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Scientific Staff:

[Prof. Pawel Zieba, Ph.D., D.Sc., Corresp. Member of PAS](#)

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[Associate Prof. Kazimierz Drabczyk, Ph.D., D.Sc.](#)

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PhD Students

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Piotr Sobik, M.Sc.

Marcin Szmul, M.Sc.

Research Area

Development of new materials for solar cells and modules (Prof. Paweł Zięba, Ph.D, D.Sc.).

Research is underway to develop mixed halide perovskites for use in a highly efficient and long-term stable single-junction and tandem solar cells. The aim of these studies is to find and develop an alternative cell manufacturing technology for the current one based on crystalline silicon. Moreover, the investigation is also dedicated to semiconductor metal oxides for

application in solar cells in a role of passivating, anti-reflective, insulating or tunnelling layer, as well as transparent conductive layers and thin absorbers with different types of conductivity. On the other hand, the issue of silicon nanostructures to complement the classic texture of silicon surfaces and their use as a porous substrate for perovskite layers in tandem solar cells is also being developed. The final work of modules encapsulation concerns using systems and materials other than those currently used for silicon solar cells, i.e. glass and EVA copolymer. The study is ongoing on encapsulation processes of PV modules. The research concerns systems and materials other than those currently used for silicon cells encapsulation i.e. glass and EVA copolymer.

Interface in welds obtained with the use of explosion energy (Ph.D, D.Sc. Joanna Wojewoda-Budka, Prof. PAS)

The scientific goal of the research is the detailed characterization of the effect of the explosive welding process on the Inconel 625 / Ti Gr. 5 interface. The durable weld formed between these alloys is characterized by electron microscopy (scanning and transmission) techniques at the micro and nano scale. Because there is a strong relation between the explosive welding process and the microstructure of the joined materials close to the area of their interface, also in the case of this particular pair of materials, the presence of either thin amorphous layer or intermetallic phase(s) can be expected. The presence of brittle intermetallic phases is highly undesirable. Therefore, studies covering the detailed microstructural characteristics of the bond are aimed at developing parameters of explosive welding or the process modification that will minimize the formation of undesirable new reaction products at the interface. Additionally, the obtained welds are annealed to observe the evolution of the microstructure of joined materials near the interface zone, changes in chemical composition resulting from activated diffusion processes and the increase of intermetallic phases in the bonded zone. The annealing temperature determining the diffusion rate affects the type and amount of produced intermetallic phases or the growth of one intermetallic phase at the expense of others. The conducted tests will allow to determine the impact of extreme pressure conditions and locally temperature on the quality of the obtained bonds, its microstructure and mechanical properties.

Development of spectral and diffraction methods in dual-beam scanning electron microscope (FIB-SEM)- (Prof. Marek Faryna, PhD, DSc)

Pioneering investigations are being performed to broaden analytical capabilities by the development of advanced analytical methods in high resolution dual beam scanning electron microscope (FIB-SEM). They are referred to energy and wave length dispersive X-ray spectrometry (EDS and WDS, respectively), as well as to electron backscatter diffraction (EBSD) technique, particularly in case of "in-situ" experiments.

Final goals to achieve:

- improvement of accuracy and precision during EDS and WDS measurements,
- improvement of spatial and effective resolution in case of orientation imaging microscopy measurements by application of transmission Kikuchi diffraction (TKD),
- development of in-situ technique based on high temperature heating stage GATAN Murano 525 designed both for phase transformation analyses and EBSD measurements at elevated temperatures.

The effect of inverting stacking faults on the reorientation of martensitic variants in Ni-Mn-Ga alloys (Associate Professor- Robert Chulist)

It is the main aim of the present research to define the role of periodic and partially periodic atom displacements called modulation and inverting stacking faults on the crystal structure and the level of twinning stress in single crystalline and polycrystalline five-layered 10M and seven-layered 14M Ni-Mn-Ga alloys. The attention is directed to the role of modulation and inverting stacking faults (a-b boundaries) which according to the recent reports have a great impact on the reorientation of martensitic variants. For this purpose high energy synchrotron radiation experiments (flat Ewald zone) and 2D detector to scan the reciprocal space in transmission geometry will be employed. Such conditions allow easy detection of additional/satellite reflections. Furthermore, a dedicated EBSD (electron backscatter diffraction) software to unveil the smallest microstructural detail will be used. This issue appears to be absolutely fundamental since the additional microstructural features affect the twinning stress in modulated phases. It will also allow to confirm or exclude the adaptive concept which remains still controversial in the literature.

Research Projects (started or completed during last 5 years)

Ministry of Science and Higher Education

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R. Chulist, *On the influence of intermartensitic phase transformation on the thermal stability in magnetic shape memory alloys*, Project Iuventus Plus, No. 0063/IP2/2015/73, supervisor, IMMS PAS, 2015-2017.

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P. Zięba, Organization of National Science and Industry Conference „Photovoltaics 2020" and elaboration of "White Book of Innovation in Polish Photovoltaics, DIALOG, 0013/DLG/2017/10, Supervisor and Chairman of Scientific Committee of the Conference, Editor in-chief of "White Book", IMMS PAS, 2017-2018.

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P. Zięba, Organization of National Science and Industry Conference „Photovoltaics 2025" DIALOG, 0076/2019, Supervisor and Chairman of Scientific Committee of the Conference, IMMS PAS, 2020-2021.

National Science Centre

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P. Zieba - *Analysis of the parameters leading to steady-state in Cu-based alloys subjected to high pressure torsion*, OPUS project No. 2014/13/B/ST8/04247, IMMS PAS, supervisor, 2015-2018.

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M. Faryna - *Grain boundary analysis by three dimensional electron backscatter diffraction (3D EBSD)* . OPUS project No. 2012/05/B/ST8/00117, IMMS PAS, supervisor, 2013-2016.

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M. Lipinski - *Investigation of influence of metal and semiconductor nanoparticles on opto-electronic properties of composite materials* , OPUS project No. 2012/05/B/ST8/00087, IMMS PAS, supervisor, 2012-2016.

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G. Kulesza - *Selection and detailed analysis of the directional surface texturization of crystalline, photovoltaic silicon in order to improve the optoelectronic properties* . PRELUDIUM project No. 2013/09/N/ST8/04165, IMMS PAS, supervisor, 2014-2016.

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P. Zieba - *Analysis of the parameters leading to steady-state in Cu-based alloys subjected to high pressure torsion* , OPUS project No. 2014/13/B/ST8/04247, IMMS PAS, supervisor, 2015-2018.

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Z. Starowicz, *The effect of the process parameters of the metal nanoparticles photochemical deposition on titanium dioxide on plasmonic properties of obtained nanostructures* ., PRELUDIUM project No. 2014/13/N/ST8/00858, IMMS PAS, supervisor, 2015-2017.

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J. Wojewoda-Budka - *Periodic layers structure formation in the solid state reactions in systems Mg/SiO₂, Zn/Co₂Si and Zn/Ni₃S* i, OPUS project No. 2014/15/B/ST8/00195, IMMS PAS, supervisor, 2015-2019.

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R. Chulist - *Advanced study of real structure on elastocaloric effect in Fe-based shape memory alloys* , SONATA Project No. 2014/13/D/ST8/03108, IMMS PAS, supervisor, 2015-2018.

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M. Faryna - *The influence of grain boundary structure and distribution on electrical proprieties in solid oxide fuel cells*, OPUS Project No. 2017/27/B/ST8/00143, 2018-2021.

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M. Trybuła, *Thermodynamic, structural and physicochemical properties of liquid Al-Li-Zn alloys*, ETIUDA project No. 2014/12/T/ST8/00089, IMMS PAS, supervisor, 2014-2015.

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M. Trybuła, *Mechanism of the discontinuous precipitation reaction - an atomistic simulation study*, SONATA project No. 2016/21/D/ST8/01689, IMMS PAS, supervisor, 2017-2019.

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R. Chulist, *Adaptive martensitic structures - the role of modulation and inverting stacking faults on the crystal structure and magnetic field induced strain*, OPUS project No. 2017/25/B/ST8/02524, project leader 2018-2021.

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P. Zięba, *Mass transport processes in phase transformations at moving boundaries of discontinuous precipitates-experiment vs. modellin* g. OPUS project No. 2017/25/B/ST8/02198, IMMS PAS, supervisor, 2018-2021

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R. Chulist, *The crystallographic - phenomenological model of thermoelastic martensitic transformation in Heusler systems*, OPUS project No. 2018/29/B/ST8/02343, IMMS PAS, supervisor, 2019-2022.

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M. Lipiński, *Preparation and characterization of new materials for perovskite solar cells*, OPUS Project No. 2018/31 /B/ ST8/03294, IMMS PAS, supervisor, 2019-2022.

National Centre for Research and Development

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P. Zieba - *PV-In-line processing of n+/p and p/p+ junction systems for cheap photovoltaic module production (Inline)*, Polish-Norwegian Research Programme, No. POL-NOR/199380/89/2014, supervisor in IMMS PAS, 2014-2016.

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P. Zieba - *Isothermal and refrigeration photovoltaic car body (WOLTER), GEKON Programme - Generator of Ecological Concepts*, supervisor in IMMS PAS, 2015-2017.

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W. Wołczyński - *Development of the metallurgical method for the hard particles elimination from the brass during its continuous casting* - CASTBRASS, PBS3/A5/52/2015, supervisor in IMIM PAS, 2015-2017.

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W. Wołczyński - *Development of the innovative method for copper droplets coagulation, reduction and solidification in the post-processing slagsh- AWB1*, No. PBS3/A5/45/2015, supervisor in IMIM PAS, 2015-2017.

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K. Drabczyk - *Innovative flexible photovoltaic cover -EPF, GEKON Programme - Generator of Ecological Concepts*, supervisor in IMMS PAS, 2016-2018.

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P. Panek - *Development of technology for manufacturing of functional materials for application in non-silicon photovoltaic cells*, TECHMATSTRATEG II, 2/409122/3/NCBR/2019, supervisor in IMMS PAS, 2019 - 2021.

Structural Funds

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R. Chulist, Foundation for Polish Science - *Advanced study of the influence of real structure on magnetic field-induced strain in Ni-Mn-Ga single crystals*
, Project Homing Plus, No. Homing Plus/2013-8/3, IMMS PAS, supervisor, 2014-2015.

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P. Zięba, P. Panek, Operational Program Smart Growth, co-financed by European Social Funds
Development of technology for the production of copper component and pastes used in the manufacture of silicon cells electrical contacts
, POIR.01.01.01-1598/15-00 co-ordinators in IMMS PAS (2016-2018).

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P. Zięba, Operational Program Knowledge Education Development, co-financed by European Social Funds, *International, interdisciplinary PhD studies in the field of materials science with English as the lecturing language*
, WND-POWR.03.02.00-00-1043/16, IMMS PAS, supervisor (2017-2021).

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K. Drabczyk, *Self-cleaning, PV panels on the flexible subgrade integrated with the acoustic screen and the smart monitoring system*
, POIR.04.01-00-001/17 as part of the BRIK project (2018 - 2021).

International Cooperation

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M. Faryna - *Microstructural investigations of advanced ceramics, joinings of ceramics and ceramic composites*, Department of Materials Science and Engineering, Anadolu University, Eskisehir, Turkey, 2014-2016.

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Z. Świątek - *Microstructure and physical/chemical properties of electrolytic Zn-Mo layers*, Pidstryhach Institute for Applied Problems of Mechanics and Mathematics, National Academy of Sciences, Ukraine, 2015-2017.

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P. Zieba - *Influence of nanosized additives on the physical and mechanical properties of the bulk materials and coatings*, Space Research and Technology Institute of Bulgarian Academy of Sciences, Bulgaria, 2015-2017.

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Z. Świątek - *Properties of HgCdTe heterostructures and their modification under ion implantation*, Pidstryhach Institute for Applied Problems of Mechanics and Mathematics, National Academy of Sciences, Ukraine, 2018-2020

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J. Wojewoda-Budka - *Wettability and reactivity of lead free solders with electroless plated Ni-P and Ni-P-X layers (X - various metal additives) for surface mounting technology in the electronics industry*, Institute of Condensed Matter Chemistry and Technologies for Energy, National Research Council, Genoa, Italy, 2017-2022.

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M. Trybuła - *Structure and physical properties of aluminum based materials*, Department of Materials Science and Engineering, KTH Royal Institute of Technology, Sweden, 2019-.

PhD dissertations

2007 - Joanna Wojewoda Budka - *Characterization of phenomena at interphase boundaries of joints obtained due to diffusion soldering of copper substrates using indium alloys*
(supervisor: P. Zieba).

2007 - Roman Major - *Optimization of the structure, phase composition of biomaterials onto substrate of titanium and polyurethane*
(supervisor: A. Pawlowski).

2011 - Anna Maria Janus - *Correlation between morphology of natural hydroxyapatite and its biological interaction*
(supervisor: M. Faryna).

2012 - Przemyslaw Skrzyniarz - *Microstructural and kinetic characterization of Ag/X/Ag (X=Sn,In, Sn-In) joints obtained by diffusion soldering*
(supervisor: P. Zieba).

2013 - Katarzyna Berent - *Influence of crystal orientation on results of chemical microanalysis in SEM*
(supervisor: M. Faryna).

2014 - Grażyna Kulesza - *Influence of the acid and alkaline texturization process on basic opto-electronic parameters of the silicon solar cells*
(supervisor: P. Zieba; assistant supervisor: dr P. Panek).

2014 - Piotr Bobrowski - *Application of the three-dimensional orientation microscopy to microstructure characterization*
(supervisor: M. Faryna; assistant supervisor; dr A. Sypien).

2015- Zbigniew Starowicz - *Elaboration and characterisation of plasmonic nanostructures for*

photovoltaic applications
supervisor: dr K. Drabczyk).

(supervisor: M. Lipinski; assistant

2015 - Jakub Cichoszewski - *Metal assisted etching for silicon solar cells* (supervisor: M. Lipinski)

2017 - Dagmara Fronczek - *Microstructural and kinetic characterization of the phenomena occurring at the clads' interfaces manufactured by explosive welding*
(supervisor: Joanna Wojewoda-Budka, assistant supervisor: Robert Chulist).

2019- Katarzyna Gawlińska-Nęcek - *Engineering of semiconductor layers for perovskite solar cells*
(supervisor: M. Lipinski; assistant supervisor: dr G. Kulesza-Matlak)

PhD in progress

Piotr Sobik - *New Luminescent Solar Concentrators dedicated for packing processes in photovoltaic modules* (supervisor: Associate Prof.. Kazimierz Drabczyk, Ph.D, D.Sc., assistant supervisor: Dr Grażyna Kulesza-Matlak, company supervisor (Helioenergia): Olgierd Jeremiasz - Implementation PhD studies carried out in cooperation with Helioenergia Ltd.

Agnieszka Pająk - *Elaboration and study of properties of HTM materials for perovskite solar cells* . Two supervisors: Associate Prof. Marek Lipiński, Ph.D., D.Sc. and Prof. Ewa Schab-Balcerzak Ph.D.,D.Sc, Department of Polymer Chemistry, Institute of Chemistry, Faculty of Mathematics, Physics and Chemistry, University of Silesia in Katowice

Monika Czerny - *The effect of crystallographic orientation and the size and type of precipitation on the superelastic effect in iron- based memory shape alloys* (supervisor: Associate Prof. Robert Chulist, Ph.D., D.Sc.)- International, interdisciplinary PhD studies in the field of materials science with English as the lecturing language, Operational Program Knowledge Education Development, co-financed by European Social Funds, WND-POWR.03.02.00-00-1043/16

Izabella Kwiecień - *Diffusion phenomena at the interface zone of Al1050/Ni201 explosively welded clads* , (supervisor: Associate Prof. Joanna Wojewoda-Budka, Ph.D., D.Sc.; assistant supervisor: Dr. Piotr Bobrowski)- International, interdisciplinary PhD studies in the field of materials science with English as the lecturing language, Operational Program Knowledge Education Development, co-financed by European Social Funds, WND-POWR.03.02.00-00-1043/16

Marcin Szmul - *New technologies for welding of clad materials used in the construction of process apparatus with particular emphasis on reactive metals* , implementation doctorate realized in cooperation with FAMET SA (supervisor: Associate Prof. Joanna Wojewoda-Budka, Ph.D., D.Sc., assistant supervisor: Katarzyna Stan-Głowińska, company supervisor: Andrzej Chudzio) - Implementation PhD studies carried out in cooperation with from FAMET SA.