PRIORITY RESEARCH AREA OF THE
WARSAW UNIVERSITY OF TECHNOLOGY

MATERIAL TECHNOLOGIES

COOPERATION PROPOSAL

EXCELLENCE INITIATIVE
RESEARCH UNIVERSITY

Warsaw University of Technology

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FOREWORD BY THE HEAD OF THE PRIORITY RESEARCH AREA

Professor Marcin Leonowicz, Ph.D., D.Sc.
Head of the Priority Research Area: Material Technologies

Material – in the broadest sense of the word – is physical substance from which various useful products are made. It is, in fact, the basis of all engineering activity. Thus, it is hardly surprising that the Material Technologies Priority Research Area has been included in the Research University Excellence Initiative.

The primary goal of the Material Technologies Priority Research Area is to increase the scientific activity of the university's staff and doctoral students in the area of materials research, reflected in high-quality publications and grants, as well as the development of scientific cooperation and international exchange programmes.

The thematic scope of this priority research area mainly includes structural and functional materials, with particular focus on nanomaterials, smart materials, multifunctional materials and modern technologies of their manufacture. Research on such materials is carried out in many faculties of the Warsaw University of Technology, in particular the Faculty of Materials Science and Engineering, the Faculty of Chemistry, the Faculty of Physics, the Faculty of Chemical and Process Engineering, the Faculty of Mechanical and Industrial Engineering, the Faculty of Automotive and Construction Machinery Engineering, the Faculty of Electronics and Information Technology, and the Centre for Advanced Materials and Technologies (Cezamat). Such interdisciplinarity translates into a wide range of research topics, as shown in this brochure.

We currently support 63 projects, aimed at both scientists with a recognised track record of achievements, as well as young researchers. In particular, we promote cooperation between WUT units, which is reflected in the structure of the research groups presented in the brochure.

We are happy to present you with the first brochure of research teams from the Material Technologies Priority Research Area, which describes the scope of research of some of the teams operating within this area. I hope that it will arouse your interest, enable you to learn more about the research topics pursued by our colleagues, and inspire closer scientific collaboration. This brochure is also a cooperation proposal addressed to other research units at home and abroad.

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MATERIAL TECHNOLOGIES

1

RESEARCH TEAM OF THE

COLLOIDAL SEMICONDUCTOR NANOCRYSTAL LABORATORY

#COLLOIDAL NANOCRYSTALS #INORGANIC SEMICONDUCTORS #LUMINESCENCE PROPERTIES
#PLASMONIC PROPERTIES #THERMOELECTRIC PROPERTIES #DRUG CARRIERS

Since 2012, the Team has been working on obtaining colloidal nanocrystals of inorganic semiconductors containing no toxic elements.

As part of the research, methods were developed to obtain nanocrystals of ternary semiconductors $AgInS_2$, $CuInS_2$ and alloyed systems $AgInS_2$-ZnS and $CuInS_2$-ZnS characterised by luminescent properties.
Another group of colloidal nanomaterials includes $CuFeS_2$, $CuFeSe_2$ nanocrystals and $CuFeS_{2-x}Se_x$ alloy systems, characterised by plasmonic and thermoelectric properties.

A separate line of research involves work on ligand exchange and the preparation of stable aqueous dispersions of luminescent $AgInS_2$-ZnS nanocrystals, which are used as drug carriers in *in vitro* and *in vivo* studies for therapies applied to lung and colon cancers.

AREAS OF COOPERATION WITH OTHER TEAMS

- Producing colloidal nanocrystals of selected inorganic semiconductors
- Producing colloidal hydrophilic and hydrophobic $AgInS_2$-ZnS alloy nanocrystals, characterised by emission in the range from 500 to 700 nm

SELECTED PROJECTS

- Thermoelectric properties of functionalized nanocrystals (bilateral exchange of scientists between the Republic of Poland and the French Republic, PHC Polonium No. PPN/X/KP/1136/2020, NAWA – Polish National Agency for Academic Exchange, 2021–2022)
- New organic and hybrid (organic-inorganic) electroactive materials and nanomaterials of tunable electronic, magnetic and optical properties (OPUS, NCN – National Science Centre, 2020–2023)
- Low band gap ternary and quaternary semiconducting nanocrystals: new preparation method, surface functionalization, nanocomposites with organic semiconductors and metals and application in energy conversion (OPUS, NCN, 2016–2020)
- New organic semiconductor of controlled luminescent, magnetic and electrical transport properties for molecular electronics and spintronics (OPUS, NCN, 2016–2019)
- New solution processable organic and hybrid (organic/inorganic) functional materials for electronics, optoelectronics and spintronics (Project TEAM, FNP – Foundation for Polish Science, 2011–2015)

MAIN RESEARCH INFRASTRUCTURE

- Laboratory for the preparation of colloidal nanocrystals of inorganic semiconductors

CONTACT

Professor Piotr Bujak, Ph.D., D.Sc.
tel. (+48) 22 234 55 84
piotr.bujak@pw.edu.pl
https://www.ch.pw.edu.pl

SELECTED PUBLICATIONS

- Kowalik P., Penkala M., Bujak P., Kmita A., Gajewska M., Ostrowski A., Slodek A., Pron A. (2020), From Ag_2S to luminescent Ag-In-S nanocrystals via an ultrasonic method – an in situ synthesis study in an NMR tube. J. Mater. Chem. C, 8, 8942
- Pilch J., Matysiak-Brynda E., Kowalczyk A., Bujak P., Mazerska Z., Nowicka A. M., Augustin E. (2020), New Unsymmetrical Bisacridine Derivatives Noncovalently Attached to Quaternary Quantum Dots Improve Cancer Therapy by Enhancing Cytotoxicity toward Cancer Cells and Protecting Normal Cells. ACS Appl. Mater. Interfaces, 12, 17276
- Moodelly D., Kowalik P., Bujak P., Pron A., Reiss P. (2019), Synthesis, photophysical properties and surface chemistry of chalcopyrite-type semiconductor nanocrystals. J. Mater. Chem. C, 7, 11665
- Kowalik P., Bujak P., Penkala M., Kotwica K., Kmita A., Gajewska M., Ostrowski A., Pron A. (2019), Synthesis of $CuFeS_{2-x}Se_x$ – alloyed nanocrystals with localized surface plasmon resonance in the visible spectral range. J. Mater. Chem. C, 7, 6246
- Bujak P., Wróbel Z., Penkala M., Kotwica K., Kmita A., Gajewska M., Ostrowski A., Kowalik P., Pron A. (2019), Highly Luminescent Ag-In-Zn-S Quaternary Nanocrystals: Growth Mechanism and Surface Chemistry Elucidation. Inorg. Chem., 58, 1358

#CONTROLLED SYNTHESIS OF POLYMERS #FUNCTIONAL (BLOCK) COPOLYMERS #BIODEGRADABLE POLYMER TECHNOLOGIES #PLASTIC PROCESSING #NON-MATERIAL RECYCLING OF POLYMERS #POLYMER (NANO)COMPOSITES #HYBRID POLYMERS #STRUCTURE AND PROPERTIES OF POLYMERS #POLYURETHANES AND THEIR COMPOSITES #COMPOSITES FROM RENEWABLE RESOURCES

2 3DLIMB

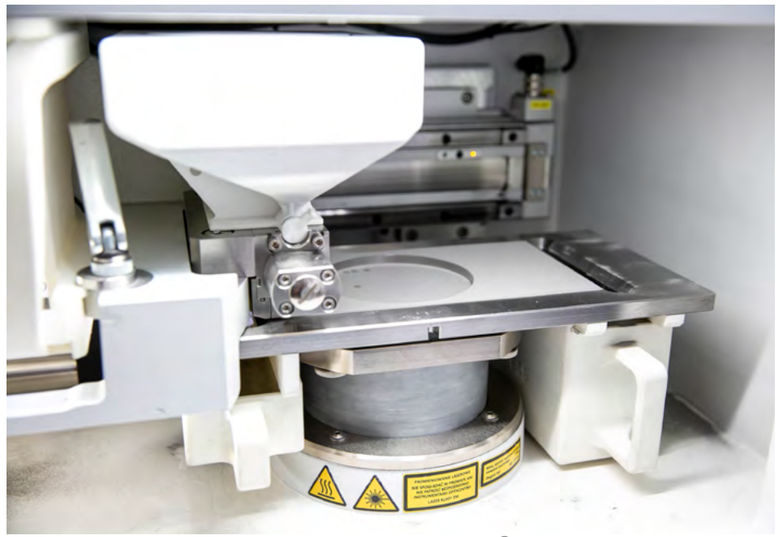
RESEARCH TEAM

The 3DLIMB Research Team is composed of:

- the Research Team for Controlled Synthesis, Processing of Functional Materials and Synthetic Biopolymers (SynBioProc) of the Faculty of Chemistry (WUT),
- the Research Team „Polymer Materials" of the Faculty of Materials Science and Engineering (WUT),
- the Research Team „Prototyping and Reverse Engineering" of the Faculty of Power and Aeronautical Engineering (WUT).

The SynBioProc team (Faculty of Chemistry, WUT) deals with the controlled synthesis of functional (co)polymers, including block, biodegradable and hybrid polymers (e.g. metal organophosphates) – the team modifies and studies their structure, properties and biodegradability. It also produces and processes (also reactively) blends and polymer (nano)composites.

The „Polymer Materials" team (Faculty of Materials Science and Engineering, WUT) specialises in analysis of the structure-property relationships and applications of polymeric materials (e.g. structure description, characterisation of the properties and degradation of polymers, recycling of thermoplastic and duroplastic polymers, as well as modern polyurethane materials).



The „Prototyping and Reverse Engineering" team (Faculty of Power and Aeronautical Engineering, WUT) focuses on research and pre-implementation issues in the field of: CAD/CAM/CAE design and analysis, prototyping (from conceptual to functional prototypes), testing of various functional solutions, additive manufacturing, CNC fabrication, 3D and CT scanning, reverse engineering.

AREAS OF COOPERATION WITH OTHER TEAMS

- Research on material composition, structure and its susceptibility to (bio)degradation
- Research on mechanical properties of plastics prepared by the Team and supplied by third parties
- Compounding or studying the structure, morphology and properties of a polymer composite/polymer blend
- Processing of thermoplastic polymers by extrusion, injection molding and thermoforming
- Processing of biodegradable polymers (PLA, PHA, PBAT) – commercially available and synthesized by the Team
- Processing and preparation of test specimens, as well as supporting clients in their preparation
- Selection of polyurethane materials for various applications
- Formulation of polyurethane materials
- Processing of polymer composites containing natural fillers
- Product design and prototyping
- Additive manufacturing
- CNC manufacturing
- Reverse engineering
- 3D and CT scanning
- Characterisation of polymeric materials:
  - analysis using infrared spectroscopy (FTIR)
  - thermal analysis (DSC, TGA)
  - thermomechanical analysis (DMA)
  - analysis and description of polymer structure
  - evaluation of degradation processes
  - evaluation of permanent deformations and rebound in flexible foams
  - evaluation of rigid foam brittleness
  - description of the structure-property relationships of polymeric materials, including polyurethanes
  - description of the structure and properties of WPC and NFC composites
  - quantitative and qualitative description of the microstructure of polymers and WPC and NFC composites
  - measurement of density, impact strength, hardness and abrasive wear
  - measurement of viscosity
  - determination of the melt flow index

CONTACT

Maciej Dębowski, Ph.D.
tel. (+48) 22 234 71 13
maciej.debowski@pw.edu.pl
synbioproc.ch.pw.edu.pl
https://wim.pw.edu.pl/Badania-i-nauka/Grupy-badawcze/Materialy-polimerowe

#CONTROLLED SYNTHESIS OF POLYMERS #FUNCTIONAL (BLOCK) COPOLYMERS #BIODEGRADABLE POLYMER TECHNOLOGIES
#PLASTIC PROCESSING #NON-MATERIAL RECYCLING OF POLYMERS #POLYMER (NANO)COMPOSITES
#HYBRID POLYMERS #STRUCTURE AND PROPERTIES OF POLYMERS #POLYURETHANES AND THEIR COMPOSITES
#COMPOSITES FROM RENEWABLE RESOURCES

SELECTED PROJECTS

- Development of technology for the preparation of the innovative, reactive, one-component polyurethane adhesives and components enabling the bonding of materials with a high surface free energy (CARBOPUR) (SynCHEM, NCBR/SYNTHOS, 2017–2021)
- Hybrid polymers based on zinc, calcium and magnesium organic phosphates: synthesis, structure, properties and application in polymer composites (OPUS 11, NCN, 2017–2021)
- Technology of manufacturing of lactides from lactic acid (LACMAN) (PBS 2, NCBR – National Centre for Research and Development, 2013–2017)
- Technology for the production of biodegradable polyesters using renewable raw materials (BIOPOL) (Innovative Economy Operational Programme, MNiSW – Ministry of Science and Higher Education/ EU, 2010–2014)
- Next-generation organically recyclable polymeric materials (MARGEN) (POIG, MNiSW/EU, 2009–2013)
- Advanced material technologies for aerospace applications (Innovative Economy Operational Programme, MNiSW/EU, 2008–2013)
- Polyurethane eco-foams derived from raw materials of natural origin (PBS1, NCBR, 2012–2015)
- Development of methods for the neutralisation of the risk of explosion of selected tanks with process gases, including with alternative power sources, in a fire environment for the needs of rescuers taking part in rescue and firefighting actions (DOB-BIO6, NCBR, 2014–2017)
- Flame retardancy of flexible polyurethane foams using nanofillers (development project, NCBR, 2009 –2012)
- Flexible materials for use in intervertebral disc implant structures (development project, NCBR, 2009 –2012)
- Polymer composites with biomass (development project, NCBR, 2009–2012)
- Development of a diesel fuel composition system based on rapeseed oil esters at LOTOS GROUP (development project, NCBR, 2003–2006)
- Development and fabrication (in cooperation with the client) of UWS aerodynamic demonstrators for the PB-1 and PB-2 aerodynamic rudders; Development and fabrication (in cooperation with the client) of energy storage and electric motors for UWS for the PB-1 and PB-2 (programme for national defence and security, NCBR, 2018–2019)
- Development of a propulsion system for aerodynamic rudder servos (national defence and security programme, NCBR, 2018–2019)
- Improving the quality of the rigid endoscope repair service provided by POL-MED OPTYKA (FPOL-MED. OPTYKA/PARP – Innovation vouchers, 2017–2018)

MAIN RESEARCH INFRASTRUCTURE

- Laboratories of organic synthesis, including polymer synthesis, adapted to inert gas conditions, with laboratory equipment
- Large-scale apparatus for organic sythesis (2 L steel reactor; cascade: 5 L glass reactor and 2 L steel reactor; 10 L steel reactor equipped with stirrers, temperature and pressure sensors and a system for process control and data archiving)
- GPC apparatus (Viscotek GPCmax TDA 305): measurements in dichloromethane at 30 °C, on JordiLabs columns
- Measuring systems allowing to determine the purity of monomers, initiators and reaction progress (Agilent GC-FID gas chromatograph), chemical structure (Nicolet iS5 FTIR spectrometer with transmission and ATR accessories and spectral databases) and size of (nano)particles in aqueous and organic dispersions using the DLS method (Malvern Zetasizer Nano ZS)
- Instron 5566 universal testing machine and thermal chamber (tensile, bending and compression tests under forces up to 10 kN, accessories for testing of specimens in the form of bar, dumbbell, thin film and cord) and pendulum hammer for Izod and Charpy impact tests (Zwick HIT50 Plus) with a notch cutter
- Haake MiniLab II twin-screw (co-rotating or counter-rotating configuration) conical laboratory extruder with return channel and the option of measuring viscosity (material feed size approx. 7 g)
- Kraus Maffei twin-screw co-rotating extruder with configurable screws
- Arburg Allrounder 180 S 170-30 hydraulic screw injection molding machine with SELOGICA control and measurement software
- Kompleksrem thermoforming machine
- 3D printer (FDM printing technology): Omni3D
- Zwick Roell Mflow plastometer
- DMA Q800 Dynamic Mechanical Thermal Analyser (TA Instruments)
- TGA Q500 Thermogravimetric Analyser (TA Instruments)
- DSC Q1000 Differential Scanning Calorimeter (TA Instruments)
- Nicolet 6700 FTIR ATR spectrometer (Thermo Scientific)
- BIOLAR PI polarisation-interference X-ray microscope
- HITACHI TM3000 scanning electron microscope
- Charpy Resil 5.5 CEAST pendulum impact hammer with a notch cutter
- Brookfield DV-II+ PRO viscosity meter with thermostat
- HAAKE 8482 MiniJet Pro Piston Injection Molding System
- HAAKE MiniLab extruder
- Vacuum dryers (up to 200 °C)
- Single- and two-stage vacuum pumps
- Ultrasonic disintegrators
- Mechanical and magnetic stirrers
- Polyurethane synthesis units
- Glass reactor for chemical syntheses
- Shore A and D hardness testers
- 5-axis machining centre AVIA X-5 1000/500
- Numerical lathe (AVIA E-turn 40)
- DMLS 3D printer (ORLAS CREATOR printer)
- Industrial 3D FDM printer (Stratasys Fortus 450mc)
- SLS 3D Printer (Sinterit Lisa PRO)
- SLA 3D Printer (DWS XFAB)
- Industrial tomograph (NIKON Metrology XT H 225)
- 3D scanner (Artec EVA handheld scanner)
- Digital Image Correlation System – DIC (Dantec Dynamic)
- High-speed cameras (NAC HX-3 colour 32 GB)

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#COMPOSITES FROM RENEWABLE RESOURCES

SELECTED PATENTS

- Method for obtaining carbon dioxide block terpolymers, PL 225849, 2016
- Reactive modifier of poly(actic acid) and method for producing the reactive modifier of poly(actic acid), PL 227237, 2017
- Method for producing new copolyesters containing segments of poly(lactic acid), PL 227029, 2017
- Method for producing granulated polylactide, PL 222692, 2015
- Method of obtaining lactide, telechelic and (multi)telechelic oligomers of lactic acid, PL 222450, 2015
- Method for preparing poly(ester-carbonates) from alkylene carbonates, PL 222348, 2016
- Methods of Preparing Modifiers for Liquid Epoxy Resins and Reducing Flammability Thereof, EP 2628766 B1, 2014
- Process for the preparation of biodegradable polymer material, PL 217819 B1, 2014
- The manner of obtaining of plasticizers for polymers of lactic acid, PL 210092, 2011
- Method for producing organophosphorus derivatives of aluminium, PL 197233, 2008
- Production of integral foams using an environmentally friendly method, PL 230383, 2018
- Method for producing washable viscoelastic foams, PL 227703, 2018
- Use of chokeberry pomace as a filler for the manufacture of polyurethane foam biocomposites, PL 233444, 2019
- Use of raspberry seeds as a filler for the manufacture of polyurethane foam biocomposites, PL 234693, 2019
- Device for transporting children in vehicles, PL 236856, 2020
- Piezoelectric sensor and methods of its production, PL 225481, 2021

3 BIOLUMPOR

RESEARCH TEAM

The Team synthesises and studies the properties of organoboron compounds for their application in materials chemistry and medicine. In particular, these include photoactive materials that exhibit luminescent (e.g. thermally activated delayed fluorescence) and photocatalytic (e.g. in singlet oxygen generation reactions) properties, and substances with antimicrobial properties.

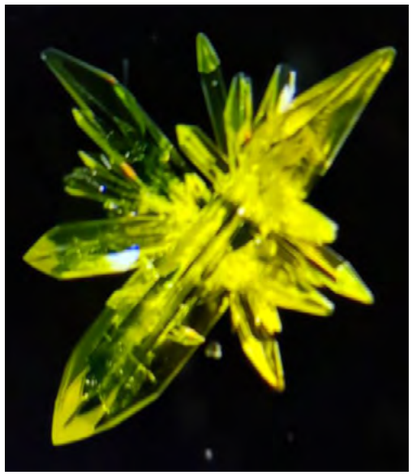
We also design, synthesise and study the properties of microporous materials.

CONTACT

Krzysztof Durka, Ph.D.
tel. (+48) 22 234 75 75
krzysztof.durka@pw.edu.pl
http://lulinski.ch.pw.edu.pl

AREAS OF COOPERATION WITH OTHER TEAMS

- Photoactive compounds photosensitizers
- Photoconvertible systems
- Organic materials for optoelectronic applications
- Compounds with antimicrobial properties
- Microporous materials



#PLASMA TECHNOLOGIES #GAS PHASE DEPOSITION #SENSORS #FIBRE OPTICS #METAL OXIDES #CARBON LAYERS #ELECTROCHEMISTRY #OPTICAL MEASUREMENTS #BIOSENSORICS #CONSTRUCTION OF MEASUREMENT DEVICES

SELECTED PROJECTS

- Searching for structure – antimicrobial activity correlation for selected boraheterocycles (OPUS 16, NCN, 2019–2023)
- THIO-SWITCH: towards novel photo-active switchable materials – exploration of dithienylethene-based transition metal complexes via advanced in situ photocrystallographic and spectroscopic approaches (OPUS 17, NCN, 2020–2023)
- Effective triplet-state photosensitizers based on four coordinated spiro organoboron complexes immobilized on the solid state surface Warsaw University of Technology (PRA-MT1, WUT, 2020–2021)
- Covalent and hybrid porous materials based on organoboron compounds (OPUS, NCN, 2016–2019)
- Four-coordinate organoboron complexes with rigid scaffolds as efficient light-emitting materials (SONATA, NCN, 2015–2019)
- Bimetallic compounds derived from heteroarylboranes – new attractive building blocks for organic synthesis and material chemistry (SONATA, NCN, 2012–2015)
- Aryl- and heteroaryldiboronic acids as synthons in the construction of supramolecular materials and potential gas storage materials (SONATA, NCN, 2011–2014)
- From simple molecules of diboronic acid derivatives to tunable organoboron functional supramolecular complexes (PRELUDIUM, NCN, 2011–2013)
- Simulation of structures and sorption properties of boron-phosphorous Covalent Organic Frameworks doped with transition metals (University of Bath, Chemical Engineering Department, HPC-Europa3 Transnational Access programme, project no. HP- C17RNAEH, 2018)
- Efficient triplet photosensitizers derived from rigid organoboron structures as singlet oxygen generators (OPUS 20, NCN, 2021–2024)

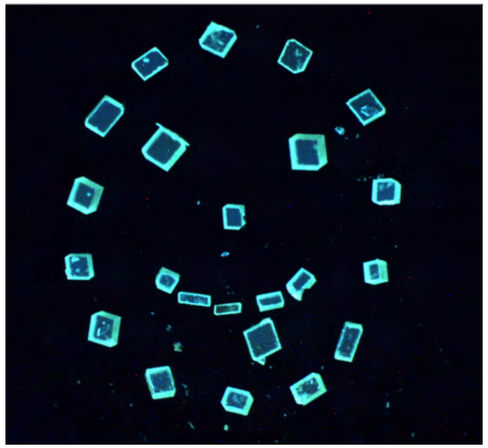
#PLASMA TECHNOLOGIES #GAS PHASE DEPOSITION #SENSORS #FIBRE OPTICS #METAL OXIDES #CARBON LAYERS #ELECTROCHEMISTRY #OPTICAL MEASUREMENTS #BIOSENSORICS #CONSTRUCTION OF MEASUREMENT DEVICES

SELECTED ACHIEVEMENTS

- Ministry of Science and Higher Education scholarship for an outstanding young scientist, 2020
- Featured scientific paper (front cover and hot paper): Pacholak P., Gontarczyk K., Kamiński R., Durka K., Luliński S. (2020), Boronate Covalent and Hybrid Organic Frameworks Featuring P(III) and P=O Lewis Base Sites, Chemistry – A European Journal, 26, 12758–12768, DOI: doi.org/10.1002/ chem.202001960; https: / doi.org/10.1002/ chem.202001960
- Featured scientific paper (hot paper): Urban M., Durka K., Górka P., Wiosna-Sałyga G., Nawara K., Jankowski P., Luliński S. (2019), The effect of locking π-conjugation in organoboron moieties in the structures of luminescent tetracoordinate boron complexes, Dalton Transactions, 48, 8642–8663, DOI: 10.1039/ C9DT01332F
- Featured scientific paper (front cover): Urban M., Górka P., Nawara K., Woźniak K., Durka K., Luliński S. (2018), The effect of conformational isomerism on the optical properties of bis(8- oxyquinolato) diboron complexes with a 2,2′-biphenyl backbone, Dalton Transactions, 47, 15670–15684, DOI: http://dx.doi.org/10.1039/C8DT03197E
- Featured scientific paper (back cover): Durka K., Urban M., Czub M., Dąbrowski M., Tomaszewski P., Luliński S. (2018), An intramolecular ortho-assisted activation of the silicon-hydrogen bond in arylsilanes: an experimental and theoretical study, Dalton Transactions, 47, 3705–3716, DOI: http:// dx.doi.org/10.1039/ C7DT04858K
- Scholarship of the Foundation for Polish Science “START”, 2016

MAIN RESEARCH INFRASTRUCTURE

- Fully equipped organic synthesis laboratory with the possibility of carrying out processes in an inert gas atmosphere
- Hitachi 2300 II UV-Vis spectrophotometer
- Edinburgh Instruments FS5 spectrofluorometer additionally equipped with an integrating sphere and front face attachment
- Retch M400 ball mill
- Clarus 580 Gas chromatograph with MS detector



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- Marek-Urban P.H., Urban M., Wiklińska M., Paplińska K., Woźniak K., Blacha-Grzechnik A., Durka K. (2021), Heavy-Atom Free spiro Organoboron Complexes As Triplet Excited States Photosensitizers for Singlet Oxygen Activation, DOI: doi.org/10.1021/acs.joc.1c01254
- Pacholak P., Gontarczyk K., Kamiński R., Durka K., Luliński S. (2020), Boronate Covalent and Hybrid Organic Frameworks Featuring P(III) and P=O Lewis Base Sites. Chemistry – A European Journal, 26, 12758–12768, DOI: doi.org/10.1002/chem.202001960
- Urban M., Durka K., Górka P., Wiosna-Sałyga G., Nawara K., Jankowski P., Luliński S. (2019), The effect of locking π-conjugation in organoboron moieties in the structures of luminescent tetracoordinate boron complexes. Dalton Transactions, 48, 8642–8663, DOI: 10.1039/C9DT01332F
- Durka K., Laudy A.E., Charzewski Ł., Urban M., Stępień K., Tyski S., Krzyśko K.A., Luliński S. (2019), Antimicrobial and KPC/AmpC inhibitory activity of functionalized benzosiloxaboroles. European Journal of Medicinal Chemistry, 171, 11–24, DOI: https://doi.org/10.1016/j.ejmech.2019.03.028
- Urban M., Górka P., Nawara K., Woźniak K., Durka K., Luliński S. (2018), The effect of conformational isomerism on the optical properties of bis(8-oxyquinolato) diboron complexes with a 2,2′-biphenyl backbone. Dalton Transactions, 47, 15670–15684, DOI: doi.org/10.1039/C8DT03197E
- Tomaszewski P., Wiszniewski M., Serwatowski J., Woźniak K., Durka K., Luliński S. (2018), Synthesis of tetraarylborates via tetralithio intermediates and the effect of polar functional groups and cations on their crystal structures. Dalton Transactions, 47, 16627–16637, DOI: doi.org/10.1039/C8DT04068K
- Gontarczyk K., Bury W., Serwatowski J., Wieciński P., Woźniak K., Durka K., Luliński S. (2017), Hybrid Triazine-Boron Two-Dimensional Covalent Organic Frameworks: Synthesis, Characterization, and DFT Approach to Layer Interaction Energies. ACS Appl. Mater. Interfaces, 9, 31129–31141, DOI: 10.1021/acsami.7b09061
- Urban M., Durka K., Jankowski P., Serwatowski J., Luliński S. (2017), Highly Fluorescent Red-Light Emitting Bis(boranils) Based on Naphthalene Backbone. Journal of Organic Chemistry, 82, 8234–8241, DOI: 10.1021/ acs.joc.7b01001
- Durka K., Gontarczyk K., Luliński S., Serwatowski J., Woźniak K. (2016), Isomeric and Isostructural Oligothienylsilanes−Structurally Similar, Physicochemically Different: The Effect of Interplay between C−H···C(π), S···C(π), and Chalcogen S···S Interactions. Crystal Growth&Design, 16, 4292–4308, DOI: 10.1021/ acs.cgd.6b00358
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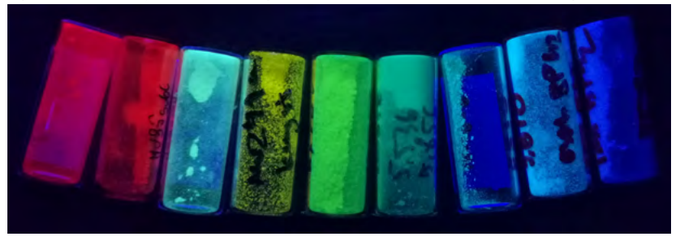


4

RESEARCH TEAM FOR

SURFACE FUNCTIONALISATION OF TITANIUM AND ITS BIOMEDICAL ALLOYS

#BIOMEDICAL TITANIUM ALLOYS #MECHANICAL SURFACE TREATMENTS #CHEMICAL SURFACE TREATMENTS #LASER SURFACE TREATMENTS #HYBRID SURFACE TREATMENTS #COMPOSITE BIOACTIVE COATINGS #PHYSICAL AND CHEMICAL PROPERTIES OF SURFACES #MICROSTRUCTURE OF SURFACE LAYERS #SURFACE MORPHOLOGY/TOPOGRAPHY

The Research Team for Surface Functionalisation of Titanium and its Biomedical Alloys has its roots in advanced research into metallic biomaterials for dental and passive ear implants. The establishment of cooperation between the Department of Materials Design of the Faculty of Materials Science and Engineering at the Warsaw University of Technology and the Department of Chemical Technology of the Faculty of Chemistry at the Warsaw University of Technology has broadened the scope of the Team's scientific activities.

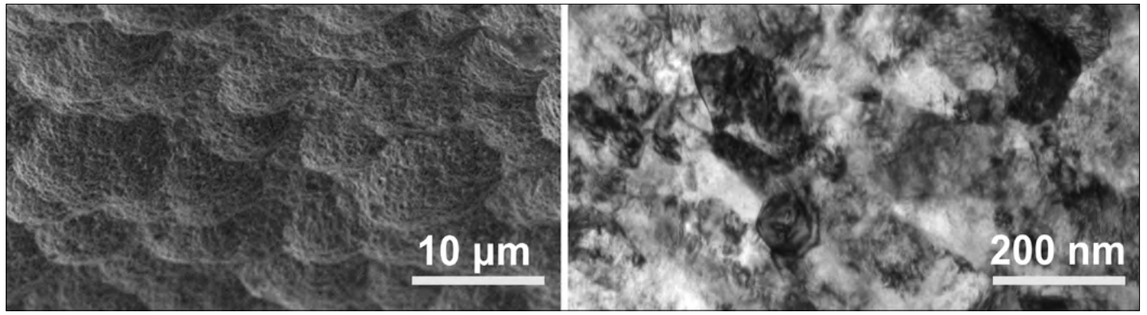
Its members have extensive experience in shaping and testing both metallic and ceramic materials. The combination of the aforementioned competencies will allow a more informed production and detailed characterisation of bioactive composite coatings containing ceramic bio-glass particles produced on functionalised titanium biomaterial surfaces.

CONTACT

Professor Halina Garbacz, Ph.D., D.Sc.
tel. (+48) 22 234 87 92
halina.garbacz@pw.edu.pl
https://www.wim.pw.edu.pl/Badania-i-nauka/Grupy-badawcze/Metale-niezelazne-i-ich-stopy

AREAS OF COOPERATION WITH OTHER TEAMS

- Research on the microstructure and functional properties of metals and their alloys for biomedical applications
- Sample preparation of titanium and its biomedical alloys, including thin films for TEM testing
- Microstructure characterisation of thin near-surface films
- Evaluation of surface morphology/topography based on microscopic observations and profilometric studies
- Surface mechanical and chemical treatments of titanium and its alloys for biomedical applications
- Production and control of the properties of suspensions containing ceramic bio-glass particles
- Production of bioactive coatings on the surface of metallic materials
- Bioactivity testing of metallic materials
- Sterilisation of biomedical materials
- Corrosion resistance testing of biomedical metals



SELECTED PROJECTS

- Effect of high strain on the microstructure and properties of Ti-29Nb-13Ta-4.6Zr alloy for biomedical applications (OPUS 11, NCN, 2016–2021)
- Effect of low-temperature annealing on the evolution of the nanostructure and properties of hexagonal Ti with varying interstitial elemental content (OPUS 15, NCN, 2018–2022)
- Oxide nanocrystalline semiconductor materials formed with enzymes (SONATA 12, NCN, 2017–2021)
- Impact of titanium surface modification on bone mineralisation, for applications in otolaryngology (PRELUDIUM 12, NCN, 2017–2021)
- Evaluation of the impact of synergistic interaction of proteins and inflammatory response products on the degradation rate of titanium materials for bone implant applications (PRELUDIUM 15, NCN, 2019–2021)
- Development of a low-waste explosive plating and processing technology for multilayer high-strength lightweight and superlight materials with reactive and functional layers, as well as sheets explosively plated with reactive metals and their alloys (EMuLiReMat TECHMAT- STRATEG, NCBR, 2019–2022)
- Integrated system of tools for diagnostics and telerehabilitation in sensory organs disorders (hearing, vision, speech, balance, taste, smell) (STRATEGMED 1, NCBR, 2014–2018)

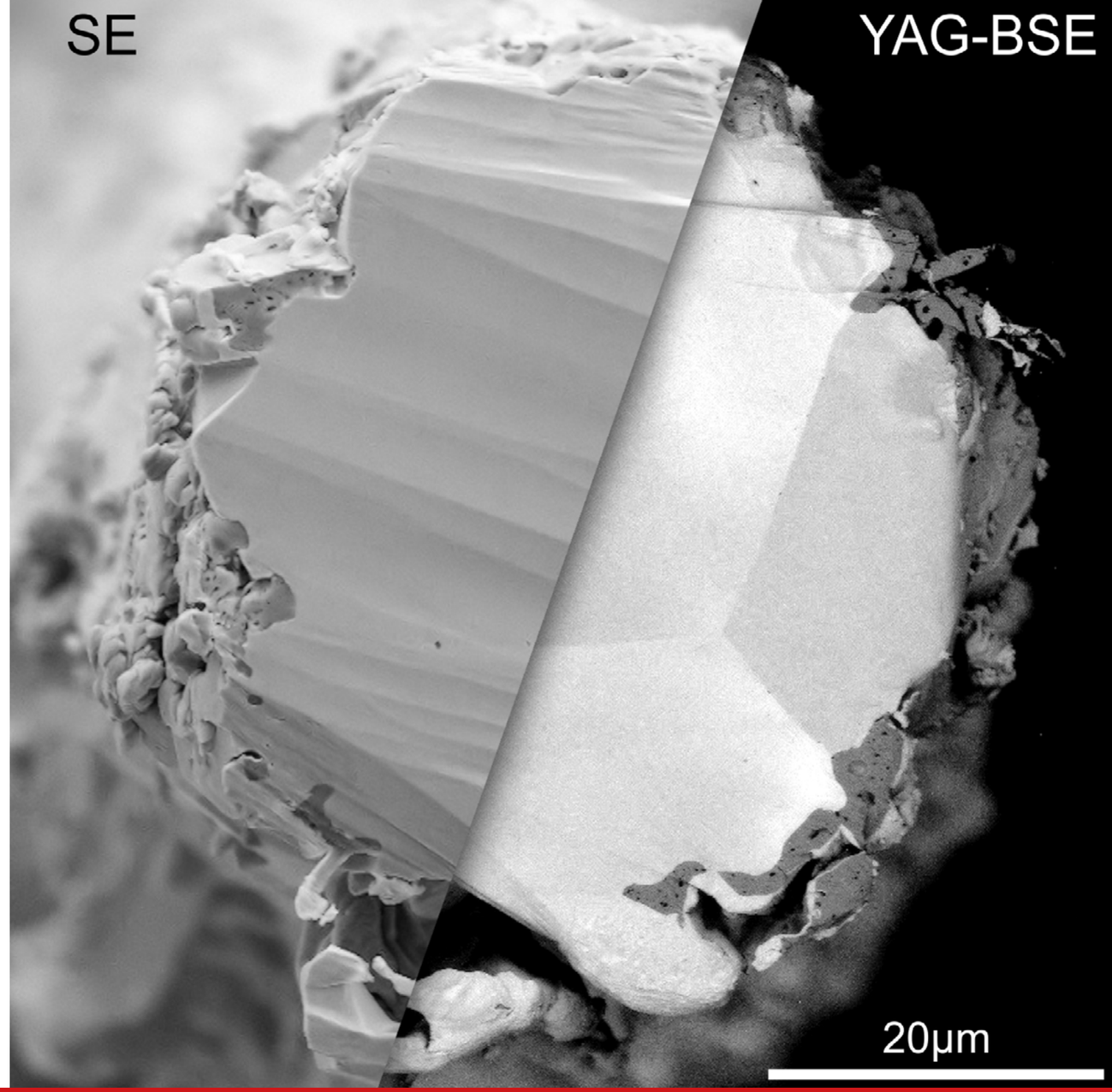
MAIN RESEARCH INFRASTRUCTURE

- Hitachi SU70 scanning electron microscope
- TEM JEOL JEM 1200 transmission electron microscope
- Zeiss Axio Observer light microscope
- NB5000 microscope with integrated SEM and FiB systems
- Wyko NT9300 Optical profilometer
- Sterilclave 18 COMINO autoclave
- Thermo Scientific™ Midi 40 CO_2 atmosphere-controlled incubator
- Zetasizer Nano ZS Zeta-Potential Measuring Device (Malvern Instruments)

SELECTED PATENTS

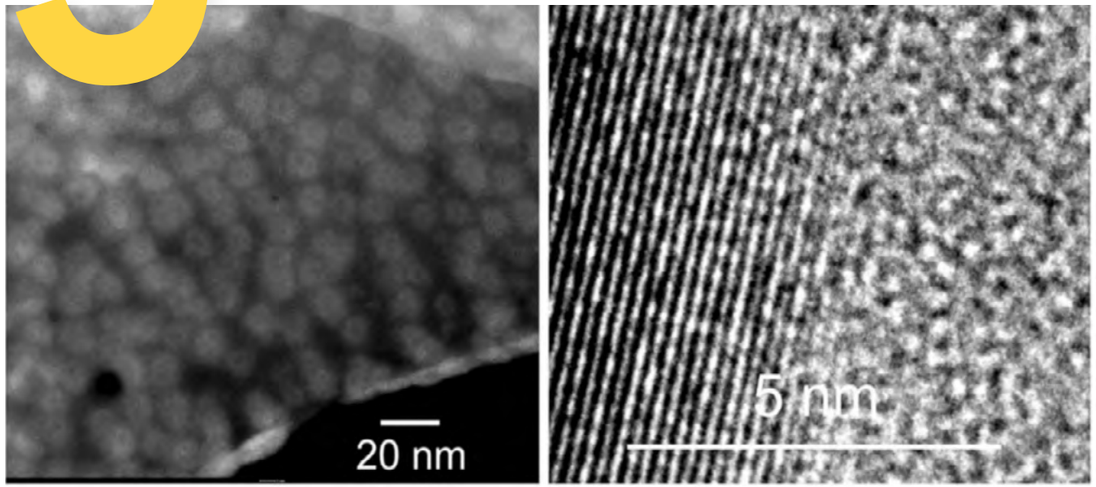
- Press container for plastic processing of metals and their alloys, PAT.417874, 2018
- Method for producing nanocrystalline titanium, PAT.225395, 2016
- Platinum alloy (PtRe) obtained by melting and casting or powder metallurgy, containing platinum, rhenium and unavoidable impurities, with a rhenium content of 0.01–40.00% by weight, PAT.228512, 2017
- Platinum alloy (PtRhRe) obtained by melting and casting or powder metallurgy, containing platinum, rhodium (0.01–40% by weight) and rhenium, as well as unavoidable impurities, with a rhenium content of 0.01 –40.00% by weight, PAT.228514, 2017
- Palladium alloy (PdAuRe) obtained by melting and casting or powder metallurgy, containing palladium, gold (0.01–30% by weight) and rhenium, as well as unavoidable impurities, with a rhenium content of 0.01 –40.00% by weight, PAT.228516, 2017

#BIOMEDICAL TITANIUM ALLOYS #MECHANICAL SURFACE TREATMENTS #CHEMICAL SURFACE TREATMENTS #LASER SURFACE TREATMENTS #HYBRID SURFACE TREATMENTS #COMPOSITE BIOACTIVE COATINGS #PHYSICAL AND CHEMICAL PROPERTIES OF SURFACES #MICROSTRUCTURE OF SURFACE LAYERS #SURFACE MORPHOLOGY/TOPOGRAPHY



RESEARCH TEAM

5 LABORATORY OF NANOCRYSTALLINE SUPERIONIC CONDUCTORS



#NANOMATERIALS #GLASS-CERAMICS #SUPERIONIC CONDUCTORS #GLASS WITH IONIC ELECTRICAL CONDUCTIVITY
#NANOCRYSTALLIZATION #NANOCOMPOSITES #NEW MATERIALS #OXYGEN ION CONDUCTORS #SOFC FUEL CELLS
#IMPEDANCE SPECTROSCOPY

The laboratory investigates the physical properties of nanomaterials and composites with ionic or electron conductivity in the context of their applications in energy conversion and storage devices (Li/Na – batteries, SOFC fuel cells). The Team is composed of two professors, one doctor of science, three researchers with PhD degree, four PhD students and a number of graduate students.

In order to carry out its tasks, the Team can make use of a diverse research infrastructure, including: furnaces for obtaining test samples, state-of-the-art impedance meters, mechanosynthesis mills and cryostats. In addition, the Team has unlimited access to an XRD diffractometer and DTA/DSC/TG thermal analysis equipment. It collaborates with Raman spectroscopy and SEM/TEM electron microscopy laboratories.

The Team is recognised in the international scientific community thanks to numerous publications, papers presented at conferences, international collaborations and contacts. Its aim is to obtain materials with high electrical conductivity.

CONTACT

Professor Jerzy Garbarczyk, Ph.D., D.Sc.
tel. (+48) 22 234 53 50
jerzy.garbarczyk@pw.edu.pl
https://jeg.fizyka.pw.edu.pl/

SELECTED PROJECTS

- Stabilisation of the high-temperature, super ionic delta phase of Bi2O3 to room temperature in glass-ceramic nanomaterials (PRA Material Technologies-1, Warsaw University of Technology, 2020–2021)
- Research on structural and electrical properties of composite ceramic lithium ion conductors formed in Li1.3Al0.3Ti1.7(PO4)3-Li4SiO4 and Li1.3Al0.3Ti1.7(PO4)-3-LiAlSiO4 systems (PRA Material Technologies-2, Warsaw University of Technology, 2021–2022)
- NASICON-type and alludite nanomaterials as cathodes for sodium batteries (IDUB PRA EnergyTech-1 Impulse, Warsaw University of Technology, 2020–2021)
- New glassy and nanocrystalline phosphors for white LED lighting safe for human vision (IDUB PRA FoTech-2, Warsaw University of Technology)
- Mechanism of enhancement of electron conductivity as a result of thermal nanocrystallisation of amorphous olivine equivalents (OPUS 4, NCN, 2013–2016)

SELECTED ACHIEVEMENTS

- The Head of the Team (and of the Department of Solid State Ionics of the Faculty of Physics, WUT) was invited to deliver an online lecture during the 14th International Symposium on Systems with Fast Ionic Transport, 2021
- The Head of the Team was invited by Nanomaterials (IF = 5.08, Open Access journal) to prepare, as a guest editor, a special issue of this journal on “Preparation and Applications of Nanostructured Glass-Ceramics and Nanocomposites”, 2021

AREAS OF COOPERATION WITH OTHER TEAMS

- At the Warsaw University of Technology, the team cooperates with the Faculty of Materials Science and Engineering and the Faculty of Chemistry
- In addition, it also collaborates with third parties, including the High Pressure Research Centre and the Institute of Physics of the Polish Academy of Sciences (joint publications)
- International informal collaborations include contacts with the neutron research centre ISIS (UK), the Physics Department of Vilnius University and the University of Lille (France)

MAIN RESEARCH INFRASTRUCTURE

- X-ray Diffractometry XRD Laboratory
- DTA/DSC/TG Thermal Analyses Laboratory
- Set of state-of-the-art meters for impedance spectroscopy testing

6 UFG BY SPD

RESEARCH TEAM

AREAS OF COOPERATION WITH OTHER TEAMS

- Production of UFG materials using stationary and incremental methods
- Determination of the properties of ultra-fine-grained materials
- Methods of bonding UFG materials

The Team is involved in the development of technologies for the production of UFG (ultra-fine grained) metals.

We specialise in the manufacture of UFG metals through suitable plastic processing of conventional metals. We press batches of different shapes and cross-section sizes through angular channels of various configurations (the so-called ECAP method – equal channel angular pressing). We also use the I-ECAP (Incremental-ECAP) method of incremental pressing, which can be used for the processing of rods as well as tubes and sheets – as for the latter, the incremental method was applied for the first time at the Faculty of Mechanical and Industrial Engineering of the Warsaw University of Technology.

CONTACT

Jacek Goliński, Ph.D.
tel. (+48) 22 234 82 72
jacek.golinski@pw.edu.pl
https://lolejnik.eta.pl

#ECAP #SPD #I-ECAP #FUNG MATERIALS #ULTRA-FINE GRAIN MATERIALS #ANGULAR CHANNEL #UFG METALS

SELECTED PROJECTS

- Ultrafine-grained metal joints friction-welded using high welding energy (OPUS 14, NCN, 2018–2022)

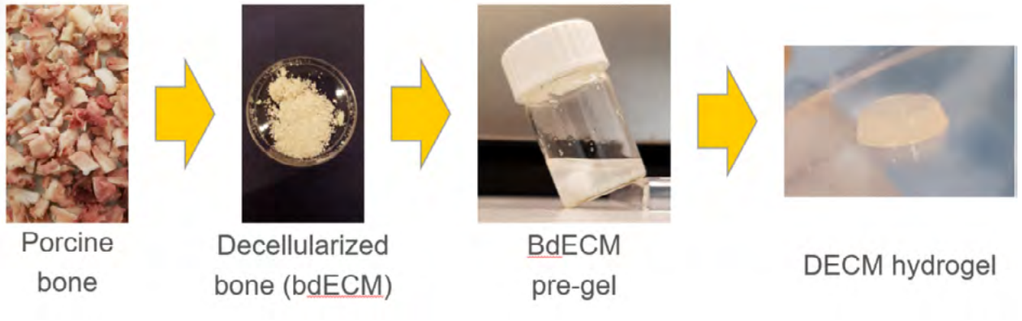
MAIN RESEARCH INFRASTRUCTURE

- Machinery and tooling for stationary and incremental plastic processing of metallic materials

7

RESEARCH TEAM FOR

BIOHYDROGELS



The research team implementing the PRA MT project entitled "Osteoinductive hydrogels for bone tissue regeneration and bioprinting" is led by Joanna Idaszek, Ph.D., collaborating with two PhD students and one technician on the project. The research is conducted in the Biomaterials group at the Faculty of Materials Science and Engineering (WUT).

The Members of the team have experience in the production and characterisation of hydrogel materials, 3D bioprinting, cell culture, and the biological evaluation of the developed biomaterials/ 3D structures gained both while conducting research at the Warsaw University of Technology and during numerous internships abroad (e.g. in Switzerland, Japan, Germany and Ireland).

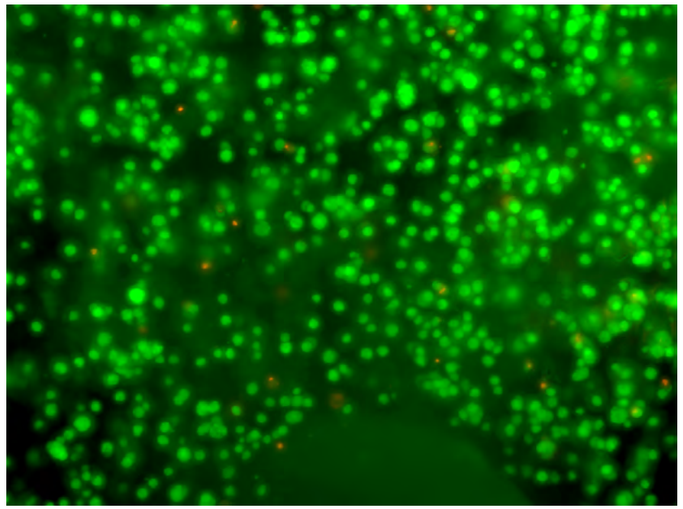
AREAS OF COOPERATION WITH OTHER TEAMS

- Biological evaluation of materials and 3D structures (all biomaterials, cytotoxicity, *in vitro* biocompatibility)
- 3D printing (polymer materials, polymer matrix composites, hydrogels (including bio-printing)
- Characterisation of hydrogel materials
- Confocal microscopy observations
- Computed microtomography

#BONE DEFECT REGENERATION #EXTRACELLULAR MATRIX #DECELLULARISATION #OSTEOGENESIS IN VITRO #OSTEOGENESIS IN VIVO

SELECTED PROJECTS

- Bionic – 3D bioprinting of scaffolds using living pancreatic islands or insulin-producing cells to create a bionic pancreas (STRATEGMED 3, NCBR, 2017–2020)
- iTE – Method for the treatment of large bone defects in oncology patients using *in vivo* tissue engineering (STRATEGMED 3, NCBR, 2017–2020)



MAIN RESEARCH INFRASTRUCTURE

- Chemical laboratory
- Cell laboratory with cell culture equipment (CO_2 incubators, laminar flow cabinet, centrifuges, plate reader, etc.)
- 3D bioprinters (e.g. 3D-Biobioplotter by EnvisionTec), mechanical tester
- Fluorescence and confocal microscope

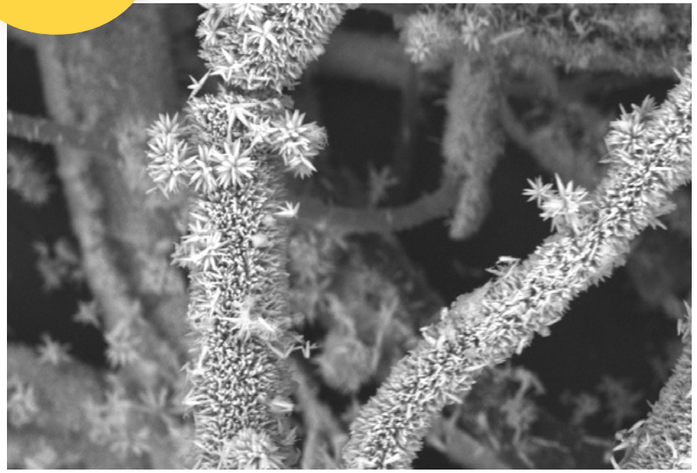
CONTACT

Joanna Idaszek, Ph.D.
tel. (+48) 22 234 86 86
joanna.idaszek@pw.edu.pl
https://wim.pw.edu.pl/Badania-i-nauka/Grupy-badawcze/Biomaterialy
http://bio.materials.pl/nowa/

8

RESEARCH TEAM OF THE

SEPARATION TECHNIQUES LABORATORY – AEROFIL



#FILTRATION #FIBRE FILTERS #AEROSOLS #SEPARATION #MODIFICATION #POLYMERIC STRUCTURES #MODELLING

AREAS OF COOPERATION WITH OTHER TEAMS

- Separation techniques, including air filtration
- Production of filter materials for specific applications
- Modification of filter materials to improve their performance or to give them new properties
- Precise characterisation of newly developed filter materials
- Testing of filter materials for bactericidal and fungicidal properties
- Modification of filter materials

The Research Team of the Separation Techniques Laboratory is operating at the Faculty of Chemical and Process Engineering (WUT), in the Department of Integrated Process Engineering. It cooperates with research units and companies in the filtration industry at home and abroad. The Team has successfully completed several research projects and contracts involving analysis and research for industry.

The Team focuses on the separation (filtration) of aerosols of different morphologies and a wide range of particle diameters – from nano- to micrometric ranges.

The team takes a holistic approach, as the scope of its activities includes:

- design and manufacture of non-woven filter structures using the polymer melt-blowing technique,
- modification of existing filtration structures,
- testing of the effectiveness of the structures in various process conditions,
- mathematical modelling of the process of aerosol particles filtration in non-woven polymer filters.

SELECTED PUBLICATIONS

- Przekop R., Jackiewicz-Zagórska A. (2020), Effect of mesoscale inhomogeneity and fibers size distribution on the initial stage of deep-bed filtration process. Journal of Aerosol Science, 142, 1–13
- Gac J., Jackiewicz-Zagórska A., Werner Ł., Jakubiak Sz. (2018), Numerical modeling of solid deposits reorganization during consecutive solid-liquid aerosol filtration: Influence on the dynamics of filtration efficiency. Journal of Aerosol Science, 119, 13–21
- Jackiewicz-Zagórska A., Szwast M, Gac J., Werner Ł., Zalewski M., Jakubiak Sz. (2018), New methods of natural gas adjusting for technological purposes based on modern filtration materials. Ecological Chemistry and Engineering S, 25(1), 61–72
- Gac J., Jackiewicz A., Werner Ł., Jakubiak Sz. (2016), Consecutive filtration of solid particles and droplets in fibrous filters. Separation and Purification Technology, 170, 234–240
- Jackiewicz A., Jakubiak Sz., Gradoń L. (2015), Analysis of the behavior of deposits in fibrous filters during non-steady state filtration using X-ray computed tomography. Separation and Purification Technology, Pergamon, 156(1), 12–21
- Jackiewicz A., Werner Ł. (2015), Separation of nanoparticles from air using meltblown filtering media. Aerosol and Air Quality Research, 15 (6), 2422–2435

SELECTED PROJECTS

- New methods of bed gas preparation for technological purposes and distribution based on modern filtration materials (LIDER, NCBR, 2013 –2015)
- De-oiling of liquids and gases using aerogel modified filter materials (LIDER, NCBR, 2016–2019)
- Polypropylene-ZnO filtration composite materials for efficient removal of abiotic and biotic particles from the air to improve the quality of life and safety of humans and the environment (PRA Material Technologies-1, Warsaw University of Technology, 2020–2021)

MAIN RESEARCH INFRASTRUCTURE

- PALAS test benches for testing the filtration process of nanoparticles, nanodroplets, submicron and micron objects
- Apparatus for producing both solid and liquid aerosols (droplets) with a wide range of diameters
- Apparatus for the production of non-woven polymeric filter materials using the melt-blow technique
- Apparatus for the analysis of the structure of filter materials, including SEM microscope, goniometer

CONTACT

Anna Jackiewicz-Zagórska, Ph.D.
tel. (+48) 22 234 62 47
anna.jackiewicz@pw.edu.pl
https://ichip.pw.edu.pl

9

RESEARCH TEAM FOR

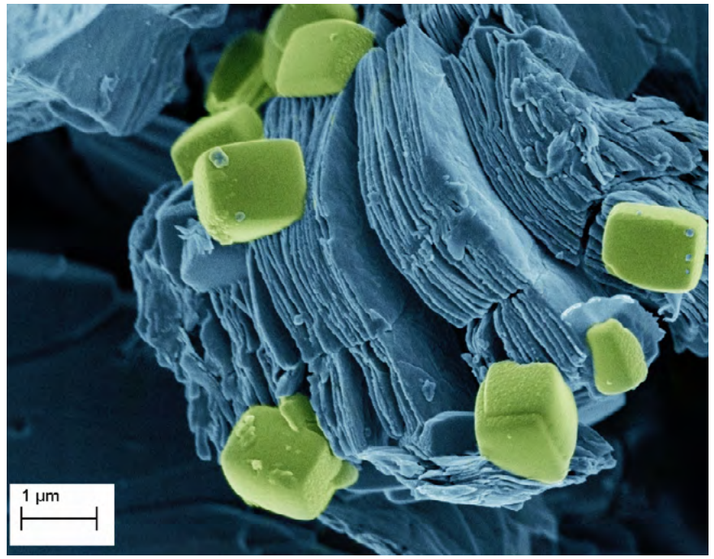
BIOACTIVE NANOMATERIALS

#NANOPARTICLES #NANOCOMPOSITES #NANOCERAMICS # 2D MATERIALS
#MXENES #CYTOTOXICITY #ANTIMICROBIAL #BIOCIDAL
#BIOCOMPATIBLE #ECOTOXICITY

The Research Team for Bioactive Nanomaterials operates at the Department of Ceramic and Polymer Materials of the Faculty of Materials Science and Engineering (WUT).

It focuses on the properties of bioactive nanomaterials with nanocomposite, nanohybrid and two-dimensional structures. The Team works on the development of synthesis and modification methods and investigates the mechanisms of interaction with biological systems in terms of chemical composition, morphology, structure, and physicochemical properties.

The Team also investigates the application and impact of material modifications (including two-dimensional materials such as graphene and MXenes) on their biological activity, biocidal efficacy, broadly defined toxicity to humans and the environment, or anti-cancer properties. In the synthesis of nanomaterials, the Team uses sol-gel and hybrid methods.



CONTACT

Professor Agnieszka Jastrzębska, Ph.D., D.Sc.
tel. (+48) 22 234 74 49
agnieszka.jastrzebska@pw.edu.pl
https://www.wim.pw.edu.pl/index.php/Badania-i-nauka/Grupy-badawcze/Bioaktywne-nanomaterialy-o-strukturze-2D-krysztalu

AREAS OF COOPERATION WITH OTHER TEAMS

- Synthesis of nanomaterials and 2D materials, as well as their modification using sol-gel, hybrid, hydro- and solvothermal methods
- Research on interactions with micro-organisms and biosorption on the surface of materials, as well as *in situ* analysis using zeta potential analysis
- Stability testing of nano-colloidal systems – zeta potential testing
- Research on particle size and shape of nano- and microcolloidal systems
- Research on the specific surface area and porosity of powders using the physical sorption of nitrogen
- Toxicity analysis
- Analysis of the surface chemistry of nanomaterials using infrared spectrometry
- Analysis of nanocolloids and compound concentrations using UV-Vis spectroscopy
- Optimisation of reactant concentrations, reaction conditions and the morphology and physicochemical properties of the final product to achieve the best bioactivity and selectivity of the developed nanoparticles
- Morphological and structural characterisation of the produced nanoparticles – microscopic characterisation of the morphology, analysis of the mode and efficiency of dispersion of metal nanoparticles on the surface or in the volume of the ceramic particle
- Physicochemical characterisation of the produced nanoparticles – investigation of specific surface area, pore volume and diameter, pycnometric density, analysis of elemental composition and chemical state of the surface (valence state of atoms)
- Microbiological characterisation of the produced materials – investigation of antibacterial and fungicidal properties of selected strains
- Microscopic analysis of preferential sites for adsorption of the microorganisms studied, including the evaluation of bacterial adsorption efficiency
- Research on surface electrostatic charge – zeta potential in real time of adsorption duration and wide pH range, the analysis of the impact of surface electric charge of sorbents and cells, their morphology, structure and surface physicochemistry on the sorption phenomenon and electrostatic interactions between sorbent and cell
- Analysis of the interaction with the environment (algae, beneficial micro-organisms isolated from the environment, embryophytes and simple aquatic organisms such as crustaceans)
- Comparison of the properties of nanoparticles obtained with the use of the developed methods with nanoparticles produced using other methods and evaluation of the application value of the developed materials with the addition of bioactive nanoparticles

SELECTED PROJECTS

- 2D Ti_3C_2 MXene for biomedical purposes (BIOTECHMED-1, IDUB, PRA Biotechnology and Biomedical Engineering, Warsaw University of Technology)
- Research on anti-cancer properties of 2D nanocrystals of carbides and titanium nitrides – MXenes phases (SONATA BIS 7, NCN, 2018–2022)
- Research on bioactive properties of novel 2D carbide structures of light transition metals (Iuventus Plus, MNiSW, 2016–2019)
- Advanced techniques for in situ investigation of bacterial sorption phenomena on the surface of novel nanohybrid graphene sorbents in aqueous systems (SONATA BIS 7, NCN, 2014–2018)

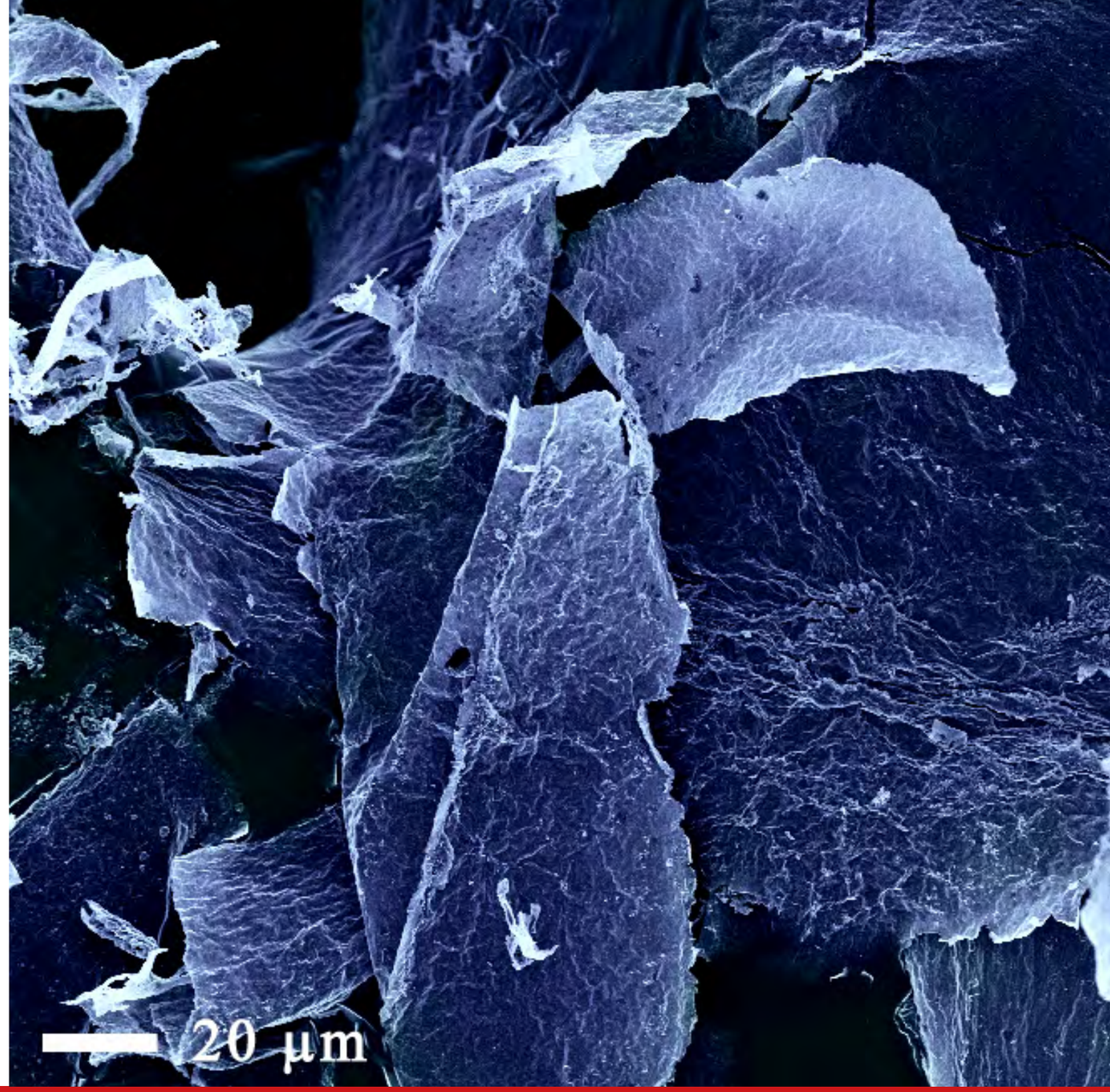
SELECTED PATENTS

- Method for obtaining modified graphene flakes and surface-modified graphene flakes, PAT.227753, 2017
- Method for obtaining modified graphene flakes, PAT.226568, 2017
- Method for obtaining modified graphene flakes and surface-modified graphene flakes, PAT.227754, 2017
- Method for obtaining modified graphene flakes, PAT.225568, 2016

#NANOPARTICLES #NANOCOMPOSITES #NANOCERAMICS # 2D MATERIALS
#MXENES #CYTOTOXICITY #ANTIMICROBIAL #BIOCIDAL
#BIOCOMPATIBLE #ECOTOXICITY

MAIN RESEARCH INFRASTRUCTURE

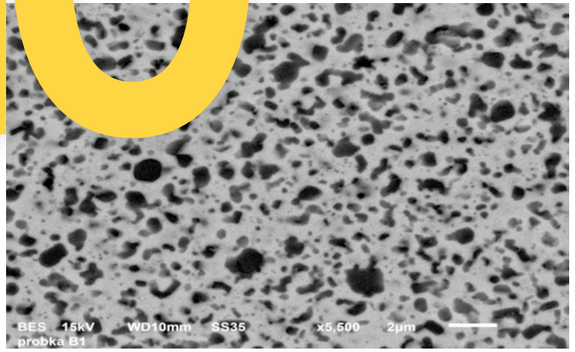
- Zetasizer Nano-ZS particle size (DLS) and zeta potential analyser by Malvern Instruments, equipped with a Flo Vac degasser and dip cell kit
- Quadrasorb SI specific surface area and porosity characterisation apparatus by Quantachrome Instruments
- SONICS VCX 750 ultrasonic homogeniser
- Rotina 420 laboratory centrifuge by Hettich Zentifugen (up to 5,000 rpm)
- MPW-352 Centrifuge by Med Instruments (up to 10 000 rpm)
- Scan 100 automatic colony counter by Interscience International
- Reaction system for the synthesis of nanomaterials, composite nanoparticles and 2D materials using the sol-gel method with a fume hood
- Orbital Shaker-Incubator ES-80 by Grant Instruments
- Evolution 210 dual-beam UV-Vis spectrometer by Thermo Scientific, equipped with a xenon lamp (190–1100 nm range) and a reflectance system for solid sample measurements
- FTIR spectrometer, Nicolet iS5, Thermo Scientific, equipped with DRIFTS and ATR (diamond and germanium crystal) attachments
- Alpha 2–4 LD Plus lyophiliser, Martin Christ, (up to -85°C) with a capacity of 4 kg of ice/24 hours
- Ertec MAGNUM v2 microwave reactor, 110 ml, 600 W, 2.45 GHz, with an automatic control system
- XRF spectrometer PI 100 by Polon-Izot, with fast SSD detector, 125 to 140 eV resolution
- GeneExplorer gradient thermal cycler by Syngen Biotech (range 4–105°C) equipped with 96-well block, 0.2ml tubes, strips



10

CERMETALIK

RESEARCH TEAM



The Cermetalik Research Team is composed of employees of the Faculty of Materials Science and Engineering and the Faculty of Chemistry at the Warsaw University of Technology. They conduct joint works on the production of a composite from a mixture of ceramic and pre-composite powders.

The Team has extensive experience in ceramic materials and ceramic matrix composites. Its members have knowledge and skills in both material fabrication methods and material characterisation. The joint research of the team managed by Professor M. Szafran, Ph.D., D.Sc. and that of Professor K. Konopka, Ph.D., D.Sc. (project leader), which has been carried out for many years, has resulted in numerous projects, publications in highly ranked journals, and patent applications.

The project also envisages cooperation with the Faculty of Mechanical Engineering at the Military University of Technology in Warsaw. Joint research will be carried out on the structure of ceramic-intermetallic composites using advanced research methods such as TEM, SEM, STEM and EDS.

#MICROSTRUCTURE #CRACK RESISTANCE #HARDNESS #SLIP CASTING
#POWDER CONSOLIDATION #MECHANICAL SYNTHESIS

AREAS OF COOPERATION WITH OTHER TEAMS

- Ceramic matrix composites
- Microstructure analysis
- Analysis of mechanical properties (hardness, compressive strength, fracture toughness, bending strength, abrasion resistance)
- Manufacture of solid materials, including composites, using powder consolidation
- Use of different powder consolidation methods (compression and sintering, slip casting, gelcasting, centrifugal slip casting)
- Characterisation of the microstructure and phase composition, hardness measurements and density analysis of sintered materials
- Research using scanning electron microscopy
- Measurements of powder particle size, d-zeta potential, density and porosity
- Determination of hardness and fracture toughness (KIC – indentation method)
- Brazilian test
- Quantitative descriptions of the microstructure of composites – stereological analysis using computer software

SELECTED PROJECTS

- Optimisation of the microstructure of a ceramic--metal composite to increase its resistance to brittle fracture (KBN – State Committee for Scientific Research, 1998–2000)
- Structure and properties of ceramic-metal interfaces in infiltrated composites (KBN, 2001–2004)
- Structures and properties of ceramic-polymer composites for cyclic loads (Ministry of Science and Information Technology, 2005–2007)
- Impact of synthesis and finishing technologies on optimisation of properties of low-friction nickel--copper matrix composites (international project awarded by the Ministry of Science and Higher Education with the University of Ukraine in Kyiv under the trilateral agreement made in 2006 by the National Technical University of Ukraine in Kyiv, St. Petersburg State Technical University and the Warsaw University of Technology, 2009–2010)
- Production and characterisation of a new material from diatom carapaces with a different proportion and size of pores (MNiSW, 2008-2010)
- Ceramic-metal composites formed by gel casting (NCN, 2011–2013)
- Advanced ceramic-metal composites and nanocomposites for aerospace and automotive industry (KomCerMet) (Innovative Economy Operational Programme, KCM2 package “Metal-ceramic matrix composites” (OPUS, NCN, 2008–2013)
- Ceramic-metal composites in ZrO_2-Ti system (OPUS, NCN, 2014–2017)
- Hybrid ceramic-metal composites with gradient reinforcement (OPUS, NCN, 2018–2021)
- Innovative gradient ceramic-ceramic composites from Al_2O_3-ZrO_2 system formed by centrifugal slip casting (IDUB - PRA Material Technologies 1, Warsaw University of Technology, 2020–2021)

MAIN RESEARCH INFRASTRUCTURE

- Equipment used for the manufacture and characterisation of ceramics and ceramic matrix composites available at the Faculty of Materials Science and Engineering and the Faculty of Chemistry at Warsaw University of Technology as part of ongoing research collaboration, including:
  - powder grinding mills
  - homogenisation devices
  - furnaces for sintering in various atmospheres
  - laboratory dryers
  - analytical balance with density measurement attachment
  - d-zeta potential measuring device
  - hardness tester
  - X-ray diffractometer for phase composition analysis
  - scanning microscopes

SELECTED PATENTS

- Method for manufacturing composite elements with a metallic phase gradient, PL 234766, 2019

CONTACT

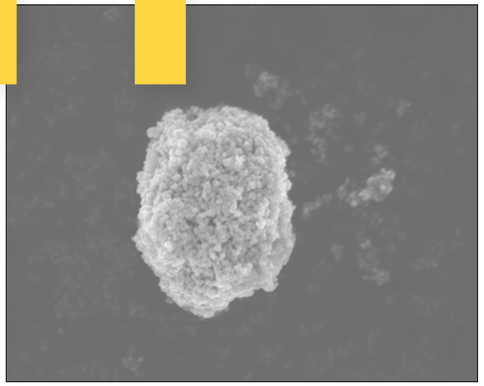
Professor Katarzyna Konopka, Ph.D., D.Sc.
tel. (+48) 22 234 87 38
katarzyna.konopka@pw.edu.pl
https://wim.pw.edu.pl

11

RESEARCH TEAM FOR

PRODUCT ENGINEERING

#CHEMICAL REACTOR ENGINEERING #MIXING PROCESSES #SEPARATION PROCESSES #COMPUTATIONAL FLUID DYNAMICS #POPULATION BALANCE #POWDERS AND SUSPENSIONS #PRODUCT ENGINEERING



The Team is operating at the Department of Separation Processes of the Faculty of Chemical and Process Engineering (WUT).

It deals with solving practical problems in the field of selective fabrication of products of complex chemical reactions, production and processing of micro- and nanoparticles with defined properties, and studies the rheology of suspensions in relation to their structure by conducting experiments, creating models and modelling the fabrication of products on the basis of computational fluid dynamics and population balance.

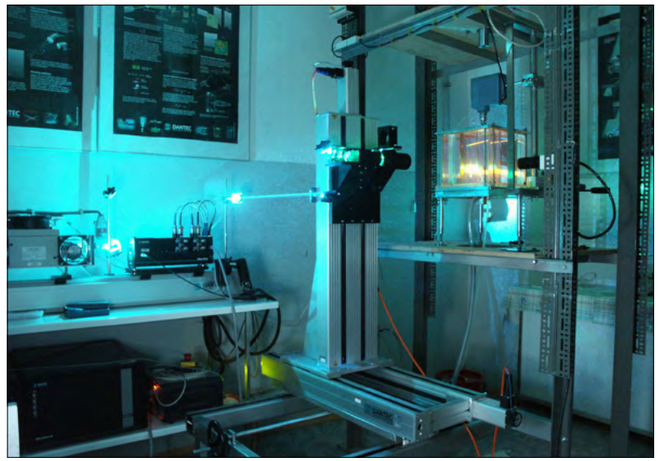
It also conducts works in the field of design and selection of process conditions for industrial systems using computer-aided process engineering software.

AREAS OF COOPERATION WITH OTHER TEAMS

- Process design for the selective manufacture of products of complex chemical reactions
- Production and processing of micro- and nanoparticles with defined properties
- Research on rheological and tribological properties of suspensions in relation to their structure – experiments and theoretical models
- Modelling of product manufacturing on the basis of computational fluid mechanics and population balance
- Practical applications of modelling methods for highly efficient manufacturing and processing of nanopowders and nanosuspensions
- Development of new methods and designs of industrial apparatus for continuous production (from microreactor to mesoreactor scale) in chemical processes
- Design and testing of new industrial mixers
- Predicting the impact of process parameters on the properties of liquid-solid systems in industrial multiphase reactors
- Design and selection of process conditions for industrial systems using computer-aided process engineering software for separation processes

SELECTED PROJECTS

- Large-eddy simulations of complex chemical processes in impinging jet reactors (OPUS, NCN, 2014–2017)
- Development and implementation of user-defined subroutines for the commercially available CFD software package “Ansys Fluent” with respect to micromixing phenomena and population balances (Bayer Technology Service, 2014–2015)
- Interpretation, modelling and CFD calculations of process involving comminuting of particles (Bayer Technology Service, 2015–2017)
- Grinding process in a dissolver and ball mill (ICHEMAD-Profarb, 2016–2018)
- Development of utility models for the design of a set of energy-efficient equipment for the chemical industry, in particular for the production of paints and varnishes (ICHEMAD-Profarb, 2016–2018)
- Research on the kinetics of molybdenum disulphide crystal formation to obtain a product with desired properties in impinging jet reactors (OPUS, NCN, 2019–2021)



MAIN RESEARCH INFRASTRUCTURE

- Particle Image Velocimetry (PIV) measuring system
- Planar Laser Induced Fluorescence (PLIF) measuring system
- Laser Doppler Anemometry (LDA) measuring system
- Beckman Coluter LS 13 320 and Malvern Zetasizer microparticle and nanoparticle size analysers
- PERLAN Technologies Agilent 1260 Infinity HPLC liquid chromatograph
- Anton Paar MCR 302 rotational rheometer
- T-PTD200, T-PID/44 Anton Paar Tribometer

CONTACT

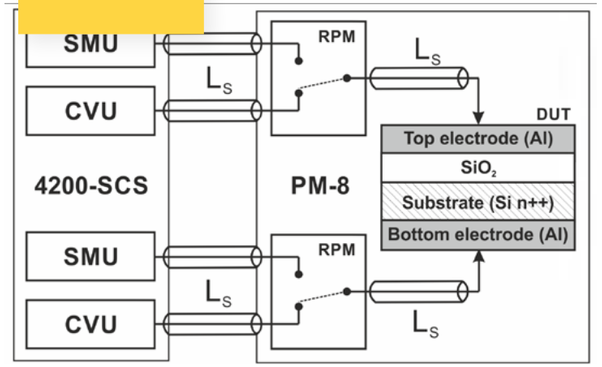
Professor Łukasz Makowski, Ph.D., D.Sc.
tel. (+48) 22 234 62 94
lukasz.makowski.ichip@pw.edu.pl
https://www.ichip.pw.edu.pl

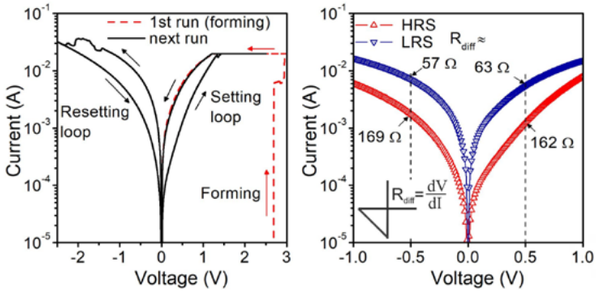
12

RESEARCH TEAM FOR

METAL-INSULATOR-METAL (MIM) STRUCTURES FABRICATION AND CHARACTERIZATION

#METAL–INSULATOR–METAL STRUCTURES #RESISTIVE RANDOM ACCESS MEMORY #CHARGE TRANSPORT MECHANISMS #FILAMENT FORMATION #SEMICONDUCTOR NANOCRYSTALS #TRANSMISSION ELECTRON MICROSCOPY #SCANNING ELECTRON





AREAS OF COOPERATION WITH OTHER TEAMS

- Technology of semiconductor devices
- Characterisation of semiconductor devices
- Modelling of semiconductor devices

CONTACT

Andrzej Mazurak, Ph.D.
tel. (+48) 22 234 60 65
andrzej.mazurak@pw.edu.pl
https://www.imio.pw.edu.pl/index.php/badania-naukowe/projekty-badawcze

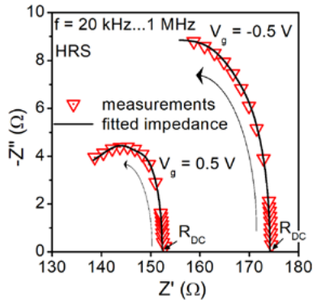
The Team is composed of the employees of Department of Microelectronics and Nanoelectronics Devices of the Institute of Microelectronics and Optoelectronics at the Faculty of Electronics and Information Technology (WUT) – Andrzej Mazurak, Ph.D., Jakub Jasiński, Ph.D. (characterisation and modelling of semiconductor devices) and Professor Robert Mroczyński, Ph.D., D.Sc. (semiconductor device technology and characterisation), CEZAMAT Centre for Advanced Materials and Technology – Piotr Wiśniewski, Ph.D. (modelling and technology of semiconductor devices), and at the Faculty of Materials Science and Engineering (WUT) – Tomasz Płociński, Ph.D. (application of advanced electron microscopy techniques in the study of functional materials with nanometric structure).

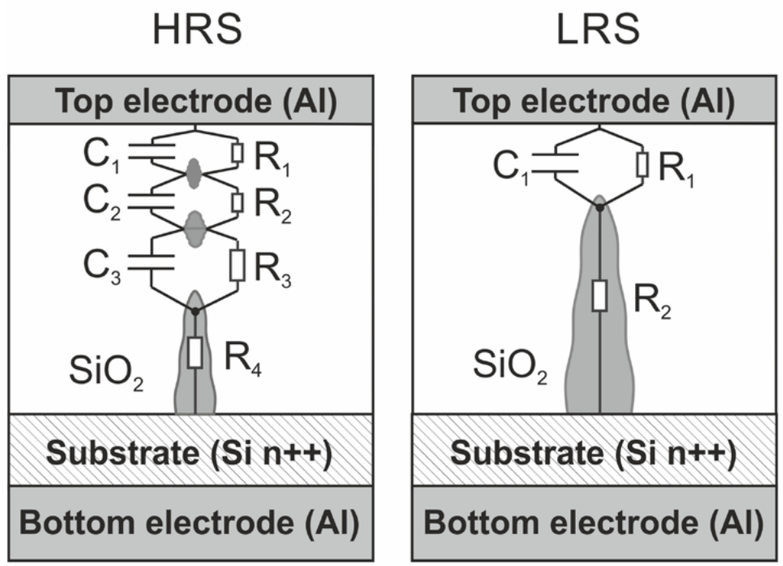
SELECTED PROJECT

- Nanophotonics with metal – group-IV-semiconductor nanocomposites: From single nanoobjects to functional ensembles (Visegrad Group (V4)-Japan Joint Research Program on Advanced Materials, NCBR, 2016–2019)

MAIN RESEARCH INFRASTRUCTURE

- Laboratory of semiconductor technology (cleanroom)
- Laboratory of electrical characterisation of semiconductor devices
- Laboratory of electron microscopy





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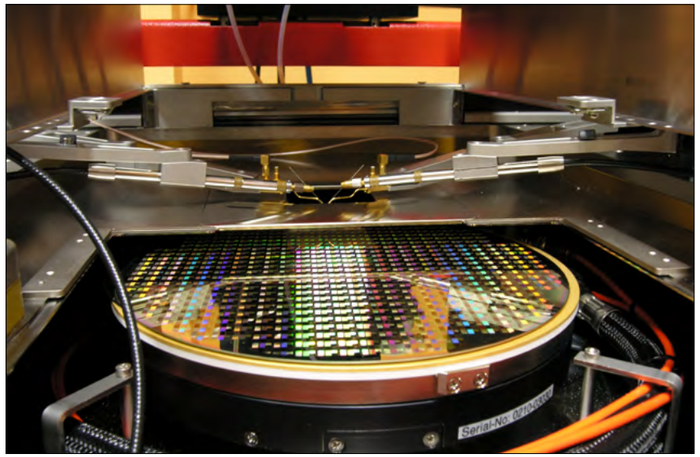
RESEARCH TEAM FOR

TECHNOLOGY, DIAGNOSTICS AND MODELLING OF MATERIALS AND STRUCTURES FOR NANOELECTRONICS AND PHOTONICS (TDM-NANO)

#TECHNOLOGY #CHARACTERISATION #NANOTECHNOLOGIES #ELECTRONICS #PHOTONICS #MEASUREMENT AUTOMATION #EMBEDDED SOFTWARE #INTERNET OF THINGS #IOT #MATERIAL

CONTACT

Professor Robert Mroczyński, Ph.D., D.Sc.
tel. (+48) 22 234 60 65
robert.mroczynski@pw.edu.pl
https://www.robert-mroczynski.net



The Team is operating within the structures of the Institute of Microelectronics and Optoelectronics of the Faculty of Electronics and Information Technology (WUT). It is composed of eleven members, including one associate professor, five assistant professors (including one with a D.Sc. degree), two Ph.D. students and three graduate students.

The main research areas of the Team include:

- semiconductor technologies (development, modelling and optimisation of materials and test instrument technologies),
- technologies for nanoelectronics, nano-photonics, sensorics and bioengineering,
- technologies for complex MEMS/MOEMS and IoT systems,
- research on materials, structures and devices for nanoelectronics and semiconductor photonics,
- materials engineering,
- measurement and industrial automation,
- embedded electronics systems,
- wireless measurement/sensor networks.

AREAS OF COOPERATION WITH OTHER TEAMS

- Development of thin and ultra-thin dielectric, semiconductor and conductive film technologies
- Construction and design of test structures for the launch of new technologies (microelectronics, photonics and microsystems)
- Optimisation and design of electrical and optical properties of thin films for nanoelectronics and semiconductor photonics structures and devices
- Use of experiment planning methods for process optimisation
- Use of plasma methods for ultrafine ion implantation and solid surface modification processes
- Research on electrical, optical and structural properties of semiconductor materials and structures
- Integration and testing of low-dimensional (2D) materials and semiconductor nanocrystals in modern electronic and photonic devices
- Modelling and simulation of electronic and photonic structures and devices
- Modelling and simulation of electrical characteristics (static and dynamic) of nano-electronic structures and devices
- Modelling of semiconductor technology processes
- Comprehensive design of electronic devices in the fields of measurement automation and industrial automation
- Design of analogue, digital and analogue-digital electronics devices
- Comprehensive design of embedded electronics devices with particular emphasis on portable precision measurement automation devices

- Design of autonomous nodes of wireless sensor networks of the smart mesh and smart dust type and IoT, using energy-harvesting technology
- Hardware solutions to problems of short- and long-range wireless communication based on specified technologies and standards, including NFC, HDX, FDX, EPC and Bluetooth, Sub-GHz, WiFi, GSM, ZigBee, as well as others in 802.15.4 standard

#TECHNOLOGY #CHARACTERISATION #NANOTECHNOLOGIES #ELECTRONICS #PHOTONICS
#MEASUREMENT AUTOMATION #EMBEDDED SOFTWARE #INTERNET OF THINGS #IOT #MATERIAL

SELECTED PROJECTS

- Nanophotonics with metal-group-IV-semiconductor nanocomposites: From single nanoobjects to functional ensembles (NaMSeN) (V4 Countries-Japan, NCBR, 2016–2019)
- Technology and characterisation of ultra-thin silicon layers produced with the use of the PECVD method for nanoelectronic structures (OPUS, NCN, 2012 –2016)
- High-voltage Schottky diodes based on GaN monocrystals for high-power device applications (PBS, NCBR, 2016–2017)
- Tunable hyperbolic metamaterials for the next generation of photonic devices (HYPER-MAT) (TECHMATSTRATEG, NCBR, 2017–2021)
- Photograph – Ultra-fast Photodetector based on Graphene (GRAF-TECH, NCBR, 2013–2016)
- Ultrafine plasmonic ion implantation for the technology of advanced MOS/MOSFET structures fabricated on silicon and silicon carbide – characterisation of the phenomenon, attempts of technological optimisation (SONATA, NCN, 2011–2017)
- Technology and characterisation of MIS structures with a double layer of gate dielectric for non-volatile semiconductor memory (NVSM) applications (MNiSW/NCN, 2009–2013)
- Silicon-based nanostructures and nanodevices for long term microelectronics applications (NANOSIL) (7 PR UE, 2008–2011)
- Pulling the Limits of NanoCMOS electronics (PULLNANO) (6 PR UE, 2006–2008)
- NoE Silicon-based Nanodevices (SINANO) (6 PR UE, 2004–2007)

MAIN RESEARCH INFRASTRUCTURE

- A set of four reactors by OXFORD INSTRUMENTS PLASMA TECHNOLOGY for plasma-assisted deposition and etching and for reactive magnetron sputtering of dielectric, semiconductor and conductive layers
- SUSS device (MJB4) for photolithography with a resolution of up to 1 µm and the necessary accessories for processing photosensitive layers
- KEITHLEY (SCS 4200) and KEYSIGHT (B1500) measuring systems for high-resolution measurements of electrical parameters and characteristics of semiconductor materials, structures and devices
- SUSS and SIGNATONE shielded probe system for low-noise electrical measurements in the temperature range from -60°C to 200°C
- UVISEL spectroscopic ellipsometer by HORIBA JOBYN-YVON for measurements of optical parameters, thicknesses and system of layers in the range from single-atom layers to layers with the thickness of up to several tens of micrometres
- ThetaMetrisis reflectometer in the range 190 –1100 nm for measurements of optical parameters (reflectance, transmittance), thickness and system of layers in the range from single-atom layers to layers with the thickness up to several tens of micrometres

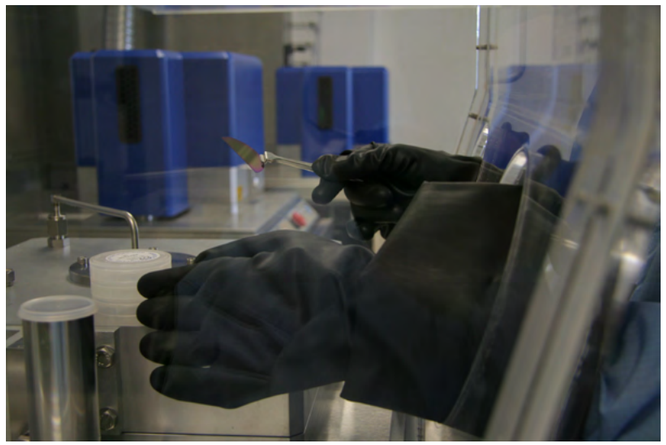
SELECTED PATENTS

- Measuring device to monitoring vertical displacement and vertical deflection of building construction, 01/2010, 04-01-2010, PL, 2010
- Method of detection of dynamics balance of measurement device suspended above its COG, 13/2012, 18-06-2012, PL, 2012
- Set for fastening of measuring device, particularly rangefinder, to monitored element of building construction, especially of the roof, fastening method of measuring device using such set and suspension for fastening of measuring device, 11/2012, 21-05-2012, PL, 2012
- A monitoring method of vertical displacement and vertical deflection change of building construction elements, especially of the roof, and a system for realization of this method, 14/2012, 02-07-2012, PL, 2012
- A monitoring method of vertical displacement and vertical deflection change of building construction elements, especially of the roof, and a system for realization of this method, US 2012/0166136 A1, Jun 28, 2012, USA, 2012
- Set for fastening of measuring device, particularly rangefinder, to monitored element of building construction, especially of the roof, fastening method of measuring device using such set and suspension for fastening of measuring device, US 2012/0128406 A1, May 24, 2012, USA, 2012
- Resistive paste, PL 212291 B1, 13-03-2012, 2012

SELECTED ACHIEVEMENTS

The Members of the Team were honoured with distinctions awarded by the President of the Republic of Poland, including:

- Medal of the Commission of National Education
- the Gold, Silver and Bronze Cross of Merit
- Medals for Long Service



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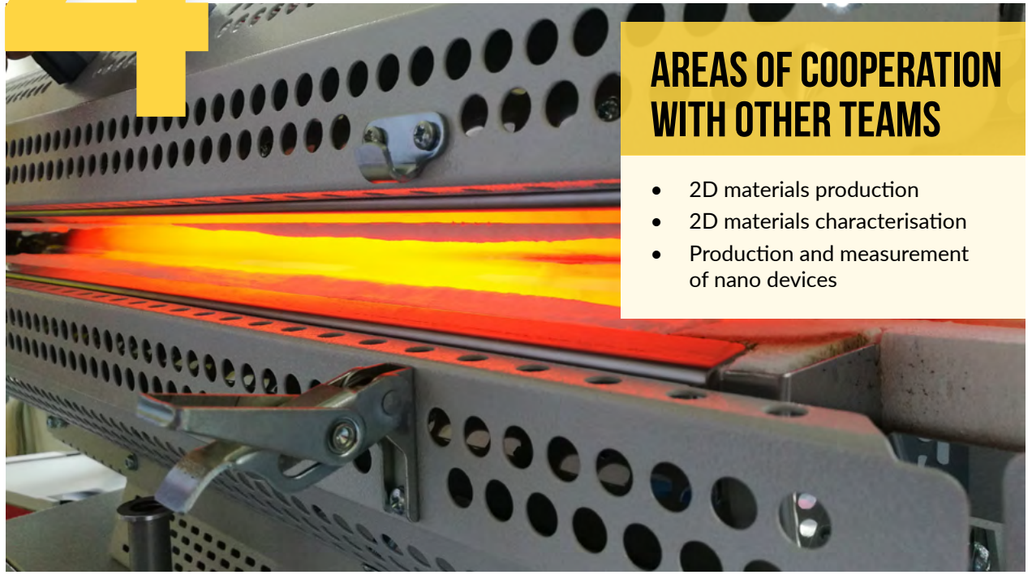
RESEARCH TEAM FOR

NANOSTRUCTURES



AREAS OF COOPERATION WITH OTHER TEAMS

- 2D materials production
- 2D materials characterisation
- Production and measurement of nano devices

The Team is composed of:

- Iwona Pasternak, Ph.D. – has been focusing on 2D materials in her work since 2011; at WUT, she is involved in the development of technologies for obtaining 2D materials; she has experience in managing domestic and international research projects; she is co-author of more than 80 publications, index H:26,
- Michał Świniarski, Ph.D. – specialist in electrical measurements and production of nanodevices with the use of electron lithography; co-author of 12 publications published in journals from the Philadelphia list, H:7 index; manager and contractor of domestic and international projects,
- Karolina Czerniak-Łosiewicz, M.Sc. – a 4th year Ph.D. student at the Faculty of Physics (WUT); as part of her dissertation, she is conducting research on the photoconductivity of two-dimensional transition metal dichalcogenides,
- Jakub Sitek M.Sc. – a 4th year Ph.D. student at the Department of Physics (WUT), as part of his dissertation, he is dealing with the growth of 2D materials, in particular the impact of the substrate on the structural properties of the synthesised layers.

#FLUID MECHANICS #RHEOLOGY #NON-NEWTONIAN FLUIDS #SHEAR THICKENING #ENERGY ABSORPTION #KINETIC ENERGY #PROCESS MODELLING #DATA PROFILING #BIG DATA #PROCESS AUTOMATION

SELECTED PROJECTS

- Graphene Flagship (European Commision, 2020–2022)
- CHARMING Carbon nanomaterial enhanced optical fibers for biomedical imaging and sensing (EOS, FWO, 2018–2021)
- A novel transparent electrodes for VCSEL (M.ERA-NET, NCBR, 2020–2022)
- Technology for the production of key novel epitaxial structures and VCSEL laser devices for the development of photonics (Ścieżka dla Mazowsza, NCBR, 2020–2022)
- Growth of graphene on Ge substrates with different crystallographic orientation with the use of CVD (SONATA 12, NCN, 2017–2021)

SELECTED PUBLICATIONS

- Sitek J., Płocharski J., Pasternak I., Gertych A.P., McAleese C., Conran B.R., Zdrojek M., Strupiński W. (2020), Substrate-Induced Variances in Morphological and Structural Properties of MoS2 Grown by Chemical Vapor Deposition on Epitaxial Graphene and SiO2. In: ACS Applied Materials & Interfaces, 12/4, 45101–45110
- Sitek J., Pasternak I., Grzonka J., Sobieski J., Judek J., Dąbrowski P., Zdrojek M., Strupiński W. (2020), Impact of germanium substrate orientation on morphological and structural properties of graphene grown by CVD method. In: Applied Surface Science, 499
- Backes C., Pasternak I., Strupinski W., García Jorge M. [et al.] (2020), Production and processing of graphene and related materials. In: 2D Materials, 7
- Adamowicz J., Pasternak I., Kłoskowski T., Gniadek M., Van Breda S.V., Buhl M., Balcerczyk D., Gagat M., Grzanka D., Strupiński W., Pokrywczyńska M., Drewa T. (2020), Development of a conductive biocomposite combining graphene and amniotic membrane for replacement of the neuronal network of tissue-engineered urinary bladder. In Scientific Reports, 10

MAIN RESEARCH INFRASTRUCTURE

- Carbolite Gero split tube furnace
- Bruker Dimension Icon atomic force microscope
- Raman spectroscope
- Hall effect measurement system of own construction
- Raith eLINE electron beam lithography
- Kurt J. Lesker Nano 36 thermal deposition system
- Photocurrent measurement system
- Wire bonder

CONTACT

Iwona Pasternak, Ph.D.
tel. (+48) 22 234 72 81
iwona.pasternak@pw.edu.pl
https://nano.fizyka.pw.edu.pl

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RESEARCH TEAM FOR

TECHNICAL CATALYSIS

The Research Team for Technical Catalysis is composed of employees and PhD students of the Chair of Chemical Technology at the Faculty of Chemistry (WUT).

The Team conducts works on the design, preparation and characterisation of catalysts for large-scale processes in the inorganic industry of great importance to the economy. In its operations, the Team combines the practical aspect (i.e. development of new and improvement of existing catalytic systems) with the scientific aspect (striving to understand the principles of their operation). To this end, it carries out material analyses in terms of structure, surface area, gas-phase interaction, catalytic activity and other properties.

The Team's broad experience also enables it to provide advice and expert opinions on the design, operation and development of a variety of chemical technologies. In all areas of activity, the members of the Team actively cooperate with domestic and foreign industrial partners.

#HETEROGENEOUS CATALYSIS #AMMONIA SYNTHESIS #AMMONIA OXIDATION #CARBON MONOXIDE METHANATION #GAS CLEANING #THERMAL ANALYSIS #SORPTION TECHNIQUES

AREAS OF COOPERATION WITH OTHER TEAMS

- Development of new and optimisation of existing chemical reaction catalysts, preparation of materials with properties tailored to the needs of the technology under examination
- Preparation of expert opinions and advice on the development, operation and advancement of chemical technologies
- Performance of material analyses of textural parameters of materials, their surface properties, gas-phase interaction and catalytic activity, thermal analysis and chemisorption temperature-programmed measurements
- Development and optimisation of auxiliary solutions complementing chemical technologies and processes

SELECTED PROJECTS

- Structure sensitivity of ammonia synthesis reaction over promoted cobalt catalysts (PRELUDIUM, NCN, 2017–2020)
- Cobalt catalyst for low-energy process of ammonia synthesis (PBS, NCBR, 2014–2017)
- A support for patent protection of the invention entitled "Method for purification of ammonia, mixtures of nitrogen and hydrogen, or nitrogen, hydrogen and ammonia" submitted under PCT procedure (PATENT PLUS, NCBR, 2014–2017)
- Carbon-supported ruthenium catalysts for carbon oxide methanation (SONATA, NCN, 2011–2015)

SELECTED PATENTS

- Method for obtaining promoted cobalt catalysts for synthesis of ammonia, PL 234181, 2019
- A method for obtaining promoted cobalt catalysts for ammonia synthesis, EP3318326, 2018
- Ammonia synthesis catalyst and a method for preparing a catalyst for ammonia synthesis, PL 220277, 2014
- Cerium and barium promoted cobalt catalyst for ammonia synthesis and process for the preparation of cerium and barium promoted cobalt catalyst for ammonia synthesis, PL 216899, 2013
- Method for purification of ammonia, mixtures of nitrogen and hydrogen, or nitrogen, hydrogen and ammonia, PL 224195, 2016, EP2858949, 2018, RU2612686C2, 2017, 11201406281X, 2017, CA2875257, 2017, CN104364196B, 2017, US9272906, 2016, JP591694, 2016

MAIN RESEARCH INFRASTRUCTURE

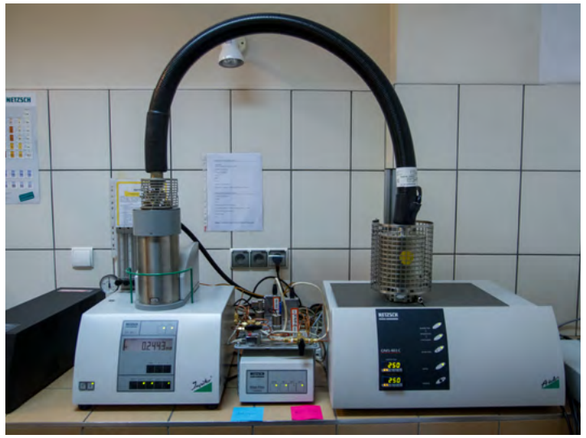
- Netzsch STA 449 Jupiter thermal analysis system coupled to a QMS 430C Aëolos quadrupole mass spectrometer
- ASAP 2020 apparatus for physical sorption measurements at liquid nitrogen temperature by Micromeritics Instrument with chemisorption attachment
- AutoChem 2920 temperature--programmed chemisorption measuring apparatus by Micromeritics Instrument
- A unique apparatus for measuring reaction rates (average and actual) of ammonia synthesis and decomposition, COx methanation
- A set of laboratory equipment for preliminary works, e.g.: vacuum evaporators, furnaces with controlled gas atmospheres, material reduction equipment, etc.

CONTACT

Professor Wioletta Raróg-Pilecka, Ph.D., D.Sc.
tel. (+48) 22 234 57 66
wioletta.pilecka@pw.edu.pl

SELECTED ACHIEVEMENTS

- Title of Innovation Leader of the 13th edition of the ARP Innovation Pitch, organised by the Industrial Development Agency, 2018
- Gold Medal for the invention “Promoted cobalt catalyst for low-temperature ammonia synthesis” at the International Exhibition of Technical Innovations, Patents and Inventions INVENT ARENA 2018 in Třinec, Czech Republic, 2018
- Gold Medal for the invention “Promoted cobalt catalyst for low-temperature ammonia synthesis” at the International Exhibition of Inventions iENA 2017 in Nuremberg, 2017
- Gold Medal for the invention “Method for obtaining cerium-barium promoted cobalt catalysts for low--temperature ammonia synthesis” at the 20th Moscow International Salon of Inventions and Innovative Technologies “Archimedes 2017”, 2017



#HETEROGENEOUS CATALYSIS #AMMONIA SYNTHESIS #AMMONIA OXIDATION #CARBON MONOXIDE METHANATION #GAS CLEANING #THERMAL ANALYSIS #SORPTION TECHNIQUES

#PLASMA TECHNOLOGIES #GAS-PHASE DEPOSITION #SENSORS #FIBRE OPTICS #METAL OXIDES #CARBON LAYERS
#ELECTROCHEMISTRY #OPTICAL MEASUREMENTS #BIOSENSORS #CONSTRUCTION OF MEASURING DEVICES

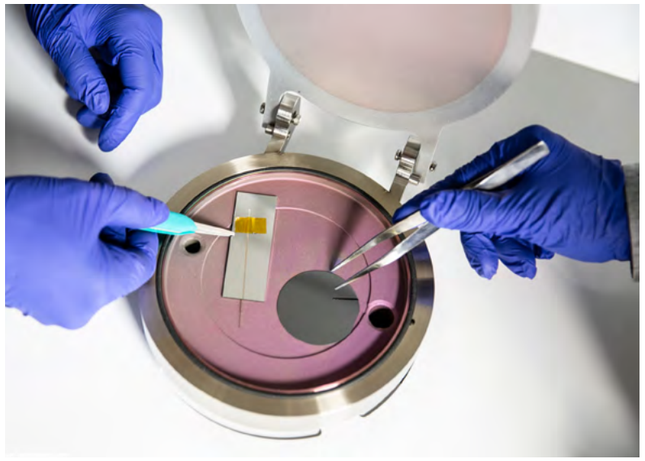
16

NOS RESEARCH TEAM
– NANOTECHNOLOGY, OPTICS, SENSING

The team is operating at the Faculty of Electronics and Information Technology (WUT). The area of interest of the Team include modern sensing and biosensing systems, mainly using optical solutions, in particular fibre optics.

The research topics focus on the use of advanced thin-film techniques and surface modifications to induce or intensify optical and electrical interactions between a sensor and a test parameter.

The Team has developed a number of optical and electrochemical sensing solutions for the selective detection of bacteria, viruses, proteins, toxins and DNA. Numerous projects financed by the National Science Centre, the National Centre for Research and Development, the Foundation for Polish Science, as well as industrial subcontracts from Horizon 2020 funds have also been implemented.



AREAS OF COOPERATION WITH OTHER TEAMS

- Deposition of thin films and analysis of their properties
- Research works on bio-based materials
- Design of sensors and measurement methodology

SELECTED PROJECTS

- Optical analysis of electrochemical reaction products in picoliter volumes (OPUS, NCN, 2019–2021)
- DIAMSEC – ultrasensitive sensing platform for fast detection of epidemic and pandemic infections (Strategic research and development programme “Modern material technologies” TECHMATSTRATEG, NCBR, 2017–2021)
- Conductive photonic structures for multiparametric bio-chemical diagnostics (SONATA BIS 4, NCN, 2015–2019)
- Investigation on interaction between bio-active media and electromagnetic field in photonic crystal fiber devices with suspended core (OPUS 7, NCN, 2015–2018)
- Optical fiber sensors with nanofilms for diagnostics of liquids containing bio-ingredients (LIDER, NCBR, 2011–2014)

CONTACT

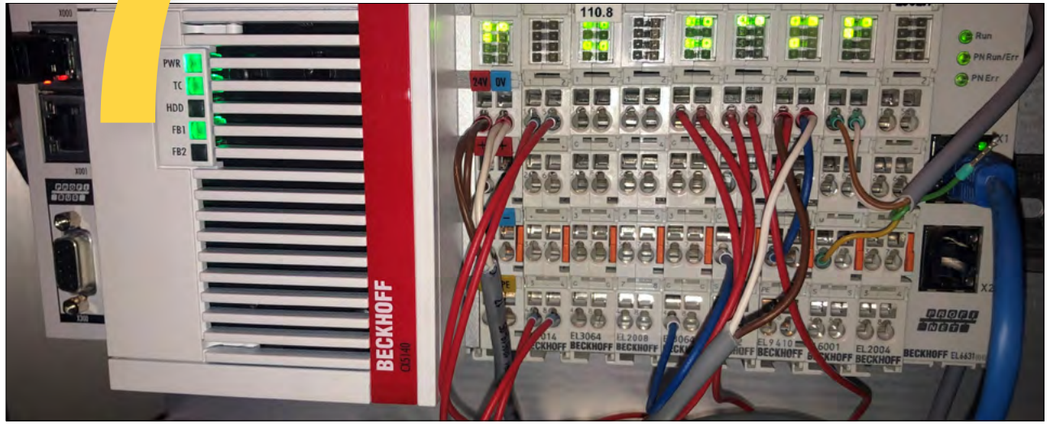
Professor Mateusz Śmietana, Ph.D., D.Sc.
tel. (+48) 22 234 63 64
mateusz.smietana@pw.edu.pl
https://nos.imio.pw.edu.pl

MAIN RESEARCH INFRASTRUCTURE

- Advanced vacuum systems for the deposition of a wide range of thin films and layered systems on complex substrates for their protection, functionalisation or decoration
- Equipment for comprehensive research on the surface of materials and layers, in particular their optical properties
- Equipment for comprehensive studies range of fibre optic devices and systems
- Systems for testing sensors and biosensors under highly controlled conditions
- Systems for laser surface modification and micromodification
- Software (commercial and in-house developed) for the design of optical and fibre optic systems and their sensing applications

17 FLUIDSHIELD

RESEARCH TEAM



#FLUID MECHANICS #RHEOLOGY #NON-NEWTONIAN FLUIDS #SHEAR THICKENING #ENERGY ABSORPTION #KINETIC ENERGY #PROCESS MODELLING #DATA PROFILING #BIG DATA #PROCESS AUTOMATION

The Team has experience in optimising the physicochemical properties of shear thickening fluids through the selection of appropriate formulations and manufacturing methods.

Since 2012, members of the Team have been working on the subject of rheological fluids characterised by a non-linear increase in viscosity as a function of shear stress. The current research is a continuation of the works previously conducted at the Faculty of Materials Science and Engineering and the Faculty of Chemistry of the Warsaw University of Technology. The scientific achievements of the Team include numerous scientific publications, patents and projects, as well as awards at international conferences.

CONTACT

Mariusz Tryznowski, Ph.D.
tel. (+48) 22 234 81 15
mariusz.tryznowski@pw.edu.pl
https://wip.pw.edu.pl/itw

AREAS OF COOPERATION WITH OTHER TEAMS

- Production and characterisation of shear thickening fluids
- Optimisation of functional properties/functional parameters of shear thickening fluids using machine learning
- Fluid mechanics and simulation of phenomena
- Process data profiling
- Automation of manufacturing processes with advanced data acquisition systems

SELECTED PROJECTS

Projects carried out by members of the Team in previous research works conducted at the Faculty of Chemistry (WUT) in cooperation with the Faculty of Materials Science and Engineering (WUT) on the subject of shear thickening fluids:

- Smart passive body armour with application of rheological nanofluids (POIG, NCBR, 2014 –2019)
- Smart materials for energy absorption and protection of the human body (PBS, NCBR, 2012 –2015)

SELECTED PUBLICATIONS

- Nakonieczna-Dąbrowska P., Wróblewski R., Płocińska M. et al. (2020), Impact of the Carbon Nanofillers Addition on Rheology and Absorption Ability of Composite Shear Thickening Fluids. Materials, 13/7, 1–10
- Nakonieczna P., Wojnarowicz J., Wierzbicki Ł. et al. (2019), Rheological properties and stability of shear thickening fluids based on silica and polypropylene glycol. Materials Research Express, 6/11, 1–8
- Nakonieczna P., Wierzbicki Ł., Wróblewski R. et al. (2019), The influence of carbon nanotube addition on the properties of shear thickening fluid. Bulletin of Materials Science, 2019, 42/4, 1–4
- Wierzbicki Ł., Tryznowski M. et al. (2013), Shear Thickening Fluids Based On Nanosized Silica Suspensions For Advanced Body Armour. Composites Theory and Practice, 13/4, 214–244

MAIN RESEARCH INFRASTRUCTURE

- Advanced test bench for dynamic properties of fluids

SELECTED PATENTS

Patents developed in earlier research works conducted, e.g. at the Faculty of Chemistry (WUT) in cooperation with the Faculty of Materials Science and Engineering (WUT) on the subject of shear-thickened fluids:

- Football shin pads and method of their production, PL 231979
- Football shin pads with increased energy absorption, PL 231757 B1
- Football shin pads and method of their production, PL 231756 B1
- Football shin pads and method of their production, PL 231755 B1
- Shear thickening fluid, PL 239049
- Ceramic-polymer composite and method of its production, PL 235452
- Modified dilatant ceramic suspension, PL 234879
- Ceramic mass with shear thickening effect, PL228678 B1
- Method for obtaining a composite containing shear thickening fluid, PL 227009 B1
- Modified dilatant suspension of ceramic powders, PL226564 B1
- Ceramic mass with dilatant properties, PL 226615 B1
- Ceramic mass with dilatant properties and its application, PL223803 B1
- Dilatant ceramic suspension and its application, PL 231216 B1

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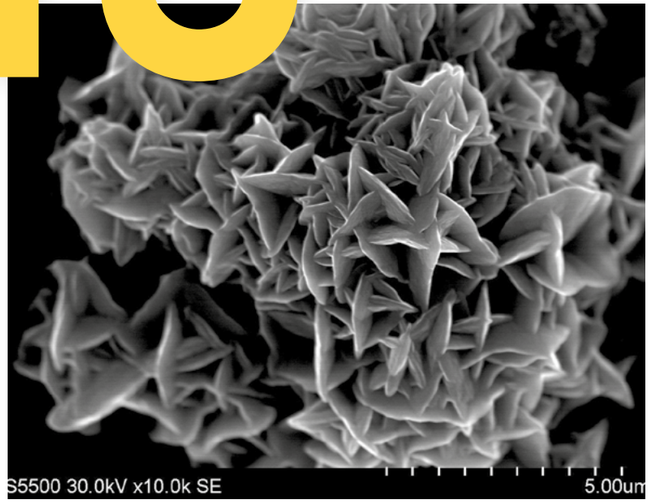
RESEARCH TEAM FOR

PARTICLE ENGINEERING



#NANOPARTICLE ENGINEERING #PARTICLE TECHNOLOGY #PHOTOCATALYTIC NANOPARTICLES #PHOTOCATALYSTS #HYDROGEN PRODUCTION #SYNTHESIS OF NANOCATALYSTS #AB INITIO #PARTICLE CHARACTERISATION #COMPOSITE FIBRE

AREAS OF COOPERATION WITH OTHER TEAMS

- Work in the field of particle synthesis and characterisation
- Production, analysis and modification of non-woven polymeric materials
- Production of non-woven polymer-nano-particle composite hybrid systems

The Team brings together scientists with expertise and experience in fundamental research in such disciplines as materials engineering, chemical engineering and physical sciences.

The researchers take a comprehensive approach to the development of modern composite materials: from the synthesis of nanoparticles with appropriate structure and their optimisation supported by numerical modelling, through the characterisation of materials in terms of microstructure parameters and functional properties or the optimisation of the method of particle deposition on polymer scaffolds (e.g. highly porous non-woven materials) to the assessment of the effectiveness of new hybrid structures.

SELECTED PUBLICATIONS

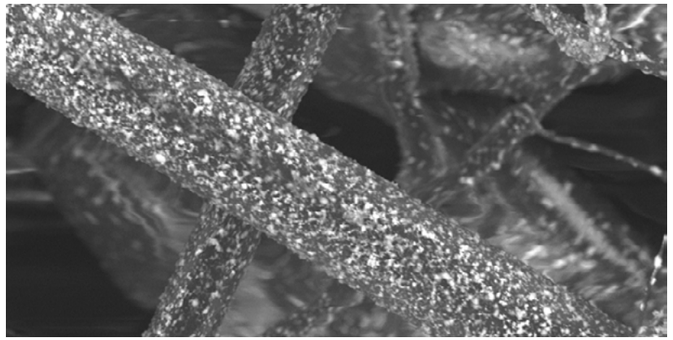
- Czelej K., Colmenares J.C., Jabłczyńska K., Ćwieka K., Werner Ł., Gradoń L. (2021), Sustainable hydrogen production by plasmonic thermophotocatalysis. Catalysis Today, vol. in press, s. 1–31. Available online 24 February 2021; in press, Corrected Proof, DOI: 10.1016/j.cattod.2021.02.004
- Ćwieka K., Czelej K., Colmenares J.C., Jabłczyńska K., Werner Ł., Gradoń L. (2021), Supported plasmonic nanocatalysts for hydrogen production by wet and dry photoreforming of biomass and biogas derived compounds: Recent progress and future perspectives Chemcatchem, vol. in press, nr: 1–104, DOI: 10.1002/cctc.202101006

SELECTED PROJECTS

- Composite non-woven – nanoparticle photocatalytic structures for efficient filtration of microbiologically contaminated air (PRA Material Technologies-1, Warsaw University of Technology, 2020–2021)
- Design and characterization of rhenium-modified porous catalysts for high temperature energy conversion (PRA Material Technologies-1, Warsaw University of Technology, 2020–2021)
- Synthesis and characterisation of nanocatalysts based on two-dimensional rhenium disulphide (ReS2) for photocatalytic hydrogen production (PRA Material Technologies-2: Start, Warsaw University of Technology, 2021–2022)
- High-performance flow system for photocatalytic hydrogen production from biomass (LIDER XI, NCBR, 2021–2024)

SELECTED PATENT APPLICATIONS

- The manufacturing technology of nonwoven (fabric) – nanoparticles hybrid systems, P.432594, 2020
- Technology of manufacturing nanoparticles of rhenium disulfide with high electrocatalytic and photocatalytic activity, P.440673, 2022



MAIN RESEARCH INFRASTRUCTURE

- Apparatus for the production of non-woven polymeric materials with the use of melt-blowing
- Photocatalytic testing system
- SEM microscopes
- TGA thermogravimetric analysis
- Paritcle size distribution analyzers
- Photocatalytic reactor coupled to a gas chromatograph
- Spraytec laser diffraction system (Malvern Panalytical) for measuring particle and droplet size distribution
- B-290 spray dryer (Buchi)

CONTACT

Łukasz Werner, Ph.D.
lukasz.werner@pw.edu.pl
https://ichip.pw.edu.pl

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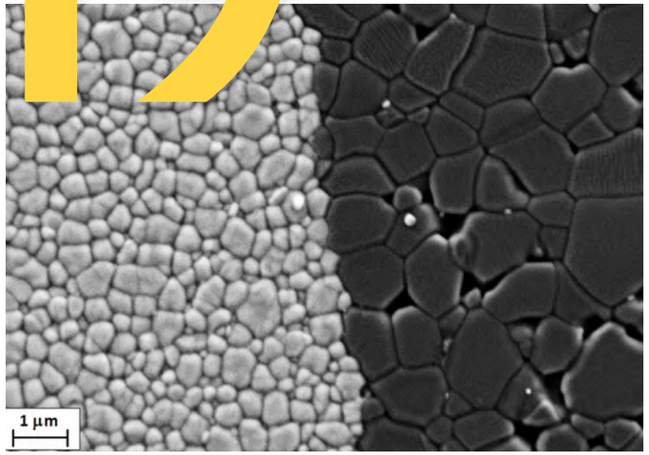
ADVANCED CERAMICS

GROUP



For more than 20 years, the Advanced Ceramics Group has been working on the broadly defined issue of shaping of ceramic and composite materials. The research concerns the preparation of oxide ceramic materials with dielectric, semiconducting and ferroelectric properties, including Al_2O_3, ZrO_2, ZnO, $Ba(Sr)TiO_3$ and ceramic composites reinforced with metallic phase and graphene.

One of the research topics pursued by the Team is 3D printing of ceramic and composite materials. 3D printing of these materials uses multi-phase colloidal systems that are cured by photopolymerization. In order to protect the environment, new, low-toxic and water-soluble organic compounds are being designed and researched for use in ceramic processing. An important issue in the context of industrial processes is the possibility of using water in place of organic solvents for 3D printing of ceramics. Obtaining ceramic and composite materials with complex geometries using 3D printing methods allows the elimination of the machining process performed with diamond tools and opens up new application possibilities. In recent years, the Advanced Ceramics Group has collaborated with a number of foreign centres, including: National Institute for Materials Science (NIMS) in Japan, Swiss Federal Laboratories for Materials Science and Technology (EMPA) in Switzerland or Northwestern Polytechnical University (NPU) in China.

AREAS OF COOPERATION WITH OTHER TEAMS

- Stability measurements of colloidal systems (zeta potential, pH of high-viscosity suspensions, particle size)
- Rheological measurements of non-Newtonian fluids
- Characterization of ceramic materials (e.g. density, mechanical strength, hardness)
- Sintering of ceramic and composite materials
- Designing shear thickening fluids with controlled parameters for protection of the human body (in cooperation with the Faculty of Materials Science and Engineering (WUT))

#CERAMIC MATERIALS #3D PRINTING #STEREOLITHOGRAPHY #CERAMIC-METAL COMPOSITE #SHAPING #FUNCTIONAL CERAMICS

SELECTED PROJECTS

- Design, fabrication and properties of ceramic–polymer composites with high dielectric tunability (SHENG, NCN, 2019–2023)
- Nanocrystalline oxide semiconductors obtained with the use of enzymes (SONATA, NCN, 2017–2021)
- Living polymerization as high–tech solution in 3D printing of ceramic materials (PRELUDIUM, NCN, 2018–2021)
- Colloidal systems of type ceramic powder–functional monomer in preparation of ceramic composite materials (SONATA, NCN, 2015–2018)
- Smart materials for energy absorption and protection of the human body (PBS, NCBR, 2012–2016)

SELECTED PATENTS

- Method for obtaining ceramic materials using the gel casting method, PAT.238558, 2021
- Method for obtaining a mixture of unsaturated diglycerin monoesters, PAT.233975, 2019
- Method for obtaining ceramic materials using the gel casting method, PAT.234779, 2019
- Processing for the fabrication of dental restorations, US 10182895, 2019
- Ceramic mass with shear thickening effect, Pat. PL 228678, 2018
- Method for producing ceramic components, PAT.221462, 2015
- Application of a monosaccharide derivative in the process of forming ceramic products, PAT. 216914, 2013
- Method for obtaining 3-O-acryloyl-D-glucose, Pat.212145, 2012

MAIN RESEARCH INFRASTRUCTURE

- Hunter 3D stereolithographic printer
- Nikon LV 150 light microscope
- Zetasizer Nano ZS Zeta potential and particle size measuring device
- Kinexus Pro rotational rheometer
- HVS-T30 hardness tester
- AccuPyc II 1340 Micromeritics helium pycnometer
- Carbolite laboratory furnaces up to 1700°C and 1800°C
- Tube furnace up to 1600°C, allowing for sintering in different atmospheres
- MSK-AFA tape casting machine

CONTACT

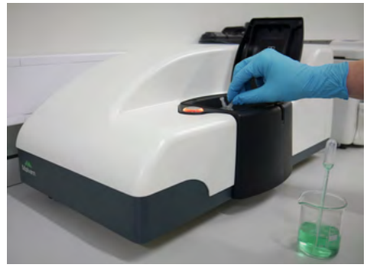
Professor Paulina Wiecińska, Ph.D., D.Sc.
tel. (+48) 22 234 74 13
paulina.wiecinska@pw.edu.pl

SELECTED ACHIEVEMENTS

- Polish Ceramic Society Award for contributions to the development of the technology of structural ceramics manufacturing, 2019
- Gold Medal at Taiwan Innotech Expo, 2018
- Distinction and additional Special Award of the President of the Polish Patent Office in the 7th edition of the National Student-Inventor Competition for a series of inventions involving smart shear-thickening fluids used for protecting the human body, 2017
- Special Award in the Polish Product of the Future competition, 2016

SELECTED PUBLICATIONS

- Żurowski R., Falkowski P., Zygmuntowicz J., Szafran M. (2021), Rheological and Technological Aspects in Designing the Properties of Shear Thickening Fluids. Materials, 14, 1–25
- Wiecińska P., Żurawska A., Falkowski P., Jeong D., Szafran M. (2020), Sweet ceramics – how saccharide-based compounds have changed colloidal processing of ceramic materials. J. Kor. Ceram. Soc., 57, 231–245
- Wieclaw-Midor A., Falkowski P., Szafran M. (2019), Influence of core-shell structure on the cure depth in photopolymerizable alumina dispersion. Int. J. Appl. Ceram. Technol., 17, 248–254
- Kukielski M., Kędzierska-Sar A., Kuś S., Wiecińska P., Szafran M. (2019), Application of highly sensitive spectrophotometric analysis in detection of metal content in molybdenum reinforced alumina obtained by precursor infiltration of ceramic preforms. Ceram. Int., 45, 22047–22054
- Pietrzak E., Wiecińska P., Poterała M., Szafran M. (2019), Diglyceryl acrylate as alternative additive dedicated to colloidal shaping of oxide materials – synthesis, characterization and application in manufacturing of ZTA composites by gelcasting. J. Eur. Ceram. Soc., 39, 3421–3432
- Wiecińska P., Wiecław A., Bilski F. (2017), Selected sugar acids as highly effective deflocculants for concentrated nanoalumina suspensions J. Eur. Ceram. Soc., 37, 4033–4041
- Wiecińska P., Skrzos L., Prokurat N. (2017), New route for processing of multilayer Al_2O_3-Co_3O_4 materials through gelcasting. J. Eur. Ceram. Soc., 37, 1627–1634
- Wiecińska P. (2016), Thermal degradation of organic additives used in colloidal shaping of ceramics investigated by the coupled DTA/TG/MS analysis. J. Therm. Anal. Calorim., 123, 1419–1430



#CERAMIC MATERIALS #3D PRINTING #STEREOLITHOGRAPHY
#CERAMIC-METAL COMPOSITE #SHAPING #FUNCTIONAL CERAMICS

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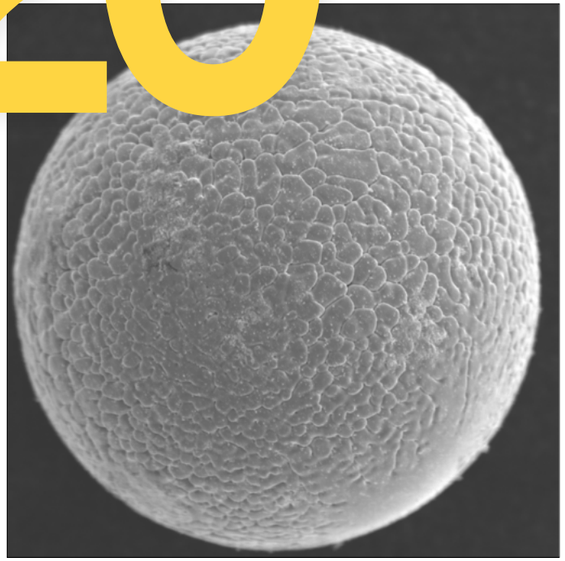
RESEARCH TEAM FOR

3D MATERIALS



#3D PRINTING #ATOMISATION #FUNCTIONAL MATERIALS #POROUS MATERIALS #BIOMATERIALS #POLYMERS #COMPOSITES #FUEL CELLS #SMART DEVICES #COMPUTER MODELLING

CONTACT

Professor Robert Zalewski, Ph.D., D.Sc.
tel. (+48) 22 234 84 79
robert.zalewski@pw.edu.pl

Ryszard Sitek, Ph.D., D.Sc.
tel. (+48) 22 234 81 57
ryszard.sitek@pw.edu.pl

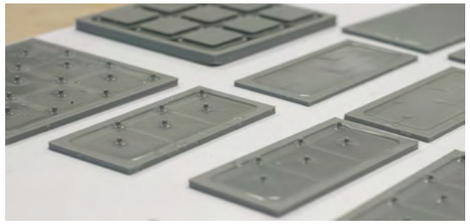
Rafał Wróblewski, Ph.D.
tel. (+48) 22 234 87 31
rafal.wroblewski@pw.edu.pl

https://www.wim.pw.edu.pl/wim_en/Research/Research-groups/3D-Materials

The Multidisciplinary Research Team for 3D Materials is composed of representatives of the Faculty of Automotive and Construction Machinery Engineering and the Faculty of Materials Science and Engineering of Warsaw University of Technology. The Team conducts research on a wide range of structural, functional and smart materials, including metallic, solid and porous materials, as well as polymeric and composite materials.

In its approach, the Team focuses on additive material production techniques, which allow obtaining complex shapes and properties impossible to achieve with standard technologies. In addition, the Team develops practical applications of the manufactured and characterised materials in various areas of the economy, such as: the preparation of input materials for 3D printing, energy generation and conversion, materials for biomedical applications, robotics and smart devices.

An important part of activity includes designing materials using computer modelling with FEM, DFT or DEM methods.



SELECTED PROJECTS

- Innovative electrolyte matrix materials for molten carbonate fuel cells (Polish-Taiwanese collaboration, NCBR, 2016–2019)
- Improved manufacturing process of fuel cells aimed at extending lifetime, improving performance, in particular power per unit volume/mass of the cell, and reducing investment and operating costs through the use of alternative catalytic systems in polygraphic technology (POIR, NCBR, 2016–2020)
- Development of technologies for the recovery of precious metals and rare earth metals for the production of molten carbonate fuel cell components (POIR, NCBR, 2017–2021)
- Multidisciplinary European training network for development of personalized anti-infective medical devices combining printing technologies and antimicrobial functionality (Horizon 2020, EU, 2016–2020)
- Promoting patient safety by a novel combination of imaging technologies for biodegradable magnesium implants (Marie Skłodowska-Curie Innovative Training Networks, ITN-ETN, Horizon 2020, EU)
- Technologies for autonomous reconfiguration of materials in vehicles (PBS3, NCBR, 2015–2018)
- Research and design of a vibration damping system using smart magnetorheological dampers dedicated to the universal base of a special object (INNOTECH, NCBR, 2013–2015)
- Development of assistive technologies for regeneration of protective coverings of aircraft engine turbine blades (NCBR, 2018–2019)

AREAS OF COOPERATION WITH OTHER TEAMS

- Empirical research on materials (strength, fatigue, rheological testing)
- Numerical and analytical analyses
- Expertise in the field of smart materials and other areas of mechanics
- Exploration of new solutions in the field of soft robotics
- Design of special materials and smart devices
- Production of metallic materials using the DMLS--technique
- Design of post-process heat treatments for DMLS-produced materials
- Atomisation of metals and alloys using ultrasonic techniques
- Characterisation of the microstructure and strength properties of DMLS-produced metallic materials
- Tissue engineering – synthesis of polymeric biomaterials
- 3D printing of polymers and composites
- Bioprinting
- Solution electrospinning
- Advanced imaging using micro- and nano-computed tomography
- Computer modelling of biomaterials and their degradation processes
- Drug administration systems

SELECTED PUBLICATIONS

- Żrodowski Ł., Wróblewski R., Choma T., Morończyk B. i in. (2021), Novel Cold Crucible Ultrasonic Atomization Powder Production Method for 3D Printing. Materials, 14(10), 2541; https: //doi.org/10.3390/ma14102541
- Sitek R., Szustecki M., Żrodowski Ł., Wysocki B., Jaroszewicz J., Wiśniewski P. and Mizera J. (2020), Analysis of microstructure and properties of a Ti–AlN composite produced by Selective Laser Melting. Materials 2020, 13, 2218, DOI: 10.3390/ma13102218
- Chlewicka M., Dobkowska A., Sitek R., Adamczyk-Cieślak B., Mizera J. (2022), Microstructure and corrosion resistance characteristics of Ti–Al N composite produced by selective laser melting. Materials and Corrosion, 73(3), 451–459, DOI: https:// doi.org/10.1002/maco.202112703
- Sitek R., Molak R., Zdunek J., Bazarnik P., Wiśniewski P., Kubiak K., Mizera J. (2021), Influence of an aluminizing process on the microstructure and tensile strength of the nickel superalloy IN 718 produced by the Selective Laser Melting. 186, 110041, DOI: https: /doi.org/10.1016/j.vacuum.2020.110041

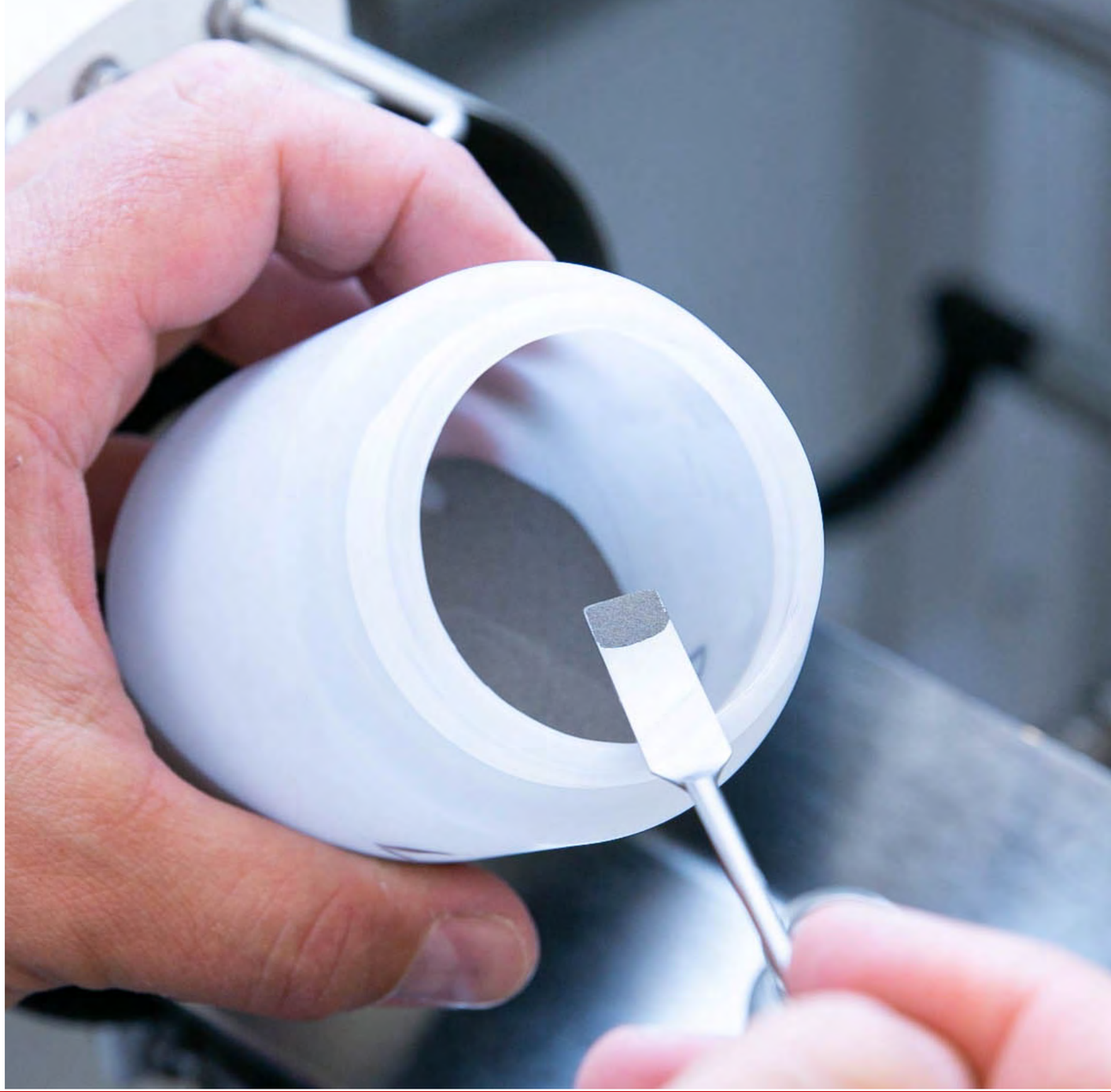
SELECTED PATENTS

- Method for manufacturing three-dimensional objects based on ternary phases of the TiAlN system, P.420974, 2021
- Method for additive manufacturing of three-dimensional objects from metallic glasses, EP 17707419, 2016
- Bioactive intraosseous dental implant, P.425508, 2021

#3D PRINTING #ATOMISATION #FUNCTIONAL MATERIALS #POROUS MATERIALS #BIOMATERIALS
#POLYMERS #COMPOSITES #FUEL CELLS #SMART DEVICES #COMPUTER MODELLING

MAIN RESEARCH INFRASTRUCTURE

- EOS M 100 metal 3D printer
- Ultimaker S5 FDM printer
- 3D printer for printing large-scale objects
- Ultrasonic atomiser
- Testing machine with DATEC system for measuring strain fields using the DIC method
- Horiba LA-950 particle size analyser
- Bruker D8 Advance and Rigaku MiniFlex II X-ray diffractometers (XRD) for phase composition analysis
- X-ray spectrometer (XRF)
- Hitachi SU 70 scanning electron microscope – 2x tape caster
- Electrochemical test bench NORECS AS
- GAMRY3000 impedance spectroscopy test kit
- Permeability test bench
- Electrical conductivity test bench
- Series of specialist test benches for testing vibrating components (torsional and transverse vibrations) with different types of excitation (force, impulse and kinematic)
- High-resolution thermal imaging camera
- Carl Zeiss Axio Scope light microscope equipped with bright field (BF), dark field (DF), differential interference contrast (DIC) and differential interference contrast in circular polarised light (DIC-R) modules
- Nikon Eclipse LV100ND high-temperature microscope with Linkam TS1500 table (up to 1500°C)
- High-performance computing stations – software: ANSYS/Fluent, Abaqus, Yade, Matematica, LAMMPS, VASP, MicroMeter



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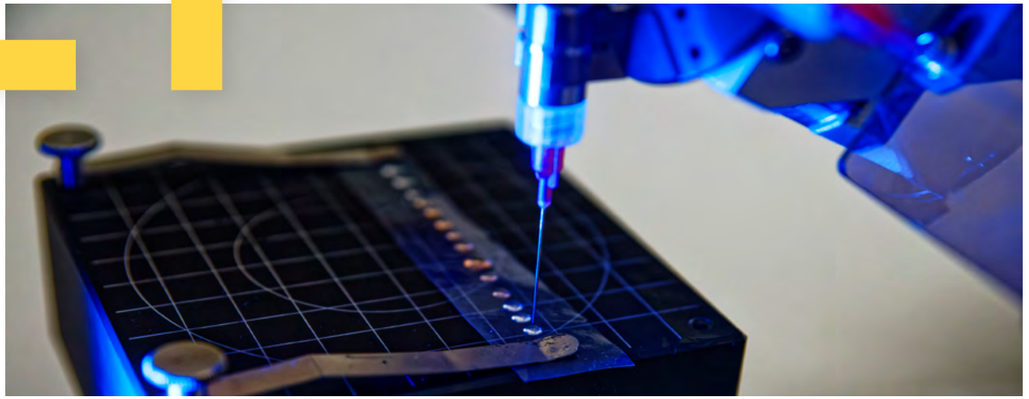
RESEARCH TEAM OF THE

LABORATORY OF PHYSICOCHEMICAL PROCESSES IN PRINTING

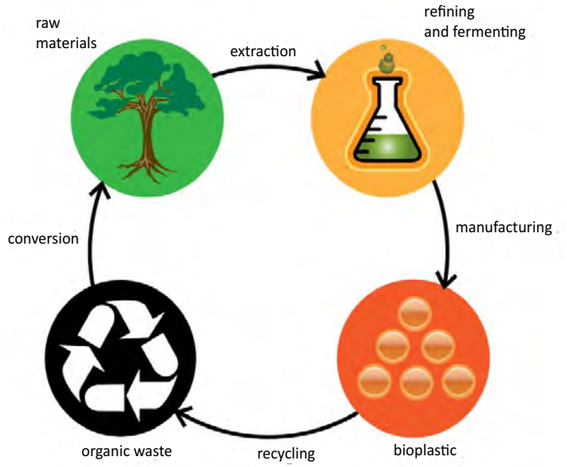
#PRINTING INKS #FREE SURFACE ENERGY #WETTABILITY #SURFACE TENSION #WETTING ANGLE
#PRINTING QUALITY #PACKAGING #ENVIRONMENTALLY FRIENDLY MATERIALS #STARCH FILMS



The Team is experienced in assessing print quality on non-absorbent materials (plastic films and biodegradable films).

The Team's research work focuses on the study of surface free energy and its components, the impact of corona and plasma activation on the adhesion of the dried ink layer, the abrasion resistance of the print and the properties of printing materials. The Team also conducts works on modifying ink to improve their properties, such as wettability on non-absorbent materials, as well as research on new environmentally friendly materials.

The Team has implemented a NCN project (Sonata) and some small-scale R&D works involving the modification of printing inks.

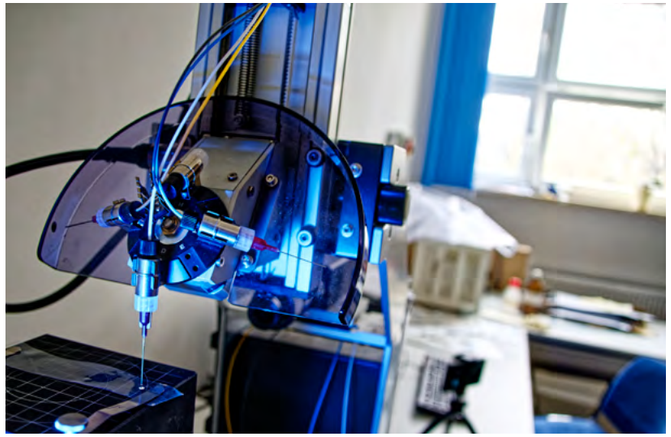


SELECTED PROJECTS

- Polyglycerols as novel environmentally friendly compounds improving the wettability of plastic substrates (Sonata, NCN, 2014–2017)
- Research on hyperbranched polymers used as additives to flexographic inks to improve print quality (Iuventus Plus, MNiSW, 2010–2012)

AREAS OF COOPERATION WITH OTHER TEAMS

- Research on the properties of environmentally friendly printing or packaging materials
- Impact of material surface layer modification on print quality
- Modification of liquid graphic inks (with low viscosity) for printing with various techniques (flexo, gravure, ink-jet)

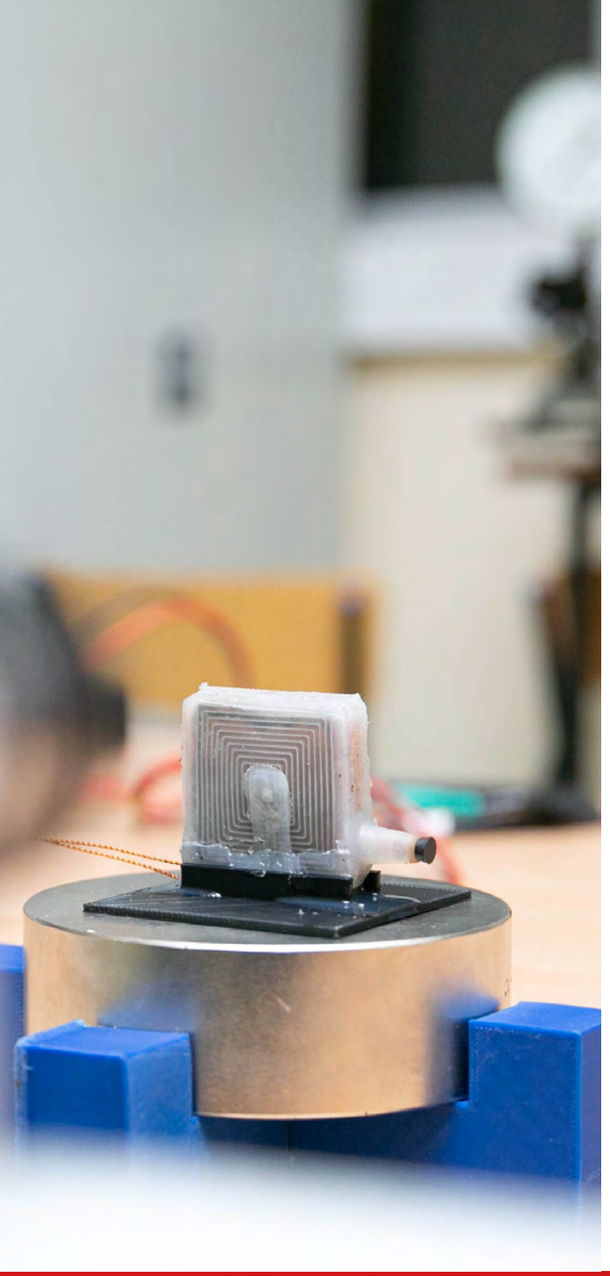


MAIN RESEARCH INFRASTRUCTURE

- Krüss goniometer, DSA 30E for measuring wetting angle and surface equipment
- Corona-Plus laboratory corona treatment (Vetaphone)
- Suntest CPS+ ageing chamber
- Zwick-Roell Z010 testing machine
- Exact spectrophotometer (x-rite)
- K Paint Applicator (RK Prints) – paint and coating applicator

CONTACT

Professor Zuzanna Żołek-Tryznowska, Ph.D., D.Sc.
tel. (+48) 22 234 33 78
zuzanna.tryznowska@pw.edu.pl
https://www.mt.pw.edu.pl/poligrafia



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MATERIAL TECHNOLOGIES
Cooperation Proposal

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