Wrocław University of Science and Technology
Department of Fundamental Problems of Technology
Division of Experimental Physics

A u t o - r e p o r t

Author's summary of professional accomplishments

Mechanism of ferroic phase transitions of metal –organic framework – dielectric and thermal investigations

Adam Sieradzki, PhD

Wrocław, September 2017

T a b l e   o f   c o n t e n t s

1. Personal and contant details

Personal details	Contact details
Name: Adam Sieradzki Date of birth: 09 listopada 1978 Place of birth: Bielawa Marital status: żonaty	Division of Experimental Physics Wrocław University of Science and Technology Wybrzeże Wyspiańskiego 27 50-370 Wrocław e-mail: adam.sieradzki@pwr.edu.pl tel.: 71 320 29 55 fax: 71 328 36

Education and degrees:

June 2006	PhD in Physics. Dissertation title: „Physical properties and ferroelastic phase transition in Li_2TiGeO_5 crystals", Institute of Physics, Wrocław University of Technology. Supervisor: Prof. Ryszard Poprawski
2002 – 2006	PhD studies: Wrocław University of Technology, Faculty of Fundamental Problems of Technology, specialization: Physics, specialty: Solids State Physics.
June 2002	MSc in Physics.
1997 – 2002	MSc studies: Wrocław University of Technology, Faculty of Fundamental Problems of Technology, specialization: Physics.
1997	baccalaureate - Liceum Ogólnokształcące im. Bolesława Chrobrego in Bielawa, class of maths and physics.

Employment information

2008 - now	Research associate at Division of Experimental Physcis (earlier: Institute of Physics), Faculty of Fundamental Problems of Technology, WUST, Group of Dielectric Physics, headed by Prof. Ryszard Poprawski
Feb 2007 – Oct 2008	Post-doc position at IPCMS, Universitet of Louis Paster in Strasbourg, France. Supervisor: Prof. Jean-Yves Bigot.
2006 - 2008	Research assistant at Institute of Physics, Faculty of Fundamental Problems of Technology, Wrocław University of Technology.
march 2004	PhD fellow at Clarendon Laboratory, Oxford UK. Supervisor: prof. Mike Glazer

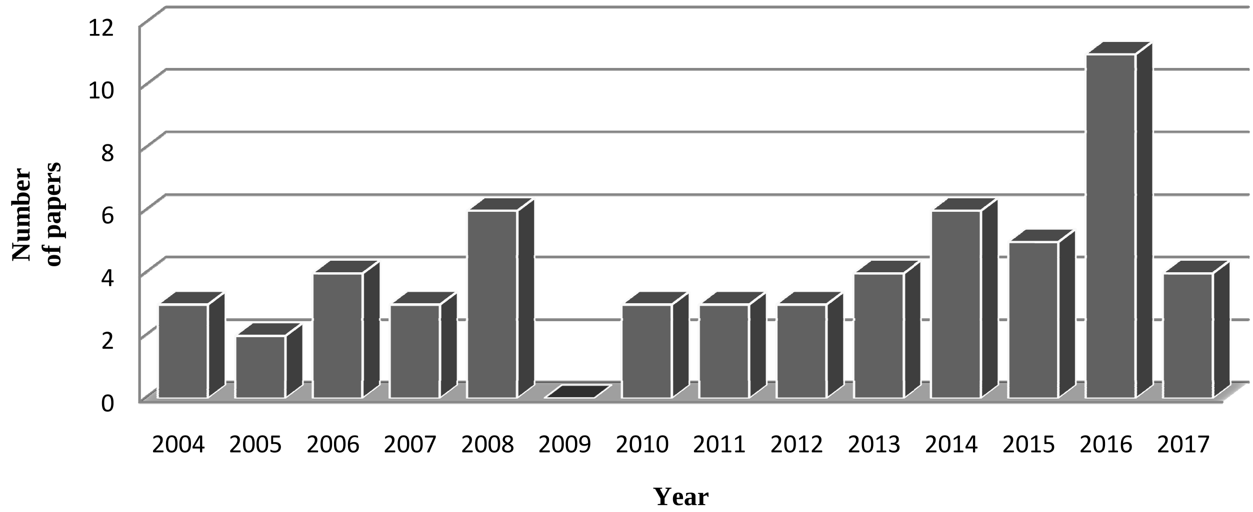
Languages:

English:	fluent written and spoken
German:	basic
French:	basic

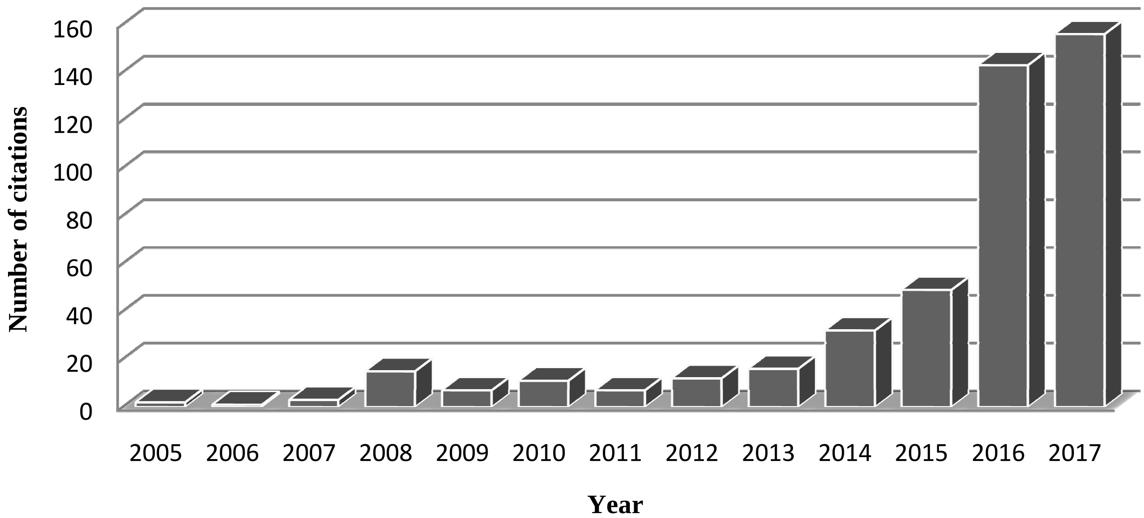
2. Summary of scientific achievements

Bibliometric date 10.09. 2017 (according to Web of Science)

- Number of publications in journals from the Master Journal List **52**



- Summarized impact factor of publications : **~120**
- Hirsh Index: **12**
- Average citations per Item: **8.56**
- Number of article citations excluding auto citations : **313**
- Total number of article citations: **450**



- Number of patents **1**

3. Course of previous scientific activity

3.1. Scientific activity before receiving Ph. D.

I have started my MSc studies in 1997 at Wrocław University of Science and Technology, on Faculty of Fundamental Problems of Technology (speciality Physics). I have finished it in 2002 with very good notes. My MSc thesis title was: "Structure and physical properties of Li_2TiGeO_5 crystal", under supervision of prof. Ryszard Poprawski. This dissertation concerns mainly the pressure investigations of ferroelastic natisite's material and determination of p – T phase diagram.

I have started my PhD studies in Institute of Physics at Wrocław University of Science and Technology (WRUT), under supervision of prof. Ryszard Poprawski in 2002. In my scientific research I have focused on experimental investigations of physical properties of ferroelastic and ferroelectric crystals. I used several experimental techniques like electrical measurements (dielectric permittivity, spontaneous polarization, pyroelectric current), dilatometric, calorimetric, structural, spontaneous birefringence, Raman and IR spectroscopy under different thermal conditions. Moreover I performed the electrical measurement under different pressure conditions. Most of this experiments were perfomed at WRUT. Interesting results were obtained for three different ferroic compounds Li_2TiGeO_5, 2APP and $DMACuCl_4$. Basing on both on isobar and isotherm families, the p-T phase diagrams were obtained for this crystals. It should be underline here, that the electrical pressure experiments are difficult in control, that why are so rare. All this results were published and presented on several scientific conferences [[1]].

Spontaneous birefringence measurements of Li_2TiGeO_5 crystal I have performed at University of Oxford in Clarendon Laboratory under supervision of prof. M. Glazer. This measurements were done using innovative imaging method developed by prof. Glazer group. This results were published in Phase Transition [[2]]. Crystal structure investigation of Li_2TiGeO_5 single crystal, were performed in collaboration with prof. A. Pietraszko from Institute of Low Temperature and Structural Research (ILTSR) of Polish Academy of Science (PAS) in Wrocław. These results allowed for the symmetry determination both in low-temperature (ferroelastic) and high-temperature (paraelastic) phase. This interesting results, cause that the structural analog was included in the project on synchrotron in Germany. This results were published in J. Physics and Chemistry of Solids [[3]]. Raman scattering and IR spectra of Li_2TiGeO_5 crystal were performer in collaboration with Dr. M. Mączka from ILTSR PAS in Wrocław [[4]]. All these results allowed to conclude that the ferroelastic phase transition is associated with the lithium ions ordering.

Another research topic I have participated since 2004 was investigations of material confinement, especially size effect on ferroic properties. This research relied on the introducing the

[1] (a) A. Sieradzki, A. Pietraszko, R. Poprawski, Integ. Ferroelectrics **62** (2004) 79-82; (b) R. Poprawski, A. Sieradzki, E. B. Radojewska, Ferroelectrics **302** (2004) 293-295; (c) A. Sieradzki, A. Ciżman, J. Komar, Phase Transitions **81** (2008) 999-1004; (d) Yu. Eliyashevskyy, A. Sieradzki, R. Poprawski, Ferroelectrics **363** (2008) 245-250.
[2] A. Sieradzki, A. Ciżman, R. Poprawski, V. Shuvaeva, A.M. Glazer, Phase Transitions **78** (2005) 351-356.
[3] A. Waśkowska, L. Gerward, J.S. Olsen, A. Sieradzki, W. Morgenroth, J. Phys. Chem. of Solids **69** (2008) 815-821.
[4] M. Mączka, A. Sieradzki, R. Poprawski, K. Hermanowicz, J. Hanuza, Journal of Physics: Condensed Matter **18** (2006) 2137.

ferroelectric crystals into the porous glass matrix with the controlled mean size of pores and investigations of physical properties of such composites. The main problem to solve was how the confinement changes the stability of embedded ferroic material. We have shown that the so called size effect has a significant impact on ferroic stability, especially non-monotolically changes the phase transition temperature. Due to the fact, that the mass of embedded material was very low, the experimental signal of investigated ferroic material was very weak and an anomaly associated with the phase transition smeared. Besides this difficulties we succeed an analysis of several composited like TGS, KNO_3, ADP [5]. We have shown, that the pressure effect associated with the difference in thermal expansion coefficient of embedded materials and glass matric has a minor impact on the thermal stability of ferroic composites. The results of these research were published in several articles and were presented on scientific conferences [6].

3.2. *Scientific activity after receiving Ph. D.*

After my PhD defence I was employed at the Institute of Physics of the Wrocław University of Technology as the assistant. In February 2007 I went to a 20-month research internship at Ludwik Pasteur University in Strasbourg. My scientific research was led by prof. J-Y. Bigot in Nonlinear Phenomena Optics Group. The title of my project was "Physical Properties of Nanostructures and Photovoltaic Metamaterials". The subject of my research were samples of silicon nanostructures made in France. The main activity of my work was to build a setup for dynamic measurements using femtosecond laser pump-probe. I have made a series of time measurements with strong optical exciters exceeding the threshold of plasma excitation. The most important result of these measurements was the discovery that the plasma excitation threshold for silicon nanostructures was one order of magnitude smaller than that of bulk crystals. In addition, basing on Drude model I explained the influence of temperature and damping on the dynamics of the excited carriers. Another important achievement during my post-doc stay was the construction of a setup for ultrafast spectral impulses excitation of investigated nanostructures. This is a very difficult and rare experiment, which at one time allows for excitation and spatial probing with ultrafast optical pulses. In the case of nanostructures, this technique allows to get the information of the dynamics of excited carriers in single layers and interfaces. The results of the measurements for photovoltaic silicon nanostructures were published in the journal Plasmonics [7].

After my return to Poland I participated as a co-investigator in a research project led by prof. R. Poprawski titled: "Synthesis and characterization of pure and doped M_2TiGeO_5 ceramics and crystals - new materials for optoelectronics". Within this project I participated in the synthesis of new

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[5] (a) E. Rysiakiewicz-Pasek, R. Poprawski, J. Polanska, A. Urbanowicz, A. Sieradzki, J. Non-cryst. Sol. **352** (2006), 4309-4314; (b) R. Poprawski, E. Rysiakiewicz-Pasek, A. Sieradzki, A. Ciżman, J. Polańska, J. Non-Cryst. Sol. **353** (2007) 4457-4461; (c) A. Sieradzki, J. Komar, E. Rysiakiewicz-Pasek, A. Ciżman, R. Poprawski, Ferroelectrics **402** (2010) 60-65.

[6] T. Marciniszyn, R. Poprawski, J. Komar, A. Sieradzki, Phase Transitions **83** (2010) 909-916.

[7] (a) A. Sieradzki, Z. T. Kuźnicki, Plasmonics **8** (2013) 1643-1646; (b) A. Sieradzki, M. Basta, P. Scharoch, J.-Y. Bigot, Plasmonics **9** (2014) 545-551.

natisite compounds and their characterization. We have shown that Na_2TiGeO_5 material, which is similarly to its structural analogue with lithium ion, ferroelastic material below 281K. For ceramic samples, we have proved that the effect of the ferroelastic domain structure appearance and the grain size strongly influence the heat transport in these materials. In addition, we have shown that doping with rare earth ions causes emissions in these materials. The results of these studies have been published in several journals [[8]].

Since 2014, I have started the study of the physical properties of MOF metal-organic materials in cooperation with prof. M. Mączka from the Institute of Low Temperatures and Structural Research of the Polish Academy of Sciences in Wrocław. My tasks were calorimetric, dielectric and pyroelectric studies of new compounds with formate ligand. Using DSC, I have already studied over 200 different compounds to determine the occurrence of phase transitions. After initial selection and determination of phase transition type, specific heat and entropy changes at the phase transition temperature, selected samples were subjected to further characterization including structural, dielectric, magnetic and Raman and IR spectroscopy. We have described physical properties for different chemical compositions to determine the mechanisms that determine the occurrence of ferroic phase transitions in the investigated structures. For several compounds, we have demonstrated the coexistence of two ferroic phases at the same low temperatures, which makes them potentially multiferroic material, if the coupling between magnetic and electrical properties will be determined. Within three years I have been co-author of 19 publications on this subject and next works are prepared. We have prepared two independent projects for the Opus13 Grants. The selected results from these works are the basis of my presented habilitation proposal.

[8] (a) A. Sieradzki, A. Ciżman, A. Strzęp, R. Poprawski, W. Ryba-Rymanowski, Ferroelectrics **429** (2012) 56-61; (b) A. Sieradzki, D. Szewczyk, M. Nankiewicz, A. Jeżowski, R. Poprawski, Phase Transitions **86** (2013) 301-305; (c) A. Sieradzki, A. Jeżowski, R. Poprawski, J. Thermal Analysis and Calorimetry **115** (2014) 467-470; (d) A. Sieradzki, D. Szewczyk, A. Gągor, R. Poprawski, A. Jeżowski, Ceramics International **40** (2014) 8027-8031.

4. **Indication of the scientific achievement based on art. 16 par. 2 act from 14 March 2003 on scientific degrees and the scientific title and on degrees and title in arts (Dz.U.nr 65, poz. 595 ze zm.).**

As a scientific achievement according to the aforementioned act I point **monothematic cycle of publications** titled: *"Mechanism of ferroic phase transitions of metal-organic framework – dielectric and calorimetric invesitgations ".*

4.1. *Publications consisting of the scientific achievement.*

Presented 11 monothemtatic publications featuring contemporary solid-state experimental physics, particularly regarding the studies of the mechanisms of ferroic (especially ferroelectric, antiferroelectric and ferroelastic) phase transitions using wideband dielectric spectroscopy, pyroelectric measurements and differential scanning calorimetry DSC techniques combined with the results of other experiments.

	IF	Points of MNiSW	**2014**
A1	4.197	40	M. Mączka, A. Pietraszko, L. Macalik, **A. Sieradzki**, J. Trzmiel, A. Pikul, *Synthesis and Order-Disorder Transition in Novel Metal Formate Framework of* $[(CH_3)_2NH_2]Na_{0.5}Fe_{0.5}(HCOO)_3]$, Dalton Trans. (2014), 43, 17075. *My contribution to this work was to carry out calorimetric measurements of mixed formate compounds and to analyze and describe these results (see subsection Thermal properties). I have performed dielectric measurements in a wide range of temperatures and frequencies. I prepared all graphs and description of dielectric measurements (subsection Dielectric properties). In addition, I participated in the preparation of the entire manuscript.* I estimate my contribution at 25%
			2015
A2	1.98	30	**A. Sieradzki**, J. Trzmiel, M. Ptak, M. Mączka, *Unusual Electronic Behavior in the Polycrystalline Metal Organic Framework* $[(CH_3)_2NH_2]Na_{0.5}Fe_{0.5}(HCOO)_3]$ Electronic Materials Letters (2015), 11, 1033-1039. *My contribution to this work was to perform all the dielectric measurements of the formate compound with the embedded dimethylamine ion. I was discussing and analyzing the results. I prepared the manuscript.* I estimate my contribution at 70%
A3	4.177	40	M. Mączka, B. Bondzior, P. Dereń, **A. Sieradzki**, J. Trzmiel, A. Pietraszko, J. Hanuza, *Synthesis and Characterization of* $[(CH_3)_2NH_2][Na_{0.5}Cr_{0.5}(HCOO)_6]$*: Rare Example of Luminescent Metal-Organic Framework Based on Cr(III) Ions*, Dalton Trans., (2015), 44, 6871. *My contribution to this work was to carry out calorimetric measurements of mixed formate compounds and to analyze and describe these results (see subsection Thermal properties). I have performed dielectric measurements in a*

			wide range of temperatures and frequencies. I prepared all graphs and description of dielectric measurements (subsection Dielectric properties). In addition, I participated in the preparation of the entire manuscript. I estimate my contribution at 25%
A4	4.696	40	M. Mączka, **A. Sieradzki**, B. Bondzior, P. Dereń, J. Hanuza, K. Hermanowicz, *Effect of aliovalent doping on the properties of perovskite-like multiferroic formates*, Journal of Materials Chemistry C 3 36 (2015) 9337-9345. *My contribution to this work was to carry out calorimetric measurements of formate compounds doped with chromium ions and to analyze and describe these results (see subsection Thermal properties). I have performed dielectric measurements in a wide range of temperatures and frequencies. I prepared all graphs and description of dielectric measurements (subsection Dielectric properties). In addition, I participated in the preparation of the entire manuscript.* I estimate my contribution at 30%
			2016
A5	5.066	40	M. Mączka, A. Ciupa, A. Gągor, **A. Sieradzki**, A. Pikul, M. Ptak, *Structural, magnetic and dielectric properties of two novel mixed-valence iron (II)–iron (III) metal formate framework*, Journal of Materials Chemistry C, (2016), 4, 1186-1193. *My contribution to this work was to carry out calorimetric measurements of mixed formate compounds and to analyze and describe these results (see subsection Thermal properties). I have performed dielectric measurements in a wide range of temperatures and frequencies. I prepared all graphs and description of dielectric measurements (subsection Dielectric properties). In addition, I participated in the preparation of the entire manuscript.* I estimate my contribution at 20%
A6	4.19	40	**A. Sieradzki**, S. Pawlus, S.N. Tripathy, A. Gągor, A. Ciupa, M. Mączka, M. Paluch, *Dielectric relaxation behavior in antiferroelectric metal organic framework $[(CH_3)_2NH_2][Fe^{III}Fe^{II}(HCOO)_6]$ single crystals*, Phys. Chem. Chem. Phys. (2016) 18, 8462-8467. *I initiate and performed all the measurements. My contribution to this work was to perform all the dielectric measurements on the small monocrystals of the mixed formate compound. I participated in the analysis of the results obtained. I led whole the process of preparing and publishing of this paper.* I estimate my contribution at 60%
A7	4.19	40	M. Mączka, N.L.M. Costa, A. Gągor, W. Paraguassu, **A. Sieradzki**, J. Hanuza, *Structural, thermal, dielectric and phonon properties of perovskite-like imidazolium magnesium formate*, Phys. Chem. Chem. Phys. (2016) 18, 13993-14000. *My contribution to this work was to carry out calorimetric measurements of formate compound with embedded imidazole ions and to analyze and describe these results (see subsection DSC). I have performed dielectric measurements in a*

			wide range of temperatures and frequencies obeying the phase transition temperature. I prepared all graphs and description of dielectric measurements (subsections Dielectric measurements). In addition, I participated in the preparation of the entire manuscript. I estimate my contribution at 20%
A8	4.177	40	M. Ptak, M. Mączka, A. Gągor, **A. Sieradzki**, A. Stroppa, D. Di Sante, J. M. Perez-Mato, L. Macalik, *Experimental and theoretical studies of structural phase transition in a novel polar perovskite-like $[C_2H_5NH_3][Na_{0.5}Fe_{0.5}(HCOO)_3]$ formate*, Dalton Trans., (2016), 45, 2574-2583. *My contribution to this work was to carry out calorimetric measurements of formate compound with embedded polar ethyloamine ions and to analyze and describe these results (see subsection Thermal studies). I have performed dielectric measurements in a wide range of temperatures and frequencies. I manage the analysis of experimental data. I prepared all graphs and description of dielectric measurements (subsections Dielectric studies). In addition, I participated in the preparation of the entire manuscript.* I estimate my contribution at 20%
			2017
A9	4.029	40	**A. Sieradzki**, S. Pawlus, S.N. Tripathy, A. Gągor, M. Ptak, M. Paluch, M. Mączka, *Dielectric relaxation and anhydrous proton conduction in $[C_2H_5NH_3][Na_{0.5}Fe_{0.5}(HCOO)_3]$ metal–organic framework*, Dalton Transactions, (2017) 46, 3681-3687 *I proposed the subject of this publication. My contribution of this work was to perform all dielectric measurements. I manage the process of the analysis of the obtained results. I led the process of paper preparing.* I estimate my contribution at 60%
A10	9.466	45	M. Mączka, A. Gągor, M. Ptak, W. Paraguassu, T.A. da Silva, **A. Sieradzki**, A. Pikul, *Phase Transitions and Coexistence of Magnetic and Electric Orders in the Methylhydrazinium Metal Formate Frameworks*, Chemistry of Materials, (2017) 29, 2264-2275 *My contribution to this work was to carry out calorimetric measurements of formate compounds with embedded methylohydrazine ions and to analyze and describe these results (see subsection DSC). I have performed dielectric and pyroelectric measurements in a wide range of temperatures. I prepared all graphs and description of dielectric and pyroelectric measurements (subsections Dielectric and pyroelectric measurements). In addition, I participated in the preparation of the entire manuscript.* I estimate my contribution at 25%
A11	4.029	40	M. Mączka, J. Janczak, M. Trzebiatowska, **A. Sieradzki**, S. Pawlus, A. Pikul, *Synthesis and temperature-dependent studies of a perovskite-like manganese formate framework templated with protonated acetamidine*, Dalton Transactions, (2017) 46, 8476-8485

My contribution to this work was to carry out calorimetric measurements of formate compound with embedded acetamine ions and to analyze and describe these results (see subsection DSC). I have performed dielectric measurements in a wide range of temperatures and frequencies. I manage the analysis of experimental data. I prepared all graphs and description of dielectric measurements (subsections Dielectric studies). In addition, I participated in the preparation of the entire manuscript.

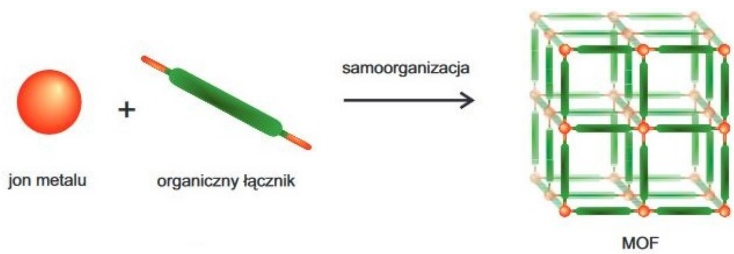
I estimate my contribution at 25%

4.2. *Discussing scientific purpose of aforementioned works and achieved results and showing applications of those*

The scientific goal of the series of works being the basis of the habilitation application was to study the mechanism of ferroic phase transitions basing on the results of calorimetric, dielectric and pyroelectric measurements combined with data from other independent experiments.

4.2.1. Introduction

For decades, a basic research of co-ordination polymer which the structure allows for one- and two-dimensional and three-dimensional networks has been intensively performed. The latter being called MOF metal-organic compounds, are investigated the most. The MOF structure contains of a network consisting of two main elements: metal cations (acting as metallic centers) and organic connectors linked together by coordination bonds. Organic ligands (linkers) contain at least two functional groups that form coordination bonds with cations. Such a structure makes it possible to obtain crystalline and three-dimensional structures [[9]]. The characteristic feature of such structures is the presence of large pores (free spaces) in the metal-organic frameworks that may be empty or filled by molecules or ions.



In recent years there has been a growing interest in MOF compounds with formate ligand (HCOO-), due to their interesting multiferroic properties. Multiferroics can be used, as extremely efficient memories. Compared to standard magnetic or ferroelectric materials, multiferroics possesses a magnetoelectric effect, i.e. they have the unique ability to change the magnetization

[9] M. Eddaoudi, J. Kim, N. Rosi, D. Vodak, J. Wachter, M. O'Keeffe, O. M. Yaghi, Science, **295** (2002), 469-472.

vector by the external electric field as well as the polarization vector by external magnetic field. In this way, there is a unique chance of realizing the four logical states [10]. From the physics point of view, the stability of the ferroic phases is a key scientific problem in the studies of multiferroicity. This topic becomes non-trivial as soon as we realize that in ordinary systems these phenomena are mutually exclusive [11].

There are many possible, different applications of these crystals and their usefulness depends mainly on the degree of reciprocal coupling of particular states, in particular electric and magnetic. The degree of such correlation depends both from the crystalline structure and the chemical composition of this crystal. However, to prove the coupling first the mechanisms that determine the stability of particular phases, in particular ferroelectric, antiferroelectric and ferroelastic should be known. Currently, there is a many potential applications of these unique multiferroic materials. They can be used in generators, phase shakers, tunnel connectors, but it is most practical to use these materials as magnetic field sensors [12]. Moreover, the thermodynamic conditions in which the material's properties remain stable or undergo a phase transition are directly depend on the molecular structure of the substance and its long-range interactions. It is well known that the specific properties of the material, under the preset temperature and pressure conditions, determine its potential use for specific applications. For this reason, understanding the mechanisms of phase transitions, in particular the effect of intermolecular interactions and crystalline properties on material properties, is a matter of cardinal importance for the design of new compounds with desirable properties. The second, not less important branch of research, is to determine how the change in thermodynamic conditions affects these properties, eg. by changing the temperature at which the transition occurs and the order of phase transition caused, by small amount of dopant.

Knowing the ferroic properties of new metal-organic compounds and describing the mechanisms that determine the stability of each phases is a difficult task due to the complexity of the crystalline structure. A feature that hinders many measurements is that metal-organic frameworks with formate ligands are generally difficult to obtain as large monocrystals, thus anisotropic measurements are not possible to develop. However, the use of many independent experimental techniques allows to determine the physical properties and describe the mechanisms of phase transitions. Amongst many experimental techniques, DSC, dielectric and pyroelectric measurements allow to determine the temperature of the phase changes, the type of transition and its mechanisms.

[10] J. F. Scott, Nature Materials **6** (2007) 256 – 257.
[11] D. I. Khomskii, Journal of Magnetism and Magnetic Materials **306** (2006) 1.
[12] M. M. Vopson, Critical Reviews in Solid State and Materials Sciences **40** (2015) 223-250.

4.2.2. Discussion of the results being the part of the scientific achievement

A1. In this paper the synthesis and the results of structural studies of a new metal-organic compound containing Na^{II} and Fe^{III} with dimethylammonium cation DMA^+ - $[(CH_3)_2NH_2][Na_{0.5}Fe_{0.5}(HCOO)_3]$ was presented. The calorimetric studies revealed a second phase structural transition at 167K. Based on the results of X-ray diffraction studies, the change in symmetry of the trigonometric system R3 in 293K to the triangular P1 in 110K was demonstrated. The disorder of DMA^+ cations in a wide range of temperatures leads to strong relaxation properties observed in dielectric measurements. Observations under the polarization microscope have unambiguously shown that the observed transition is to the ferroelastic phase. Based on the analysis of the dielectric, structural and Raman scattering and IR spectroscopy results, it was concluded that the phase transition in this compound is primarily related to the ordering of dimethylammonium cations. The deformation of the metal-organic framework at the phase transition temperature was also depicted. Based on the dielectric spectroscopic studies, the activation energies associated with DMA^+ reorientation were determined. Additionally, based on the results of magnetic tests it was found that at 8.5K the material becomes a weak ferromagnet. There is no evidence of additional phase transitions between the ferroelastic and ferromagnetic phase transition, proving that the material exhibits coexistence of ferroelastic and ferromagnetic properties below 8.5 K.

A2. This paper is a continuation of the A1 studies. An analysis of the relaxation processes observed by means of broadband dielectric spectroscopy was presented. The strong relaxation dipole process was observed, which disappeared in accordance with the Vogel-Fulcher model at 98K. It has been found that this process is associated with the "freezing" of DMA^+ reorientation movements consistent with the results of IR spectral studies. Analysis of results in the frequency domain revealed the double power law of the relaxation process, showing the formation of interaction clusters in the test material. Based on the stochastic analysis, it was concluded that the emerging clusters are of similar microscopic size. In addition, a long-range interaction between clusters has been demonstrated. It has been shown that at the ferroelastic phase transition, the relaxation process changes from the generalized function of Mittag-Leffler (GML) to Havriliak-Negami (HF).

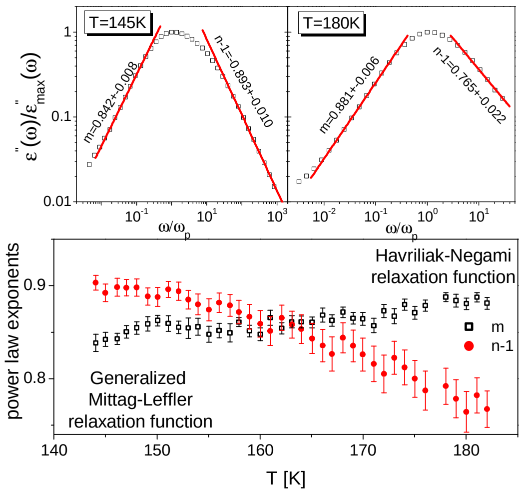


Fig. 1. The temperature dependence of power law exponents in the vicinity of the ferroelastic phase transition in $[(CH_3)_2NH_2][Na_{0.5}Fe_{0.5}(HCOO)_3]$.

A3. In this work, the results of synthesis and basic physical properties for structural analogue from works A1 and A2 were presented (Fe^{III} was substituted by Cr^{III}). The first conclusion from the calorimetry study is that the substitution of chromium in place of iron results in the disappearance of the ferroelastic phase transition. Additionally, based on the results of dielectric measurements, it was observed that the dipole relaxation process is related to DMA^+ cation reorientation movements, similarly to iron analogs (A1, A2). However, in the case of the test compound, the "freezing" of the DMA^+ reorientation movements does not lead to a structural change, which has shown that the mechanism of the ferroic transitions of the metal-organic formates is mainly caused by the frameworks deformations and the intermolecular forces, especially hydrogen-bonds. This result becomes important, because currently the ordering of the built-in cation was treated as the only mechanism of MOFs phase transitions. In addition, the results of photoluminescence studies show that at low temperatures, this material exhibits high photoluminescence due to the presence of chromium ions.

A4. In this work the results of synthesis, structural and physical properties of ferroelectric metal compounds of perovskite structure $[(CH_3)_2NH_2][Mn(HCOO)_3]$ doped with various trivalent ions M = Cr, Al, In, Eu and Er were presented. It has been observed that slight doping of $[(CH_3)_2NH_2][Mn_{1-x}Cr_x(HCOO)_3]$ (x=2.1) results in a significant reduction in the ferroelectric phase transition temperature. When increasing the amount of dopant, the phase transition temperature decreases significantly, and the nature of this transition is changed from the first order to the pure sample for highly smeared phase transition for the sample with chromium dose x = 3.1. This behavior is similar to those observed for inorganic ferroelectrics having a similar perovskite structure. It has been also shown that slight substitution with other trivalent cations, like Al^{3+} and In^{3+}, also cause the lowering of the ferroelectric phase transition temperature. Phase transition temperature shift depends not so much on the type of dopant, but rather on its amount (Figure 2). A small amount of dopant pertube a long-range interactions, which are responsible for the ferroelectric order in the studied structures. The change in force is also visible in dielectric spectra where additional relaxation processes appear for doped samples and the value of exponents in power laws describing phase change has changed. Additionally, it has been shown that chromium-doped and europium-doped samples exhibit efficient luminescence. The results of this work are very important because they show that it is easy to modify the temperature range of the ferroelectric phase by doping.

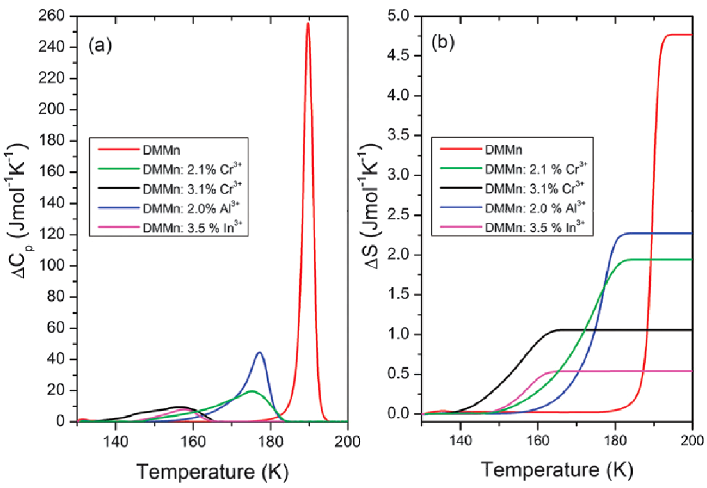


Fig. 2. a) Anomalous specific heat and b) change in entropy as a function of temperature for samples doped with different trivalent atoms.

A5. In this work, mixed metal-organic compounds with $C_2H_5NH_3^+$ ethylammonium and diethylammonium $(C_2H_5)_2NH_2^+$ were performed. The results of synthesis of new compounds with equal percentage Fe^{II} and Fe^{III} iron substitution and their basic physical properties are presented. Both MOFs crystallize in the P31c structure. Based on the results of the calorimetric measurements, it has been demonstrated that compound $[(C_2H_5)_2NH_2][Fe^{III}Fe^{II}(HCOO)_6]$ has a second phase antiferroelectric phase transition at 240K into a triclinic phase. Anomalies of dielectric permittivity as a function of temperature for a wide frequency range with small dispersion were observed. In addition, magnetic ordering has been demonstrated at 39K. Interestingly, this compound is a rare example of a compound exhibiting strong negative magnetization. This compound is therefore the second discovered mixed-valence metal formate exhibiting multiferroic properties.

A6. The fundamental aspects of the relaxation dynamics in niccolite-type, mixed valence metal–organic framework, multiferroic $[(CH_3)_2NH_2][Fe^{3+}Fe^{2+}(HCOO)_6]$ single crystals have been reported using dielectric relaxation spectroscopy covering eight decades in frequency and the temperature range from 120 K to 250 K. The compound shows antiferroelectric to paraelectric phase transition near T = 154 K with the relaxor nature of electric ordering. The temperature dependent dielectric response in modulus representation indicates three relaxation processes within the experimental window. The variable range hopping model of small polarons explains the bulk non-Debye type conductivity relaxation with an energy activation 0.37eV. The fastest relaxation with activation energy Ea = 0.17 eV is related to progressive freezing of the reorientation motions of DMA+ cations. X-ray diffraction data revealed that complete freezing of orientational and translational motions of DMA+ cations occurs well below phase transition temperature. These experimental observations are fundamentally important for the theoretical explanation of relaxation dynamics in niccolite-type metal– organic frameworks..

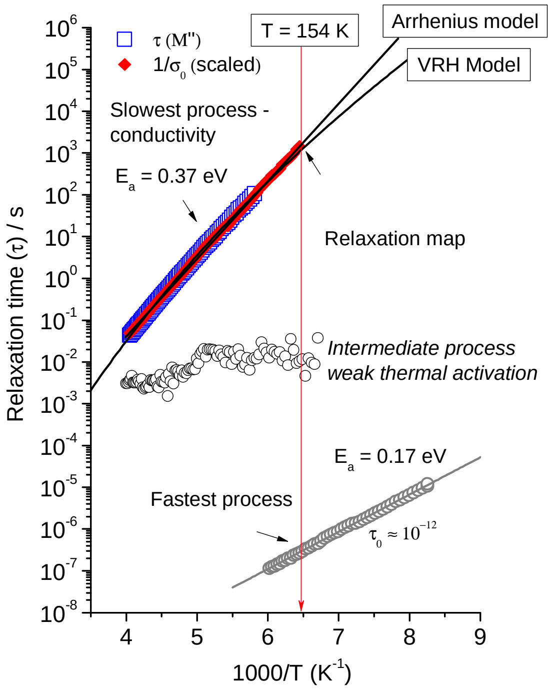


Fig. 3. Arrhenius plot of the relaxation times for fast (upper panel) and conductivity (lower panel) relaxation processes observed in the $[(CH_3)_2NH_2][Fe^{III}Fe^{II}(HCOO)_6]$ crystal. The vertical arrow indicates phase transition temperature.

A7. Here we report the synthesis and characterisation of a magnesium formate framework templated by protonated imidazole. Single-crystal X-ray diffraction data showed that this compound crystallizes in the monoclinic structure in the P21/n space group. The antiparallel arrangement of the dipole moments associated with imidazolium cations suggests the antiferroelectric character of the room-temperature phase. The studied compound undergoes a structural phase transition at 451 K associated with a halving of the c lattice parameter and the disappearance of the antiferroelectric order. Raman and IR data indicate that the disorder of imidazolium cations plays a significant role in the mechanism of the phase transition. Dielectric data show that the phase transition is associated with a relaxor nature of electric ordering. It was observed that the change in symmetry of the system influenced the activation energy of the conductivity process, which is related to the change in the length of hydrogen bonds that bind the imidazole molecule to the metal-organic framework, thus altering the strength of these bonds. This result has started a new research idea, the effect of hydrogen bonding power on the conductive conductive processes observed in metal-organic compounds. We also report high-pressure Raman scattering studies of this compound that revealed the presence of two pressure-induced phase transitions near 3 and 7 GPa. The first transition is most likely associated with a rearrangement of the imidazolium cations without any significant distortion of these cations and the magnesium formate framework, whereas the second transition leads to strong distortion of both the framework and imidazolium cations. High-pressure data also show that imidazolium magnesium formate does not show any signs of amorphization up to 11.4 GPa.

A8. In this paper we report the synthesis, single crystal X-ray diffraction, and thermal, dielectric, Raman and infrared studies of a novel heterometallic formate

$[C_2H_5NH_3][Na_{0.5}Fe_{0.5}(HCOO)_3]$ (EtANaFe). The thermal studies show that EtANaFe undergoes a second-order phase transition at about 360 K. X-ray diffraction data revealed that the high-temperature structure is monoclinic, space group P21/n, with dynamically disordered ethylammonium (EtA+) cations. EtANaFe possesses a polar low-temperature structure with the space group Pn and, in principle, is ferroelectric below 360 K. Dielectric data show that the reciprocal of the real part of dielectric permittivity above and below the phase transition temperature follows the Curie–Weiss, as expected for a ferroelectric phase transition. Based on theoretical calculations, we estimated the polarization as (0.2, 0, 0.8) μC cm^{-2}, i.e., lying within the ac plane. The obtained data also indicate that the driving force of the phase transition is ordering of EtA+ cations. However, this ordering is accompanied by significant distortion of the metal formate framework.

A9. In this work we report the temperature-dependent crystal structure and proton conduction in$[C_2H_5NH_3][Na_{0.5}Fe_{0.5}(HCOO)_3]$ metal–organic frameworks using X-ray diffraction and broadband dielectric spectroscopic techniques. The detailed analysis of the crystal structure reveals disorder of the terminal ethylene groups in the polar phase (space group Pn). The structural phase transition from Pn to P21/n at T ≈ 363 K involves the distortion of the metal formate framework and ordering of EtA^+ cations due to the reduction of the cell volume. The dielectric data have been presented in the dynamic window of permittivity formalism to understand the ferroelectric phase transition. The relaxation times have been estimated from the Kramers–Kronig transformation of the dielectric permittivity. It has been observed that the curing of EtA^+ cations with temperature in two steps. At the transition temperature from the paraelectric to the ferroelectric phase (T_c = 363K), partial ordering with a large change in activation energy of about 2eV take place. With further cooling at 330K there is a further ordering and finally, in the low temperature phase, the activation energy is 0.63eV. It has been shown that the strength and length of hydrogen bonds determine the long-range ferroelectric order in the investigated compound. A Grotthuss type mechanism of the proton conduction is possible at low temperatures with the activation energy of 0.23 eV. This type of experimental observation is expected to provide new prospective on the fundamental aspect of elementary proton transfer in anhydrous MOFs.

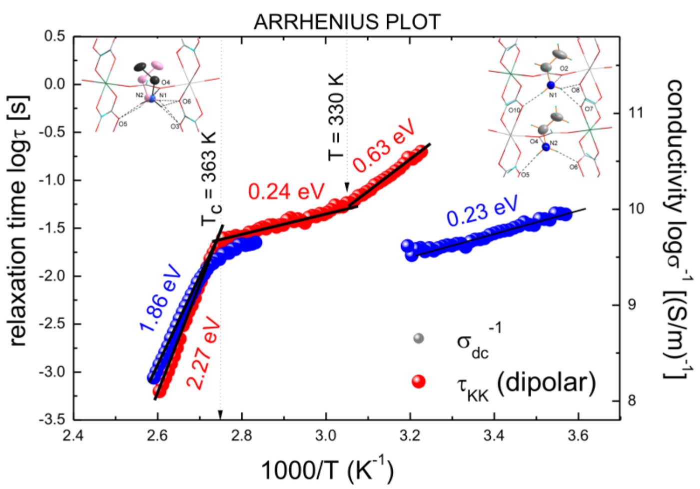


Fig. 4. Relaxation map, relaxation times and the inverse conductivity as a function of 1000/T for $[C_2H_5NH_3][Na_{0.5}Fe_{0.5}(HCOO)_3]$

A10. The results of the synthesis of a new group of metal-organic compounds with formate ligand with the first methylhydrazine ion $[CH_3NH_2NH_2][M(HCOO)_3]]$ where M = Mn, Mg, Fe, Zn were presented. On the basis of calorimetric measurements, it has been observed that regardless of the type of underlying metal, each compound exhibits two phase transitions..

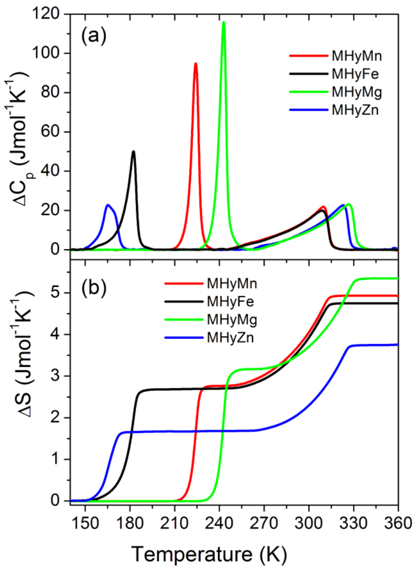


Fig. 5. Changes of specific heat (upper) and entropy (lower) during phase transitions

The first transition temperature depends weakly on a type of divalent metal and is observed at 310–327 K on heating. Xray diffraction, DSC, and vibrational studies revealed that it has a second-order character. It is associated with partial ordering of the methylhydrazinium (MHy^+) cations and change of symmetry from nonpolar $R\bar{3}c$ to polar R3c. Pyroelectric measurements suggest the ferroelectric nature of the room-temperature phase. The second, low temperature phase transition has a first-order character and is associated with further ordering of the MHy^+ cations and distortion of the metal formate framework. Magnetic susceptibility data show that MHyMn and MHyFe exhibit ferromagnetic-like phase transitions at 9 and 21 K, respectively. Since the low-temperature phase is polar, these compounds are possible multiferroic materials. MHyFe shows additional magnetic anomaly in the magnetically ordered state, which most likely manifests some blocking of magnetic moments.

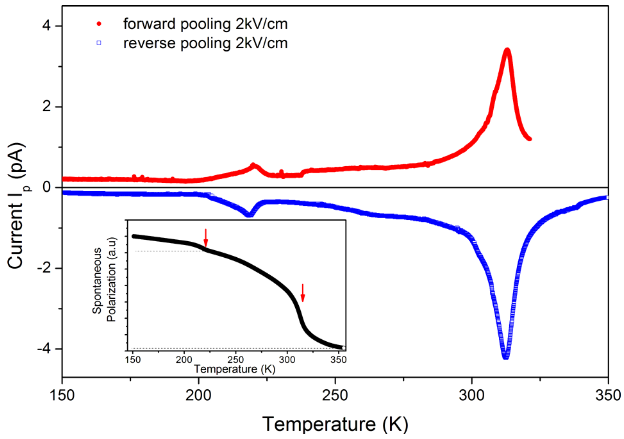


Fig. 6. Pyroelectric current as a function of temperature after poling MHyMn from 350 to 150 K with ±2 kV/cm, during heating with the temperature rate of 1 K/min. The inset shows the estimated change of the spontaneous polarization as a function of temperature.

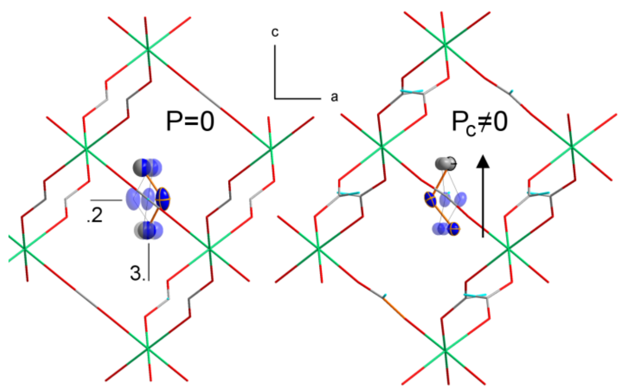


Fig. 7. Disordering of the cation in phase I (left), space group $R\bar{3}c$, MHy+ symmetry − C2, T = 330 K; (right) disordering in phase II. Displacement ellipsoids are drawn with 50% probability.

A11. The synthesis, crystal structure, thermal, dielectric, phonon and magnetic properties of the $[CH_3C(NH_2)_2][Mn(HCOO)_3]$ (AceMn) compound have been performed. Our results show that this compound crystallizes in the perovskite-like orthorhombic structure, space group Imma. It undergoes a structural phase transition at 304 K into a monoclinic structure, space group $P2_1/n$. X-ray diffraction, dielectric, IR and Raman studies show that the ordering of the acetamidinium cations triggers the phase transition. An important conclusion resulting from dielectric measurements is that the ordering of built-in cations depends not on the size of the ion but on the number and strength of hydrogen bonds. Because of the lack of large monocrystals, the nature of this transition has not been clearly defined. However, the absence of a pyrocurrent indicated that it was not a ferroelectric material. In addition, it has been shown that the material below the 9K temperature exhibits poor ferromagnetic properties.

4.2.3. Ferroelectric phase transition in metal-organic formates

The most interesting from the application point of view physical properties of the investigated metal-organic structures is ferroelectricity [[13], [14], [15]]. As it is known, ferroelectrics are a subgroup of pyroelectric materials for which the electric polarity P can be altered by applying an external electric field E. Thus, the ferroelectrics have a stable dipole moment in the unit cell which orientation can be changed by applying an external electric field, hysteresis P - E. To determine the ferroelectricity in the new compound, several measurement techniques can be used.

The first method is structural measurements, which are designed to show the change in symmetry and non-centrosymmetric crystalline structure. Determining the symmetry of the high and low temperature phase allows for the identification of potential ferroic properties according to Aizu [[16]]. Determination of the permanent dipole moment in two equivalent states in the unit cell is evidence of the presence of ferroelectricity in the investigated metal-organic compounds (A8). However, due to the complexity of the chemical and geometrical structures of the metal-organic frameworks, the determiation of symmetry in each phase is difficult and sometimes impossible to realize (A10).

Direct proof of ferroelectricity can be obtained by measuring the P-E hysteresis loop using, for example, the Sawyer-Tower bridge. However, for these measurements, the sample must be oriented along the polar axis, which is impossible for many metal-organic compounds because the monocrystals are too small. In addition, it should be remembered that this technique requires the ability to interpret the results obtained, since many times, due to the so-called "banana effect", ferroelectricity was misinterpreted [[17]]. An alternative method to proof the ferroelectricity is the pyroelectric current mesurements, since it is a direct measurement of the temperature derivative of polarization. For a group of compounds with a methylhydrazine cation for which a hysteresis

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[13] W. Zhang, R.-G. Xiong, Chem. Rev., 2012, 112, 1163-1195.
[14] K. Asadi, M. A. van der Venn, Eur. J. Inorg. Chem., 2016, 4332-4344.
[15] P. Jain, A. Stroppa, D. Nabok, A. Marino, A. Rubano, D. Paparo, M. Matsubara, H. Nakotte, M. Fiebig, S. Picozzi, E. Sang Choi, A. K. Cheetham, C. Draxl, N. S. Dalal, V. S. Zapf, Quantum Materials, 2016, 1, 16012.
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loop could not be obtained, this method proved to be very useful for the ferroelectricity determination (A10). This method for polycrystalline samples, due to the averaging of the polarity vector component, does not allow for a precise determination of the spontaneous polarization value, however, gives an insight to the changes of this magnitude as a function of temperature. For low values of spontaneous polarization of a polycrystalline sample, the pyroelectric measurements requires very high values of electric fields, which for organic samples may be destructive. In the case of a compound with ethylammonium cation, whose partial decomposition temperature is around 100°C, both hysteresis and pyroelectric measurements have been ineffective to prove ferroelectricity (A8).

The development of electrical techniques for the identification of ferroelectricity is broadband dielectric spectroscopy. Measurement of complex dielectric permittivity as a function of both temperature and frequency is a common method used to describe the mechanism of phase transitions. At the phase transition in which the electric polarity changes, the dielectric permittivity values also have to be changed. In the case of ferroelectrics at the transition from the para- to ferroelectric phase, the characteristic Curie-Weiss law must be fulfilled. In addition, it is known from the phenomenological theory that the ratio of the Curie constant in the ferro- and para phase should be 2. Using this fact polycrystalline samples can be analyzed for the type of phase transitions (A8). In the case of the ethylammonium cation, an additional way to proof the ferroelectricity was the results of the first principles calculations. Basing on this method the spontaneous polarization value (A8) was determined.

An extremely useful tool in the identification of ferroelectric mechanisms of phase transitions is the measurement of the dielectric response as a function of frequency. This technique allows to understand the relaxation processes and to link them to changes in the structure of the investigated compound, and consequently to determine the factors leading to the appearance of ferroelectric properties. In the case of the ethylammonium cation EtA^+ (A9, A8), the ordering of reorientational movements of EtA^+ groups, which was partially responsible for the ferroelectric order at low temperatures. In addition, a strong ionic conductivity (A9) was observed at high temperatures.

For metal-organic frameworks with ferroelectric properties, the interesting problem is the effect of doping with metal ions on the ferroelectric phase stability. For the perovskite structure $[(CH_3)_2NH_2][Mn(HCOO)_3]$ a stable ferroelectric phase below 187K was presented [[18], [19]]. Using differential scanning calorimetry (DSC) the temperature of the phase transitions and estimate the change in entropy at the phase transition were performed. Substitution of manganese with different trivalent ions of Cr, Al, In, Eu and Er in the investigated compound causes significant changes in the temperature of the ferroelectric phase (A4). Both the size of the substituted atom and the amount of dopant cause a decrease in the ferroelectric phase transition temperature. In addition, transition becomes more smeared and entropy changes smaller. This is caused by a

[18] G. Rogez,N. Viart and M. Drillon, Angew. Chem., Int. Ed., 2010, 49,1921–1923.
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perturbation of the long-range interferaction responsible for a stable ferroelectric phase. This opens the possibility to control the temperature range of the ferroelectric phase during the synthesis of new metal-organic.

4.2.4. Ferroelastic phase transitions in metal-organic formates

Rarely investigated ferroic property of metal-organic frameworks is ferroelasticity [[20]]. Knowing these properties seems to be increasingly important as it has been shown that magnetoelectric coupling requires ferroelastic domain switching. The studies focused on the elastic properties of MOF metal-organic compounds suggest that their high flexibility in response to local structural changes could be crucial in the formation of new high shear deformation ferroelastics [[21], [22]]. The results of the perovskite MOF-type compounds have provided evidence for this possibility, although the research focused only on the weak magneto-elastic coupling [[23]].

Controlling the deformation of the sample by varying the direction of applied stress is difficult to achieve, hence the direct measurement of the ferroelastic hysteresis loop is very rare [[24], [25]]. There are, however, other experimental methods, such as structural studies, elastic domain structure observations and Brillouin spectroscopic measurements, which can prove ferroelasticity under given thermodynamic conditions. Based on the results of structural measurements, the domain structure is shown for the first time in the mixed metallo-organic compound $[(CH_3)_2NH_2][Na_{0.5}Fe_{0.5}(HCOO)_3]$ (A1). By performing a series of independent measurements including DSC, Raman and IR spectra, the dielectric investigations, the phase transition at 167K was classified as order-disorder one associated with ordering of cations $(CH_3)_2NH_2^+$ and partial distortion of the framework (A1). Detailed data analysis from dielectric measurements provided information on the change in relaxation type of the observed dipole relaxation process associated with ferroelastic phase transition (A2). Observed two-power law relaxation processes suggest the existence of areas (clusters and superclusters) with equal average relaxation times. The ferroelastic phase dominates the process where small areas have similar average relaxation times, which is consistent with the presence of a ferroelastic domain structure. In the paraelastic phase, where the domain structure disappears, the type of relaxation changes to Havrilaka-Negami (A2). In the structural analogue where iron chromium is replaced, ferroelasticity disappears (A3), despite many similarities in the results of experimental research. Hence, it is concluded that the mechanism of ferroelastic phase transition in mixed compounds is more complex.

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[20] W. Li, Z. Zhang, E. G. Bithell, A. S. Batsanov, P. T. Barton, P. J. Saines, P. Jain, C. J. Howard, M. A. Carpenter, A. K. Cheetham, Acta Materialia, 2013, 61, 4928-4938.
[21] J. C. Tan, A.K. Cheetham, Chem. Soc. Rev., 2011, 40, 1059-1080.
[22] J. C. Tan, B. Civalleri, C. C. Lin, L. Valenzano, R. Galvelis, P. F. Chen, T. D. Bennett, C. Mellot-Draznieks , C. M. Zicovich-Wilson, A. K. Cheetham, Phys Rev Lett., 2012, 108, 095502.
[23] R. I. Thomson, P. Jain, A. K. Cheetham, J. M. Rawson, M. A. Carpenter, Phys. Rev. B, 2012,86, 214304.
[24] E. K. Salje, Phase Transitions in Ferroelastic and Co-elastic Crystals, Cambridge University Press 1993.
[25] E. K. Salje, Annual Review of Materials Research, 2012, 42, 265-283.

4.2.5. Antiferroelectric phase transitions in metal-organic formates

The antiferroelectric ordering which in a macroscopic response without an external electric field, gives a polarization value of zero, can be simply demonstrated by performing structural measurements or double-hysteresis P-E hysteresis. Knowing the change in phase symmetry during phase change, the antiferroelectric order of the low temperature phase in metal-organic compounds with the formate ligand (A5, A7, A11) can be determined. It has been shown that by incorporating various cations into the metal-organic framework structure, the temperature of the antiferroelectric phase transition can be controlled.

For formate with embbeded imidazole cation the structural, calorimetric, dielectric, and Raman spectral and IR spectra, revelead the phase transition from antiferroelectric to paraelectric phase at 451K (A7). The mechanism of this transition is related to the ordering of imidazolium cations and is associated with the change in the hydrogen bond strength. Similar results can be observed for the metal-organic compound with another ligand, where stable antiferroelectric properties above room temperature occur [26]. By substituting another cation, different antiferroelectric phase temperatures were obtained: 304K for protonated acetamidine (A11), 240K for diethylammonium cation (A5) and 164K for dimethylammonium cation (A6). Based on the analysis of the calorimetric results, including the estimation of changes in phase entropy, it was found that the phase transition mechanisms are more complex than the classic order-disorder transition. By analyzing the relaxation processes observed in the spectra of dielectric measurements and by analyzing the effect of the type of embbeded cation on the phase transition temperature and the activation energies of relaxation processes, it has been observed that the arrangement of these cations strongly depends on the amount and strength of hydrogen bonds between these cations and the surrounding framework (A11).

4.2.6. Summary

The above-mentioned scientific achievements are based on a series of 11 publications. All publications deal with the description of physical properties and the study of factors determining the presence of stable ferroic phases in metal-organic frameworks. The investigated crystals belong to a group of materials with formate ligand and with an integrated organic cation from the group of ammonium cations. In each of the presented publications, a wide characterization of the newly synthesized compounds has been made using various independent measurement techniques including structural, calorimetric, dielectric, pyroelectric, magnetic, Raman and IR measurements. The results of calorimetric, dielectric and pyroelectric measurements, which were the Habilitant's achievements at A1-A11 works, have made a significant contribution to the interpretation of the processes responsible for the mechanisms of observed structural phase transitions.

Based on the results of the calorimetric studies, the temperature of the phase transition and its order was determined. The value of the change in entropy at the transition was estimated to determine whether the phase transition is order-disordered type. Based on the results of the

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dielectric measurements, the relaxation times and activation energies of the observed relaxation processes were determined and their effects on the mechanisms of the ferroic phase transition were determined. It has been observed that the ferroic phases of the investigated crystals depend on the ordering of both the vibrations of the constructed ammonium cationic molecule and the formate ligand itself. It has been found that the length and strength of hydrogen bonds, which strongly depend on temperature, directly determine the order of the ferroic order in the investigated crystals. In addition, it has been observed that the change in the intermolecular forces by introducing a small amount of dopant into the framework of the structure causes the decreasing of the phase transition temperature. Based on the results of pyroelectric measurements, the ferroelectricity of the phase transition was shown.

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5. List of other (not included in the achievement described in par. 4) published scientific works

5.1. Publications in journals from Journal Citation Reports (JRC) database after PhD defence

Lp.	IF*	Points of MNiSW**	2017
1.	4.123	40	M. Ptak, A. Gągor, **A. Sieradzki**, B. Bondzior, P. J. Dereń, A. Ciupa, M. Trzebiatowska, M. Mączka, *Effect of K^+ cations on phase transitions, structural, dielectric and luminescent properties of [cat][$K_{0.5}Cr_{0.5}(HCOO)_3$], where cat is protonated dimethylamine or ethylamine*, Phys. Chem. Chem. Phys., (2017) 19, 12156-12166. Estimated contribution 20% (calorimetric and dielectric measurements and its analysis, I participated in the preparation of the manuscript)
			2016
2.	2.265	30	M. Mączka, A. Gągor, K. Hermanowicz, **A. Sieradzki**, L. Macalik, A. Pikul, *Structural, magnetic and phonon properties of Cr (III)-doped perovskite metal formate framework [$(CH_3)_2NH_2$][$Mn(HCOO)_3$]*, Journal of Solid State Chemistry, (2016) 237, 150-158. Estimated contribution 15% (calorimetric and dielectric measurements and its analysis, I participated in the preparation of the manuscript)
3.	4.19	40	M. Mączka, K. Pasińska, M. Ptak, W. Paraguassu, T.A. da Silva, **A. Sieradzki**, A. Pikul, *Effect of solvent, temperature and pressure on the stability of chiral and perovskite metal formate frameworks of [NH_2NH_3][$M(HCOO)_3$](M= Mn, Fe, Zn)*, Phys. Chem. Chem. Phys. (2016) 18, 31653-31663. Estimated contribution 10% (calorimetric measurements and its analysis, I participated in the preparation of the manuscript)
4.	4.19	40	M. Ptak, M. Mączka, A. Gągor, **A. Sieradzki**, B. Bondzior, P. Dereń, S. Pawlus, Phase transitions and chromium (iii) luminescence in perovskite-type [$C_2H_5NH_3$][$Na_{0.5}Cr_xAl_{0.5-x}(HCOO)_3$](x= 0, 0.025, 0.5), correlated with structural, dielectric and phonon properties, Phys. Chem. Chem. Phys., (2016) 18, 29629-29640. Estimated contribution 20% (calorimetric and dielectric measurements and its

			analysis, I participated in the preparation of the manuscript)
5.	4.19	40	M. Mączka, M. Ptak, S. Pawlus, W. Paraguassu, **A. Sieradzki**, S. Balciunas, M. Simenas, J. Banys, *Temperature-and pressure-dependent studies of niccolite-type formate frameworks of* $[NH_3(CH_2)_4NH_3][M_2(HCOO)_6]$*(M= Zn, Co, Fe)*, Phys. Chem. Chem. Phys. (2016) 18, 27613-27622. Estimated contribution 20% (calorimetric and dielectric measurements and its analysis, I participated in the preparation of the manuscript)
6.	5.066	40	M. Mączka, A. Gągor, N.L.M. Costa, W. Paraguassu, **A. Sieradzki**, A. Pikul, *Temperature-and pressure-induced phase transitions in the niccolite-type formate framework of* $[H_3N(CH_3)_4NH_3][Mn_2(HCOO)_6]$, Journal of Materials Chemistry C, (2016) 4, 3185-3194. Estimated contribution 20% (calorimetric and dielectric measurements and its analysis, I participated in the preparation of the manuscript)
			2015
7.	4.177	40	A. Ciupa, M. Mączka, A. Gągor, **A. Sieradzki**, J. Trzmiel, A. Pikul and M. Ptak, Temperature-dependent studies of $[(CH_3)_2NH_2][Fe^{III}M^{II}(HCOO)_6]$ frameworks (M^{II} = Fe and Mg): structural, magnetic, dielectric and phonon properties, Dalton Trans., (2015), 44, 8846. Estimated contribution 15% (calorimetric and dielectric measurements and its analysis, I participated in the preparation of the manuscript)
8.	2.011	25	A. Ciupa, M. Mączka, A. Gągor, A. Pikul, E. Kucharska, J. Hanuza, **A. Sieradzki**, *Synthesis, Crystal Structure, Magnetic and Vibrational Properties of Formamidine-templated Co and Fe Formates*, Polyhedron 85 (2015) 137–143. Estimated contribution 10% (calorimetric and dielectric measurements and its analysis, I participated in the preparation of the manuscript)
			2014
9.	2.605	40	**A. Sieradzki**, D. Szewczyk, A. Gągor, R. Poprawski, A. Jeżowski, *Thermal properties of Er:* Li_2TiGeO_5 *ferroelastic ceramics*, Ceramics International 40 (2014) 8027-8031. Estimated contribution 60% (ceramic synthesis, calorimetric measurements and its analysis, preparation of the manuscript)
10.	2.201	30	J. Trzmiel, **A. Sieradzki**, A. Jurlewicz, Z.T. Kuźnicki, *Dielectric spectroscopy investigations of nanostructured silicon*, Current Applied Physics 14 (2014) 991-997. Estimated contribution 40% (dielectric measurements and its analysis, I participated in the preparation of the manuscript))
11.	2.238	30	**A. Sieradzki**, M. Basta, P. Scharoch, J.-Y. Bigot, *Ultrafast Optical Properties of Dense Electron Gas in Silicon Nanostructures*, Plasmonics 9 (2014) 545-551. Estimated contribution 50% (ultrafast measurements, I managed the preparation of the manuscript)
12.	4.762	40	M. Mączka, A. Ciupa, A. Gągor, **A. Sieradzki**, A. Pikul, B. Macalik, M. Drozd, *Perovskite Metal Formate Framework of* $[NH^{2-}CH^{+}-NH_2]Mn(HCOO)_3]$*: Phase Transition, Magnetic, Dielectric, and Phonon Properties*, Inorganic chemistry 53 (2014) 5260–5268. Estimated contribution 15% (calorimetric and dielectric measurements and its analysis, I participated in the preparation of the manuscript)

13.	2.06	25	**A. Sieradzki**, A. Jeżowski, R. Poprawski, *The influence of ferroelastic domain formation on thermal conductivity in Li_2TiGeO_5 ceramics*, J. Therm. Anal. Calorim. 115 (2014) 467-470. Estimated contribution 70% (ceramic synthesis, thermal conductivity measurements and its analysis, I managed the preparation of the manuscript)
			2013
14.	2.738	30	**A. Sieradzki**, Z.T. Kuznicki, *Effects of carrier confinement and intervalley scattering on a photo-excited electron plasma in silicon*, Plasmonics 8 (2013) 1643–1646. Estimated contribution 85% (ultrafast measurements, I prepare the manuscript)
15.	0.94	25	T. Marciniszyn, **A. Sieradzki**, *Anisotropy properties of the quartzite from Jeglowa, Poland*, Acta Geologica Polonica 63 (2013) 265-269 Estimated contribution 45% (dielectric measurements and its analysis, I participated in the preparation of the manuscript)
16.	1.044	20	**A. Sieradzki**, D. Szewczyk, M. Nankiewicz, A. Jeżowski, R. Poprawski, A. Ciżman, *Evidence of the ferroelastic phase transition in Na_2TiGeO_5 ceramics*, Phase Transitions, 86 (2013) 301-305. Estimated contribution 55% (ceramic synthesis, analysis of the results, I managed the preparation of the manuscript)
			2012
17.	0.415	15	**A. Sieradzki**, A. Ciżman, A. Strzęp, R. Poprawski, W. Ryba-Rymanowski, *Synthesis and Optical Properties of Pure and Doped M_2TiGeO_5 (M = Li and Na) Ceramics*, Ferroelectrics 429 (2012) 56 -61. Estimated contribution 50% (ceramic synthesis, analysis of the results, I managed the preparation of the manuscript)
18.	0.258	15	A. Ciżman, J. Komar, T. Marciniszyn, R. Poprawski, E. Rysiakiewicz-Pasek, **A. Sieradzki**, *Size effect and dielectric properties of $NH_4H_2PO_4$ – porous glass composites*, Materials Science-Poland, 30 (2012) 143-150. Estimated contribution 10% (dielectric measurements, I participated in the preparation of the manuscript)
19.	1.918	30	A. Podhorodecki, N.V. Gaponenko, M. Banski, M.V. Rudenko, L.S. Khoroshko, **A. Sieradzki**, J. Misiewicz, *Green emission from barium–strontium titanate matrix introduced into nano-porous anodic alumina*, Optical Materials 34 (2012)1570-1574. Estimated contribution 10% (dielectric measurements and its analysis, I participated in the preparation of the manuscript)
			2011
20.	-	-	M. Basta, Z. T. Kuznicki, **A. Sieradzki**, *Optical properties of crystalline and amorphous Si:P for device fabrication and structural modeling*, SPIE ECO-PHOTONICS 2011: SUSTAINABLE DESIGN, MANUFACTURING, AND ENGINEERING WORKFORCE EDUCATION FOR A GREEN FUTURE Book Series: Proceedings of SPIE Volume: 8065 Article Nr: 80650I Estimated contribution 20% (optical measurements and its analysis, I participated in the preparation of the manuscript)
21.	-	-	M. Hosatte, M. Basta, **A. Sieradzki**, P. Meyrueis, Z. T. Kuznicki, *Current collection*

			from different Si devices based on nanoscale Si-layered systems containing a new metamaterial for photovoltaics, SPIE ECO-PHOTONICS 2011: SUSTAINABLE DESIGN, MANUFACTURING, AND ENGINEERING WORKFORCE EDUCATION FOR A GREEN FUTURE Book Series: Proceedings of SPIE Volume: 8065 Article Nr: 806508 Estimated contribution 15% (optical measurements and its analysis, I participated in the preparation of the manuscript)
22.	-	-	**A. Sieradzki**, A. Ciżman, R. Poprawski, T. Marciniszyn, E. Rysiakiewicz-Pasek, *Electrical conductivity and phase transitions in KDP- and ADP-porous glass nanocomposites*, J. of Advanced Dielectrics, 1 (2011) 337-343. Estimated contribution 40% (dielectric measurements and its analysis, I participated in the preparation of the manuscript)
			2010
23.	1.006	20	T. Marciniszyn, R. Poprawski, J. Komar, **A. Sieradzki**, *Phase transition in $NH_4H_2PO_4$:porous glass composites*, Phase Transitions, 83 (2010) 909 - 916. Estimated contribution 40% (dielectric measurements and its analysis, I participated in the preparation of the manuscript)
24.	0.511	20	**A. Sieradzki**, J. Komar, E. Rysiakiewicz-Pasek, A.Ciżman, R. Poprawski, *Physical properties of ferroelectric phase transitions in KNO_3 embedded into porous Glasses*, Ferroelectrics, 402 (2010) 60 – 65. Estimated contribution 60% (DSC measurements and its analysis, I participated in the preparation of the manuscript)
25.	1.006	20	M. Basta, **A. Sieradzki**, First-principles study of the Li_2TiGeO_5 ferroelastic phase transition, Phase Transitions, 83, 235-243 (2010). Estimated contribution 50% (analysis of the DFT results, I participated in the preparation of the manuscript)
			2008
26.	1.201	15	**A. Sieradzki**, A. Ciżman, J. Komar, *Pressure dependence of dielectric properties of the $LiNaGe_4O_9$ ferroelectric*, Phase Transitions 81, 999 (2008). Estimated contribution 90% (dielectric measurements under pressure and its analysis, I participated in the preparation of the manuscript)
27.	1.201	15	**A. Sieradzki**, *Temperature evolution of the ferroelastic order parameter of Li_2TiGeO_5*, Phase Transitions 81, 413 (2008) My contribution 100%
28.	0.562	15	A. Ciżman, R. Poprawski, **A. Sieradzki**, *Dilatometric investigations of phase transitions in TEA_2MnCl_4 crystals*, Ferroelectrics 363, 209 — 214 (2008) Estimated contribution 10% (analysis of dilatometric measurements)
29.	0.562	15	Yu. Eliyashevskyy, **A. Sieradzki**, R. Poprawski, Z. Czapla, *Influence of the hydrostatic pressure on phase transitions of $[(CH_3)_2NH_2]_3CuCl_5$ crystals*, Ferroelectrics 363, 245-250 (2008). Estimated contribution 40% (dielectric measurements under pressure and its analysis, I participated in the preparation of the manuscript)
30.	1.13	20	A. Waśkowska, L. Gerward, J. Staun Olsen, **A. Sieradzki**, W. Morgenroth, *$Na_2TiOGeO_4$: Crystal Structure Stability at Low Temperature and High Pressure*, Journal of Physics and Chemistry of Solids, 69, 815–821 (2008).

			Estimated contribution 20% (analysis of the dielectric measurements under pressure, I participated in the preparation of the manuscript)
			2007
31.	1.34	24	E. Rysiakiewicz-Pasek , R. Poprawski, **A. Sieradzki**, A. Ciżman, J. Polańska, Dielectric properties of KNO_3 embedded into porous glasses, Journal of Non-Crystalline Solids, 353, 4457-4461 (2007). Estimated contribution 20% (dielectric measurements and its analysis, I participated in the preparation of the manuscript)
32.	0.65	15	A. Ciżman, R. Poprawski, **A. Sieradzki**, Ferroelectric phase transition in $(CH_3NH_3)_5Bi_2Cl_{11}$ and $(CH_3NH_3)_5Bi_2Br_{11}$ crystal, Phase Transit. 2007 vol. 80, 171-176. Estimated contribution 10% (analysis of the results, I participated in the preparation of the manuscript)

5.2. Inventions and utility models and industrial designs that have been protected and exhibited at international or national exhibitions or fairs

Patent application:

Number of application: **P 405740 z 23.10.2013.**

Authors: A. Sieradzki, A. Galas

Title: *The measurements method of bone fragments displacement treated with external stabilizer and device for measuring relative displacement of bone fragments treated with external stabilizer*

5.3. Monographs, scientific papers in international journals

No.	Authors, title, publisher, year
1.	A. Ciżman, R. Poprawski, **A. Sieradzki**, *Dielectric physics : introduction to selected problems of dielectric physics*, Łódź, PRINTPAP (2011) ISBN 978-83-62098-54-5 *My contribution to this work was to write two chapters in a book on piezoelectricity and pyroelectricity. I estimate my contribution at 40 %.*
2.	E. Rysiakiewicz-Pasek, R. Poprawski, A. Ciżman, **A. Sieradzki**, *Nanocomposite materials - ferroelectric nanoparticles incorporated into porous matrix*, rozdział w książce: Nanodevices and nanomaterials for ecological security / ed. by Yuri N. Shunin, Arnold E. Kiv. Dordrecht [i in.] : Springer, cop. (2012) *My contribution to this work was to perform pyroelectric, dilatometric and calorimetric measurements and its analysis. I estimate my contribution at 25 %.*

5.4. Participation in scientific projects

GRANT 3 T08D 007 26 (2004-2007) - *Porous glass as a model material for testing the properties of nanostructures of different materials*, Leader **Dr E. Rysiakiewicz-Pasek.**

N N507 481338 (2008-2010) **-** *Synthesis and characterization of pure and doped M_2TiGeO_5 ceramics and crystals - new materials for optoelectronics*, Leader **prof. R. Poprawski**

5.5. National awards for scientific activities

START scholarship (for young scientists) Foundation for Polish Science in Physics in 2008.

5.6. Speeches at domestic and international thematic conferences

- **A. Sieradzki,** S. Pawlus, J. Trzmiel, A. Ciupa, M. Paluch, M. Mączka, June 2015, 13th European Meeting on Ferroelectricity, *Dielectric properties of phase transitions in some metal formate frameworks*, Porto, Portugal
- **A. Sieradzki,** Yu. Eliyashevskyy, P. Scharoch, R. Poprawski, Z. Czapla, September 2014, III Polish - Lithuanian - Ukrainian Meeting on Ferroelectrics Physics, *Ferroelectric first order phase transitions in (DMA)$CuCl_5$ under pressure – experimental and phenomenological analysis*, Wrocław
- **A. Sieradzki**, P. Łydżba, Yu. Eliyashevskyy, P. Scharoch, R. Poprawski, Z. Czapla**,** September 2013, 13th International Meeting on Ferroelectricity, Vanishing of ferroelectricity in $[(CH_3)_2NH_2]_3CuCl_5$ under pressure – phenomenological approach, Kraków
- **A. Sieradzki**, September 2005 – XXVIII International School on Ferroelectric Physics, Ferroelastic phase transition in *Li_2TiGeO_5,* Szklarska Poręba
- **A. Sieradzki,** A. Ciżman, R. Poprawski, V. Shuvaeva, A.M. Glazer**,** September 2004 – VI Polish-Ukrainian Meeting and XXVII International School on Ferroelectrics Physics, *Birefringence imaging of phase transition in ferroelastic Li_2TiGeO_5*, Ustroń Zdrój.

5.7. Participation and poster presentation on international conferences

2003 – 10th European Meeting on Ferroelectricity EMF2003, Cambridge UK
2004 – Polish-Czech Seminar of Ferroelectricity, Wierzba
2004 – VI Polish-Ukrainian Meeting and XXVII International School on Ferroelectrics Physics, Ustroń Zdrój
2005 – XXVIII International School on Ferroelectric Physics, Szklarska Poręba
2006 – Czech-Polish Seminar of Structural and Ferroelectric Phase Transitions, Znojmo, Czech Republic
2006 – VIII Ukrainian - Polish and III East-European Meeting on Ferroelectrics Physics, Lwów, Ukraina
2009 – 6th International Conference on Physics Teaching in Engineering Education PTEE2009, Wrocław

2009 – 12th International Meeting on Ferroelectricity (IMF-12) , Xian, China
2009 – XXX Jubilee International School on Ferroelectrics Physics, Przesieka
2010 – Polish-Czech Seminar of Structural and Ferroelectric Phase Transitions, Lądek Zdrój
2011 – 12th European Meeting on Ferroelectricity EMF2011, Bordeaux, France
2012 – XX Polish-Czech Seminar on structrural and ferroelectric phase transitions, Ustroń

6. Didactic and popularizing achievements and information about international collaboration of candidate

6.1. Participation in European programs and other international and national programs

1. Leading the student's research projects within the framework of cooperation between the Lower Silesian Voivodeship and the Alsatian Government: "Polish-French cooperation in physics"; English classes with students of the University of Strasbourg and Institute of Physics, Wrocław University of Technology, April 2008, 2009.
2. Lectures with demonstrations: "No such cold nitrogen" for schools from the Złotoryja District under the POKL program "Become an inventor" - Wrocław 2009.

6.2. Participation in organizational committees of international and national scientific conferences

1. XXX Jubilee International School on Ferroelectrics Physics, September 2009, Przesieka, organizer
2. International Conference of Parametric Design, Shapes of Logic, march 2015 Wrocław, member of the scientific committee.

6.3. Awards and distinctions

- 2013, 2014 main prize in the competition for the favorite lecturer of all Wroclaw University organized by the academic Radio Luz

- 2013 – WRUT Rector's Award

- 2015 - special award in the competition for the favorite lecturer of Wrocław University organized by Academic Radio Luz

6.4. Didactic and science popularizing achievements

An originator and lecturer on the physics of sport from the cycle **Red Bull Ryzyk Fizyk**:

Data	Description
march 2017	➲ Wrocław of University of Science and Technology, **Wrocław**: „Physics of speedway", guest: **Maciej Janowski** ➲ Rzeszów University of Technology, **Rzeszów**: „Physics of speedway", guest: **Maciej Janowski**

Data	Description
november 2016	➲ University of Warmia and Mazury, **Olsztyn**: „Physics vs aerobatics", guest: **Łukasz Czepiela**
may 2016	➲ Maria Curie-Sklodowska University, **Lublin**: „Physics of rallies: Theory versus power", guest: **Michał Kościuszko**
november 2015	➲ Łódź University of Technology , **Łódź**, Festival Explorers, Laboratory of adventure: "Scientific analysis of WRC rallies", guest: **Michał Kościuszko** ➲ Silesian University of Technology, **Gliwice**: „Physics of rallies: Theory vs power", guest: **Michał Kościuszko**
may 2015	➲ Opole University of Technology, **Opole**: *„Physical considerations of WRC rallies"* guest: **Michał Kościuszko**
april 2015	➲ The Officer School of the Air Force in Deblin, **Dęblin**: „Aeronautical theory versus practice", guest: **Łukasz Czepiela**
january 2015	➲ Silesian University of Technology , **Katowice**: *„Physical considerations of WRC rallies"*, guest: **Michał Kościuszko**
december 2014	➲ Warsaw University of Technology, **Warszawa**: „Physics of rallies*: Theory vs power*", guest: **Michał Kościuszko**
june 2014	➲ City beach, **Gdynia**: „Aeronautical Physics", guest: **Łukasz Czepiela** ➲ Wrocław University of Science and Technology, **Wrocław**: „Aerobatic flying and aerial racing physics", guest: **Łukasz Czepiela**
may 2014	➲ Rzeszow University of Technology, **Rzeszów**: „Aerobatic flying and aerial racing physics", guest: **Łukasz Czepiela** ➲ Poznan University of Technology, **Poznań**: *„Aerobatic flying and aerial racing physics"*, guest: **Łukasz Czepiela** ➲ Gdańsk University of Technology, **Gdańsk**: „Physics of rallies*: Theory vs power*", guest: **Michał Kościuszko**
january 2014	➲ Wrocław University of Science and Technology, **Wrocław**: *„Physics of rallies: Theory vs power"*, guest: **Michał Kościuszko**
november 2013	➲ AGH University of Science and Technology, **Kraków**: *„Physics of rallies: Theory vs power"*, guest: **Michał Kościuszko**
may 2013	➲ Wrocław University of Science and Technology, **Wrocław**: *„Volleyball in physics and practice"*, guest: **Zbigniew Bartman**

The originator and lecturer of lectures on Sport Physics and author of many other lectures:

Data	OPIS
june 2017	➲ Wrocław University of Science and Technology, third meeting in the series of Sports Physics: "*Handball Physics*". Number of participants: 500. Invited guests: Sławomir Szmal, Karol Bielecki
october 2016	➲ Plenary lectures of Physics in sport on Scientific Festival Explory in Gdynia. Number of participants: 800. Invited guests: **Kajetan Kajetanowicz, Sylwia Gruchała, Natalia Partyka**.
June 2016	➲ School of Sports Championship in Duszniki Zdrój: "*Physics of soccer*". Number of participants: 150.
may 2016	➲ Wrocław University of Science and Technology, third meeting in the series of

Data	OPIS
	Sports Physics: "*Physics of swimming*". Number of participants: 300. Invited guest: **Otylia Jędrzejczak**
april 2016	➲ Wrocław University of Science and Technology, A lecture in Health Week: "*Is sport healthy*?". Number of participants: **100**.
february 2016	➲ Academy of Young Explorers, Wroclaw University of Technology, "*Influence of UV radiation on hair structure.*", Number of participants: 60.
september 2015	➲ Gala at the end of XVIII Lower Silesian Science Festival, Wroclaw University of Technology, "*Dance vs. Physics*.", Number of participants: 350. Guest invited: **Maciej „Gleba" Florek**
june 2015	➲ School of Sports Championship in Duszniki Zdrój: "How important is aerodynamics in sport". Number of participants: 150.
may 2015	➲ Wroclaw University of Technology, the first meeting of the series Physics of Sport: "*Physics in volleyball*". Number of participants: 800. Invited guests: Krzysztof Ignaczak (World Champion 2014), Piotr Gruszka (European Champion 2009), Katarzyna Mroczkowska (Polish Vice-Champion 2014), Anita Kwiatkowska
june 2014	➲ Children's University in Wrocław: "*Why balloons burst so loud?*" Number of participants: 300. ➲ School of Sports Championship in Duszniki Zdrój: "*Physics in sport*" Number of participants: 80.
may 2014	➲ Academy of Young Explorers, Wroclaw University of Technology: "*Physics in Volleyball*". Number of participants: 50. Invited guests: Polish vice-champion in volleyball 2014, competitors of Impel Śląsk Wrocław: Katarzyna Mroczkowska, Joanna Kaczor, Bogumiła Pyziołek.
november 2013	➲ Lecture at the invitation of the Municipality of Wroclaw at the 1st Wrocław Children and Youth Congress: "*Why do not physicists play volleyball, since they know how to do it better?*" Number of participants: 200. Guest: Paweł Michocki .
september 2013	➲ Lectures within the Lower Silesian Science Festival in Wroclaw and Dzierżoniów: "*If you can understand something at all, you can teach it well - considerations about the world of electrons*." Number of participants: 200.
april 2013	➲ Lecture with demonstrations at the Secondary School in Bielawa: "*Physics in Music*". Number of participants: 60.
november 2012	➲ Academy of Young Explorers, Wroclaw University of Technology: "*Physics at the football stadium*". Number of participants: 150. ➲ Open lecture for junior high school students at Wroclaw University of Technology: "*From electron to electricity*". Number of participants: 80.
march 2012	➲ XVIII series of lectures popularizing physics, Wroclaw University of Technology "*Front is not always on the front and how the electrons move*", Number of participants 70.
september 2011	➲ Lecture for young people and adults in the Lower Silesian Science Festival in Wroclaw: "*What can we expect after EURO2012 - physics at the stadium*". Number of participants: **500**. ➲ Lecture for Children under the Lower Silesian Science Festival in Wroclaw: "*Where? Why? What for? - how to play with physics*." Number of participants: **240**.
october 2011	➲ Lecture at the primary school in Złotoryja: "*The eyes are to look, the brain to see - optical illusions.*" Number of participants: 80.
september	➲ Open lecture for young people and adults in the Lower Silesian Science Festival in

Data	OPIS
2010	Wroclaw: "*Time scale - moment is a second, an hour or maybe a year?*" Number of participants: 150. ➲ A lecture for children in the Lower Silesian Science Festival in Wroclaw: "*Physics around us - How to answer the simplest question: How is it going?*" Number of participants: 200.
april 2010	➲ XVI series of lectures popularizing physics, Wroclaw University of Technology: "Electrostatic and amber electricity".
january 2010	➲ Lecture coupled with an open discussion on "*Why science is worth learning*" – Secondary School im. John Paul II in Złotoryja, Primary School No. 1 in Złotoryja, and No. 2 in Złotoryja.
september 2009	➲ Lecture within the Lower Silesian Science Festival in Wroclaw: "Wherever there is water, there must be physicists; but where are the physicists, there are water lines ".
may 2009	➲ Lecture with demonstrations for schools from the Złotoryja District under the program "Become an inventor": "No such cold nitrogen".
march 2009	➲ XV series of lectures popularizing physics, Wroclaw University of Technology: "Water Physics".
september 2006	➲ Lectures within the Lower Silesian Science Festival in Wroclaw in primary schools "*Magical meetings with physics*".
september 2005	➲ Experimental shows at the Lower Silesian Science Festival, Ząbkowice Slaskie
june 2005	➲ Co-organizer of the Physical Festival, Wroclaw Market
september 2004	➲ Co-author of the lecture "*Several Experiments with a Wire*" at the Lower Silesian Science Festival, Wroclaw University of Technology

6.5. *Leading didactic courses*

I am the Laboratory Manager of Sensors and Processing of Non-Electric Signals. It is my responsibility to prepare and control laboratory equipment. I have developed didactic materials and working instructions (some of them in English) to the Laboratory of Sensors and Non-Electric Signal Processing and to the Laboratory of Introduction to Dielectric Physics, Laboratory of Solid State Physics, Laboratory of Physics. I led courses in uniform Master's degree in Physics, and in 1st and 2nd degree programs in the fields of Technical Physics, Biomedical Engineering:

Sensors and measurements of non-electrical quantities (lecture, laboratory)

Introduction to Dielectric Physics (laboratory)

Physics of dielectrics (lecture, laboratory)

Physics of Solid State (laboratory)

Physics (lecture, exercises)

Laboratory of Physics

6.6. Scientific supervision of students

Supervision of 28 thesis:

Engineer theses	Master theses
inż. Joanna Dobrowolska	mgr Paulina Peksa
inż. Jolanta Sławska	mgr Anna Karmazyn
inż. Maja Nowak	mgr Daria Szewczyk
inż. Zuzanna Sokalska	mgr Marcin Nankiewicz
inż. Kinga Hojczyk	mgr Bogumiła Naglik
inż. Justyna Licznar	
inż. Izabella Podsiedlik	
inż. Paulina Kałużna	
inż. Paulina Fior	
inż. Paulina Peksa	
inż. Patryk Monasterski	
inż. Grzegorz Łukasza	
inż. Dagmara Szymczyk	
inż. Anna Karmazyn	
inż. Adam Rek	
inż. Ada Różycka	
inż. Joanna Wajda	
inż. Joanna Symonowicz	
inż. Dagmara Zbawiony	
inż. Matylda Żmudzińska	
inż. Jonatan Stokłosa	
inż. Jacek Jarosik	
inż. Anna Galas	

Supervisor of student internships:

- Michał Kochanowski, student of Wrocław University of Science and Technology
- Dagmara Szymczyk, student of Wrocław University of Science and Technology
- Paulina Kałużna, student of Wrocław University of Science and Technology
- Weronika Rynkowska, student of Wrocław University of Science and Technology

6.7. Internships at foreign and national academic or academic centers

1. University of Louis Paster in Strasbourg, France, february 2007 – october 2008. Supervisor: prof. J.-Y. Bigot. Topic: Ultrafast optical spectroscopy of silicon nanostructures.
2. Clarendon Laboratory, Oxford UK, marzec 2004. Supersivior: prof. A. M. Glazer. Topics: Measurement of spontaneous birefringence of ferroic materials using imaging method.

6.8. *Foreign and domestic cooperation*

- *University of Oxford Department of Physics, UK*
  - Prof. M. A. Glazer
- *Ivan Franko National University of Lviv, Departament of Solid State Physics, Lwów, Ukraine*
  - Dr Yu. Eliyashevskyy
- *Université de Strasbourg, Institut de Physique et Chimie des Matériaux de Strasbourg (IPCMS), Strasbourg, France*
  - Prof. J.-Y. Bigot, Dr M. Vomir
- *Institute of Low Temperatures and Structural Research, Polish Academy of Sciences in Wrocław*
  - prof. M. Mączka, prof. A. Jeżowski, prof. A. Pietraszko, dr M. Ptak, dr M. Trzebiatowska, dr A. Gągor, mgr A. Ciupa
- *University of Wrocław, Institute of Experimental Physics*
  - prof. Z. Czapla, dr hab. J. Przesławski
- *Silesian University, Silesian Inter-University Center for Education and Interdisciplinary Studies*
  - prof. M. Paluch, dr hab. S. Pawlus

6.9. *Prepared expertise and other elaborations on request*

Lower Silesian Bonn for Innovation

Project co-financed by the European Union from the European Social Fund under the Measure 8.2.1 Operational Program Human Capital Operational Program

Supervisory: Wroclaw Center for Technology Transfer

1. Development of a report on the thermal analysis of rock materials, especially magnesites from the Grochów mine. Term: January-April 2013
2. Report on the determination of optimum physical parameters of sintering fine-grained rock material resulting from the mechanical treatment of stone. Term: April - August 2013
3. Design and development of a sensor prototype for controlling the mobility of the knee joint. January - April 2014

6.10. *Reviewing of publications in scientific journals.*

As per now I have revised ~20 publications in scientific journals such as:

1. Physical Chemistry Chemical Physics,
2. RSC Advances,
3. Journal of Applied Physics,
4. Applied Physics A,
5. Journal of Thermal Analysis and Calorimetry,

6. Journal of Alloys and Compounds,
7. Journal of Inorganic and Organometallic Polymers and Materials,
8. Physica E,
9. Materials Science and Engineering B,
10. Materials Research,
11. Materials Science – Poland,
12. Ferroelectrics.

6.11. *Other achievements*

- President of the Jury in the Polish Competition for Engineers Red Bull Tech Lab 2017
- Member of the Jury of the E(x)plory Polish Festival