BRNO UNIVERSITY OF TECHNOLOGY

Institute of Advanced Materials

/ Central European Institute of Technology of Brno University of Technology
/ Brno University of Technology

CEITEC
central european institute of technology
BRNO | CZECH REPUBLIC

RESEARCH GROUP CONTACT

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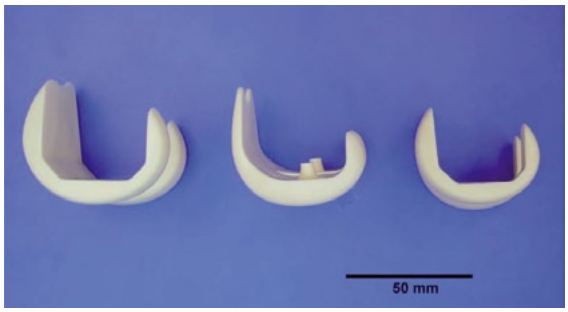

THEMATIC RESEARCH FOCUS

RESEARCH AREA

- Advanced ceramic, polymer materials and composites,
- Advanced metallic materials and metal based composites,
- Structure and phase analysis,
- Research and diagnostics of electrical properties of advanced materials

EXCELLENCE

- Advanced ceramic, polymer materials for bioapplications and electronic and structural applications

MISSION

- To establish equipment and personnel infrastructure further enhancing excellence in research of advanced (polymeric, ceramic, metallic and building) materials and their applications in various industrial segments, medicine and services

DEVELOPED TECHNOLOGIES

CONTENT OF RESEARCH

Biomaterials
development of novel composite biomaterials which can induce the growth of connective tissue on the surface of implants and therefore accelerate healing and improve the strength and biological stability of the implant-tissue connection (ceramic and metallic materials for replacement of soft and hard tissues, materials for orthopaedic devices).

Materials for energetics, communication and ecology
development of novel composite materials with a functionally graded structure for the improvement of the efficiency and lifetime of components and devices for energetics, communication and control technologies (conductive ceramic and polymer materials for electrodes, novel actuators, sensor components, control and instrumentation systems for technological processes, catalysts for the decomposition of gaseous pollutants, biopolymers and precursors from plants and plant residues).

Structural materials
development of novel polymeric, metallic and ceramic composites with excellent mechanical and thermal properties for structural applications (transparent ceramic materials; thermally and chemically resistant ceramic composite materials; impact-resistant ceramic composites; polymer multifunctional composites for high-tech engineering applications).

MAIN CAPABILITIES

Basic research
The results are published in high impal factor international journals in the mentioned fields, presented and communicated to the research and industrial community at workshops and conferences.

Application research + protection forms

- Transparent ceramics, ceramic armour, toughened engineering ceramics and composites
- New materials from easily renewable row sources (low energy materials, green materials), intelligent materials (materials with additional „smart" properties, for example – materials with high surface activity), nanomaterials.
- Innovative solutions of solar panels and diagnostics of their properties
- Application achievements in the innovation of electrode materials for NiCd batteries.
- Polymer materials: scratch-resistant materials based on nano fillers, intelligent enamels based on the application of nano fillers, soft polyurethane foams with controlled life-time

Photo 1 Bioceramics – Femoral component of knee joint

- Metallic materials for gas turbines and turbochargers (superalloys and intermetallics), metallic biomaterials for surgical implants (stainless steels, Ti-alloys, NiTi alloys) and new steels for railway traffic.
- Patent application dealing with hydrogen storage in metallic materials. This is a result of long term basic and applied research in the field of diffusion in metals

The results obtained (new materials, methodologies) create excellent conditions for expanding collaboration with hi-tech companies in the area of multilevel, multifunctional heterogeneous advanced materials.

FIELDS OF RESEARCH RESULTS APPLICATION

- Advanced materials – biomaterials, materials for energetics, communication and ecology, structural materials
- Electronic industry
- Chemical industry
- Automotive industry
- Alternative energy
- Non ferrous materials
- Plastics, polymers
- Glass, ceramics
- IT Security

Multifunctional homogeneous and heterogeneous advanced polymeric, ceramic, metallic and composite materials are expected to target a broad area of industrial segments ranging from technical sectors such as engineering, automotive industry, energetics, communication technology and medical electronics to the food industry, ecology and biomedicine. Besides traditional technical industries, the exploitation potential of multi-disciplinary scientific interactions is expected to result in novel application areas (e.g. unique mechanical characteristics of biomaterials finding applications in medicine as heart tissue substitutes in orthopaedics and dentistry, excellent mechanical and thermal properties of novel polymeric, metallic and ceramic composites exploitable in structural applications, materials originated from natural sources and environmentally compatible materials finding application in agriculture and forestry, etc.)

ALUMNI PROFILE

Doctoral graduates are on a very high technical level, provided with both the knowledge of the latest advances in the fields of materials sciences (inclusive of experimental methods for studying the structure and properties of materials) and the knowledge necessary for playing the role of a „bridge" between designers and technologists. Graduates are thus well prepared for science and research activities as members of materials science teams, for teaching activities at technical universities as well as for working in teams that, within the contemporary trend towards concurrent engineering, participate in the development of new products in manufacturing plants.

NUMBER OF RESEARCH POSITIONS ↘

SENIOR RESEARCH STAFF

29

JUNIOR RESEARCH POSITIONS (INCL. PH.D. STUDENTS)

87

KEY RESEARCH EQUIPMENT ↘

LIST OF DEVICES

- Multi-channel equipment Potentionstat/Galvanostat with multi-channel input /output for measuring very low frequency, voltage compliance 100V, current compliance 1nA - 10A.The measuring system is fully computerized and controlled by the programmable software.
- Multi-channel equipment for analyzing and data storage with fast sampling pulse generator (10Mvz/s) and scan rate 250kV/s. Usage of a broad range of electrochemical methods for analysing of material properties. The measuring system is fully computerized and controlled by the programmable software.
- Precision measurement system for dielectric and electrochemical impedance spectroscopy covers a frequency range from 3 μHz to 3 GHz, a temperature range - 160 ° C - 1 400 ° C and voltage range up to kV. The system consists of several frequency analyzers and potentionstats.
- Sensitive measurement system for spectroscopic measurements in the time domain for very small currents (below 1 fA).
- AC voltage module system – workplace for measurement breakdown voltage of electro insulating materials up to 200 kV
- Measuring bridges method covering both high and low voltage applications - workplace for precision measurement of capacity and dissipation factor (voltage up to 2 kV, frequency about 50 Hz)
- Set of climatic chambers – apparatus for exposing samples to different climatic condition (temperature range -70 – 200 °C, humidity range 10 – 99 %, solar and UV radiation, thermal shock chamber)
- Thermal analyser TG/DTA for thermoanalysis of ceramic particulate materials in the temp. range of 25-2000 °C and in driven atmosphere; sample mass 25 mgů mass spectrometric detection of evaluated gasses
- Device for the study of ionic permeability of ceramic high temperature membranes in the temp. range of 0-1200 °C and pressure range of 0-0.2 Mpa
- Equipment for testing of SOFC in the temperature range 0-1200 °C and pressure range of 0-0.2 Mpa
- Attrition mills for dispersion and homogenisation of fine and nanometre-sized ceramic powders, especially in liquid medium
- Heated kneading machine for mixing ceramic suspensions based on ceramic powders and liquids solvent or polymer melts
- Isostatic press with a pressure of liquid medium up to 1 GPa
- Machine for casting of ceramic green bodies of thin-wall sheets
- Milling machine for machining of complex ceramic green bodies
- Furnace for catalytic debinding of polymer binder

- Climatic chamber with temperature and humidity control
- Debinding muffle furnace for temperatures up to 1100°C with controlled gas atmosphere
- Device for mercury porosimetry of porous bodies
- Capillary rheometer for rheological evaluation of plastic materials
- Thermogravimetric analyzer with controlled gas atmosphere or with vacuum up to temperature of 1600°C and sample mass up to 100 g
- Equipment for solvothermal microwave synthesis of advanced ceramic particulate materials at max. temp. 300 °C and pressure 20 Mpa
- Device for high-temperature synthesis of ceramic particles in the temp. range of 0-1200 °C and pressure range of 0-0.2 Mpa
- Device for deposition of thick films and flat objects by means of ceramic colloidal dispersions. Maximum size of objects : 250x250 mm
- Device for deposition of thin films by means of liquid and gasseous precursors. Maximum size of objects : 50x50 mm
- Device for drying of g-l spray of ceramic particles and collection in cyclone separator. The volume of drying box is about 1 m3.
- Box for chemical experiments with reactive chemicals under intert conditions. The volume of chamber is 1,5 m3, contents of oxygen and water about 1 ppm
- Hot press used for pressing of inorganic powder materials at elevated temperature
- High-temperature dilatometer used for heating the sample and at the same time montoring its length changes
- High-temperature furnace intended for large samples
- High-temperature furnace working with vacuum or inert atmosphere
- High-temperature furnace working with pure hydrogen atmosphere
- Low-temperature furnaces with air atmosphere
- Catalytic reactor, with mass spectrometric product detection; capable of temperature programmed oxidation (TPO), temperature programmed reduction (TPR) and temperature programmed desorption (TPD) of ceramic catalytic materials
- Weather-Ometer Ci4000 + accessories
- Q-Sun Xe-1 desktop
- Weather station, type C
- HV Flame chamber HVUL2
- Melt-flow indexer
- Air-draft ageing chamber
- DMTA with low temperature chamber
- Servohydraulic tensile testing machine with temperature chamber
- High resolution SEM
- Confocal laser microscope
- Micro-rheological analyzer
- Nano CT Scan
- SAXS (small-angle X-ray scattering)
- High resolution TGA
- High temperature GPC
- Regular GPC
- Dynamic light scattering with MWD
- Modulated DSC
- Rheoviscosimeter
- FTIR microscope
- Lyophilizer
- Vacuum drying oven
- UV spectrophotometer
- GPC
- High performance dry box
- Micro twin-screw continuous reactor 15ml
- Bench top injection moulding machine
- 19 mm twin screw co-rotating split barrel extruder with accessories
- Gravimetric dosing system
- Axial-torsional servo-all-electric test system
- Multiaxial fatigue test stand
- Linear-Torsion All-Electric Test Instrument
- FEG -SEM High/Low vacuum + analytical attachments (EDS + WDS + EBSD)
- X-Ray Diffractometer + Goebble mirror for HR spectra acquisition + JCPDS database + high temperature chamber
- High resolution (sub nanometer) FEG scanning electron microscope + analytical attachments (EDS + WDS + EBSD)
- High resolution 300 keV FEG TEM/STEM with aberration correctors + analytical systems (EDS + EELS)
- Materialographic sample preparation unit - coarse (materialographic saw with equipment and materialographic press with equipment).
- Automatic grinder and polisher with equipment.
- TEM and SEM sample preparation unit (ion polisher for TEM foils, ion polisher for bulk SEM specimens and Electrolytical polisher for TEM foils).
- Oscilloscopes DSA9000 or equivalent
- Active meassurement equipment for DSA
- Meassurement stand for embedded systems and communication systems
- Pulse pattern generator
- Circuit board rapid prototyping system
- 3-ph programmable power supply 21kVA
- Oscilloscope + advanced functionality modules + probes
- Precise spatial measurement system
- Navigation unit
- Mobile calibration anechoic chamber
- PXI measurement system
- Set of acoustic sensors
- Reference vibration exciter with accessories
- Measurement and test workplace with dynamometers set

BUDGET ↘

TOTAL (MIL. CZK/ MIL. EUR)
40 / 1.6

PART OF THE TOTAL BUDGET FROM PRIVATE RESOURCES (%)
5

PART OF THE TOTAL BUDGET FROM FOREIGN RESOURCES (%)

10

MAIN PROJECTS

2007-2010: Heterogenous catalysts for oxidation of organic compounds based on composite perovskite oxides (Project OC 180 financed by the Ministry of Education, Youth and Sports)

2010-2012: Effect of nanoparticles on the chain mobility and crystallization kinetics in polyolefin nanocomposites (Project GAP205/10/2259 financed by the Czech Science Foundation)

2009-2011: Rheological behaviour of polymer melts and solutions loaded with nanoparticle fillers (project Project OC09040 financed by the Ministry of Education, Youth and Sports)

ACHIEVEMENTS

VOJTOVÁ, L.; JANČÁŘ, J.: Method of preparation of thermodegradable polyurethane foams. World Intellectual Property, Geneve, Patent no.: WO/2010/066211 (appl. no: PCT/CZ2009/000153), 2010-17-06.

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MACA, K., POUCHLY, V., ŽALUD, P.: Two-step sintering of oxide ceramics with various crystal structures, J. Eur. Ceram. Soc., 30, 2009, 583-589.

BARTONCKOVA, E., WIIK, K., MACA, K., LEIN, H. L., RUDBERG, E. A.: Synthesis and oxygen transport properties of La0.2Sr0.8Fe1-xTixO3 (x=0.2, 0.4) intented for syn-gas production, J. Eur. Ceram. Soc., 30, 2009, 605-611.

JANCAR, J., DOUGLAS, J. F., STARR, F. W., et al.: Current issues in research on structure-property relationships in polymer nanocomposites, POLYMER, 51 (15), 2010, 3321-3343

JANCAR, J., RECMAN, L.: Particle size dependence of the elastic modulus of particulate filled PMMA near its T-g, POLYMER, 51 (17), 2010, 3826-3828.

MAIN COLLABORATING PARTNERS

COLLABORATION WITH ACADEMIC PARTNERS

- Arrhenius Laboratory, Stockholm University (prof. Zhiijan Shen, SE),
- Department of Materials Engineering, University of Novi Sad (prof. Vl. Srdic, RS)
- National Institute for Materials Science (Dr. Taras Kolodiazhnyi, JP)
- University Duisburg-Essen (Prof. Markus Winterer, DE)
- National Centre for Scientific Research "Demokritos" (Dr. Evagelia Moshopoulou, GR)
- Institute of Materials Research, Slovak Academy of Science (Prof. Jan Dusza, SK)
- Institute of Materials Science, University of Connecticut (Prof. R.A.Weiss, US)
- S.A. Conte Polymer Engineering Center, University of Massachussets (Prof. A. Lesser, US)
- Institut für Energietechnik, Technische Universität Dresden (Prof. Dr. Ing. Uwe Gampe, DE)
- Dipartimento di Meccanica, Politechnico di Milano (Assoc. Prof. Dr. Mauro Fillipini, IT)

COLLABORATION WITH COMPANIES

- Walter (Ing. František Denk, Prague, CZ)
- Saint-Gobain Advanced Ceramics (Ing. Vladimír Šída, Turnov, CZ)
- Lasak (Ing. Zdeněk Strnad, Prague, CZ)
- mTec (Ing. Erik Elmer, Prague, CZ)
- Synpo (Dr. J. Zelenka, Pardubice, CZ)
- Rhodia (Dr. G. Mignani, Lyon, FR)
- Volkswagen AG (Dr. W. Kramer, Wolfsburg, DE)
- Metallchemie (Vrútky, SK)
- Daneher Motion (Modřice, CZ)
- Ingersoll-Rand Czech Republic (Uničov, CZ)
- Timken Česká Republika (Bystrovany, CZ)
- BOSCH Diesel (Jihlava, CZ)
- Brisk Tabor (Tábor, CZ)
- Bochemie (Bohumín, CZ)
- Solartec (Rožnov pod Radhoštěm, CZ)
- Gumotex (Břeclav, CZ)

EXPECTATIONS

REQUIREMENTS

We are looking for both academic and industrial partners in basic and applied research in the areas of biomaterials, structural materials and materials for energetics, communication and ecology.

OFFERS

- Competitive applied research
- Specialized services on top-class instruments in the area of transmission microscopy, scanning electron microscopy, microanalysis and X-ray diffraction analysis

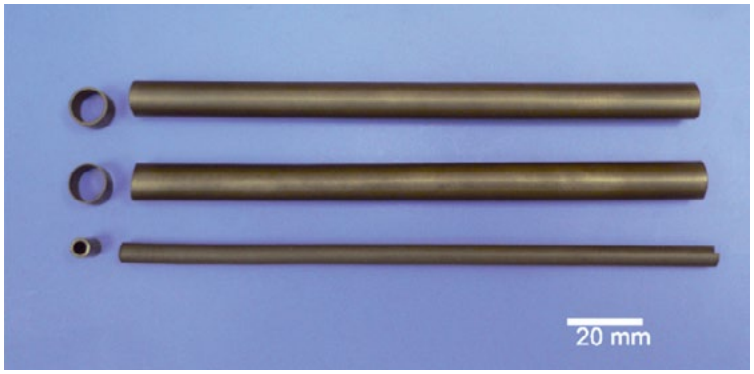

Photo 1 Electroceramics – Oxygen tubular membranes, material: La-Ca-Fe-Co perovskite