposition (EB-PVD).

Sensor und Catalyst Characterization Center (SESAM)

The sensor und catalyst characterization center which is specially constructed for testing of these materials has a gas mixing unit through which up to eight individual gases can be mixed and sent into a quartz glass reactor to heat to temperatures up to 1200°C before entering into the test chamber

Microstructural and High-Temperature Mechanical Characterization

For microstructural characterisation, scanning LEO DSM 982 GEMINI, transmission Electron (300kV) Philips TECNAI F30 microscopes and X-ray fluorescence and diffraction analysis methods are employed.

Key technologies: Fabrication of Functional and protective Coatings, Fiber-reinforced composites, Friction-stir welding, Thermal- and gas-sensors.

Infrastructures:

Key publications:

A. Flores Renteria and **B. Saruhan**, *Effect of Temperature and Time during Ageing on Microstructure of standard EB-PVD PYSZ TBCs*, J. of Europ. Ceram. Soc. Vol.: 26 (12), 2249-2255, 2006

B. Saruhan and M.C. Stranzenbach, *Development of Multifunctional NOx-Catalysts and -Sensors* in "Functionally Graded Materials VIII", eds.: O. Van der Biest, M. Gasik, J. Vleugels, Materials Science Forum", Vols: 492-493, pp. 249-254, Trans Tech Publications, Switzerland (2005)

M. Kantcheva, A. Agiral, O. Samarskaya, M. Stranzenbach, **B. Saruhan**, *Characterization of $LaMnAl_{11}O_{19}$ by FT-IR Spectroscopy of Adsorbed NO and NO/O_2*, Applied Surface Science, Vol.: 252/5 pp 1481-1491, 2005

2. Past and present research collaborations

Are you familiar with the European Framework Programme?	**X Yes** ☐ **No** **X** with Framework Programme 5 **X** with Framework Programme 6 **X** with Framework Programme 7
EU-projects you are involved in: **Past projects** **Present projects**	**Programme title / contract number / title / acronym / your function (coordinator / partner / contractor)** **5th Frame Work/Low thermal conductivity thermal barrier coatings/TBC+/Project leader for DLR-part**
Other international collaborations:	
Name(s) and contact details of potential partners:	**If you would like to suggest the participation of particular partners from the partner country based on existing contacts or collaboration experience, you are welcome to indicate their names and contact details below:**

3. Presentation at the Workshop

I will give a presentation at the workshop (approx. 10 min.) to present my institution, my expertise, and my collaboration interests. The contents of my presentations is summarised below (max. 1 page).

- Outlining the research activities in the institute
- Giving examples on developments in thermal barrier coatings
- Functional coatings including sensors and catalysis

I agree with the publication of my data on the Workshop website!

PLEASE FILL IN THIS FORM UNTIL 22 SEPT. 2006 AND RETURN IT TO:

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