Vita Summary

1. Name: **Marcin Sikora**

2. Holder of: MSc diploma, University of Mining and Metallurgy, Kraków (1999)

   PhD diploma, University of Mining and Metallurgy, Kraków (2002), thesis *X-ray Magnetic Circular Dichroism study of magnetic properties of* $La_{2/3-y}RE_yCa_{1/3}MnO_3$ *compounds* supervised by Prof. Czesław Kapusta

3. Employment: AGH University of Science and Technology[1], Kraków, Teaching Assistant, from December 2002 to September 2003, and Assistant Professor, since October 2003, at Faculty of Physics and Applied Computer Science[2]

   Consejo Superior de Investigaciones Científicas, Zaragoza (Spain), Postdoctoral Fellow at Instituto de Ciencia de Materiales de Aragón, from February 2004 to February 2005

   European Synchrotron Radiation Facility, Grenoble (France), Post-Doc, from March 2005 to February 2008, and Junior Scientist, from March to December 2008, at ID26 XAS-XES beamline

4. Habilitation achievement. Series of publications entitled *Electronic and magnetic properties of complex transition metal oxides studied with hard X-ray spectroscopy*.

(a) Composed of the following papers:

[1] M. Sikora, Cz. Kapusta, K. Knížek, Z. Jirák, C. Autret, M. Borowiec, C.J. Oates, V. Procházka, D. Rybicki, D. Zajac, *XANES study of Mn and Co valence states in* $LaMn_{1-x}Co_xO_3$ *(x = 0 to 1)*, Phys. Rev. B **73**, 094426 (2006),

[2] M. Sikora, Cz. Kapusta, M. Borowiec, C.J. Oates, V. Procházka, D. Rybicki, D. Zając, J.M. De Teresa, C. Marquina, M.R. Ibarra, *Evidence of unquenched Re orbital magnetic moment in* $AA'FeReO_6$ *double perovskites*, Appl. Phys. Lett. **89**, 062509 (2006),

[3] M. Sikora, K. Knížek, Cz. Kapusta, P. Glatzel, *Evolution of charge and spin state of transition metals in the* $LaMn_{1-x}Co_xO3$ *perovskite series*, J. Appl. Phys. **103**, 07C907 (2008),

[4] M. Sikora, O. Mathon, P. van der Linden, J.M. Michalik, J.M. De Teresa, Cz. Kapusta, and S. Pascarelli, *Field-induced magnetostructural phase transition in double perovskite* Ca_2FeReO_6 *studied via x-ray magnetic circular dichroism*, Phys. Rev. B **79**, 220402 (2009),

[5] Marcin Sikora, Amélie Juhin, Tsu-Chien Weng, Philippe Sainctavit, Carsten Detlefs, Frank de Groot, and Pieter Glatzel, *Strong K-edge Magnetic Circular Dichroism Observed in Photon-in–Photon-out Spectroscopy*, Phys. Rev. Lett. **105**, 037202 (2010),

[6] Nikolay Smolentsev, Marcin Sikora, Alexander V. Soldatov, Kristina O. Kvashnina, and Pieter Glatzel, *Spin-orbit sensitive hard x-ray probe of the occupied and unoccupied 5d density of states*, Phys. Rev. B **84**, 235113 (2011),

[7] M. Sikora, A. Juhin, G. Simon, M. Zając, K. Biernacka, Cz. Kapusta, L. Morellon, M.R. Ibarra, P. Glatzel, *1s2p resonant inelastic x-ray scattering - magnetic circular dichroism: a sensitive probe of 3d magnetic moments using hard x-ray photons*, J. Appl. Phys **111**, 07E301 (2012),

[1] formerly University of Mining and Metallurgy
[2] formerly Faculty of Physics and Nuclear Techniques

published as a result of numerous synchrotron experiments performed at the beamline A1 of Hasylab/DESY (Hamburg) as well as at the beamlines ID26 and ID24 of ESRF (Grenoble) in the years 2004-2010 in collaboration with the scientists from AGH (Kraków), FZU ASC (Prague), CSIC & University of Zaragoza, ESRF (Grenoble), Utrecht University, IMPMC UPMC (Paris) and SFU (Rostov-on-Don).

(b) It was only few weeks after I started university education, when the Nobel Prize in Physics 1994 was awarded to Bertram N. Brockhouse and Clifford G. Shull for their contribution to the development of neutron scattering and spectroscopy techniques for studies of condensed matter. In the official press release[3] of Nobel foundation one can read that neutron scattering techniques can be applied to study the relative orientation of magnetic moments and 'the X-ray method has been powerless in this field'. At that time I was unaware that the latter comment is not entirely truth. However, I realized that only three years later, during my first experimental session at synchrotron radiation facility at Hasylab/DESY in Hamburg. There I have learnt that, although neutron techniques are dominant in this field, also X-ray techniques that are sensitive magnetic moment orientation are known since late 1980s. It was X-ray magnetic circular dichroism (XMCD),[4,5] a technique that allows determination of net magnetic moment with element specificity and, moreover, for the separate determination of spin (m_S) and orbital (m_L) contributions.[6,7]

Over last twenty years, as a result of construction of the third generation synchrotron radiation facilities, a rapid progress has been achieved in X-ray based experimental techniques.[8] Among them, several methods allowing to probe magnetic properties have been developed, namely nuclear resonant scattering (NRS), X-ray resonant magnetic scattering (XRMS), X-ray absorption spectroscopy (XAS) as well as magnetic circular (XMCD) and linear (XMLD) dichroism. All of them are routinely employed in the contemporary studies of magnetic materials.[9]

The main goal of the works forming my habilitation achievement was to explore the microscopic magnetic properties of a complex 3*d* & 5*d* transition metal (TM) oxides with dominant *TM*-O-*TM* exchange interactions by means of XMCD and X-ray absorption near edge structure (XANES). Moreover, I also employed the high resolution X-ray emission spectroscopy (XES) and expanded the range of application of XMCD performing measurements of circular dichroism under high pulsed magnetic field and using resonant inelastic X-ray scattering (RIXS) principle. Detailed description of the results obtained and their potential applications are presented in the following paragraphs.

In the papers [1] and [3] the outcomes of the quest for dominant magnetic interaction between Mn and Co ions in the $LaMn_{1-x}Co_xO_3$ solid solution performed by means of XANES and XES are reported. The material of interest attracted a considerable interest due to the appearance of a ferromagnetic (FM) ground state, which is in contrast to the behavior of the end members. Magnetic ground state of $LaMnO_3$ consists of antiferromagnetically

[3] Press Release: *The 1994 Nobel Prize in Physics*, 23 Oct 1994, http://www.nobelprize.org/nobel_prizes/physics/laureates/1994/press.html

[4] G. Schütz et al., *Absorption of circularly polarized x rays in iron*, Physical Review Letters **58**, 737 (1987), DOI:10.1103/PhysRevLett.58.737.

[5] C.T. Chen et al., *Soft-x-ray magnetic circular dichroism at the $L_{2,3}$ edges of nickel*, Physical Review B **42**, 7262 (1990), DOI:10.1103/PhysRevB.42.7262

[6] B.T. Thole et al., *X-ray circular dichroism as a probe of orbital magnetization*, Physical Review Letters **68**, 1943 (1992), DOI:10.1103/PhysRevLett.68.1943.

[7] P. Carra et al., *X-ray circular dichroism and local magnetic fields*, Physical Review Letters **70**, 694 (1993), DOI:10.1103/PhysRevLett.70.694.

[8] D. Attwood, *Soft X-Rays and Extreme Ultraviolet Radiation: Principles and Applications*, (Cambridge University Press, 1999), ISBN:9780521029971.

[9] E. Beaurepaire et al., *Magnetism: A Synchrotron Radiation Approach*, Lecture Notes in Physics **697**, (Springer, Berlin Heidelberg, 2006), DOI:10.1007/b11594864.

coupled Mn^{3+} in their high spin configuration ($3d^4$, S=2), while $LaCoO_3$ is diamagnetic with a low spin state of Co^{3+} ($t_{2g}^6e_g^0$, S=0). At optimum Co concentration, x~0.15, the net magnetic moment rises up to 3.5 μ_B/f.u.[10] Originally, the appearance of the ferromagnetism for the intermediate x was attributed to the superexchange Mn^{3+}-O-Mn^{3+} interaction due to dynamical Jahn-Teller effect.[11] Soon, the strong tendency to formation of Mn^{4+}+Co^{2+} clusters coupled via positive superexchange interaction was suggested upon detailed analysis of susceptibility data.[12] Recent systematic studies performed on samples prepared using different synthesis routes led to the scenario of competition between numerous ferromagnetic (mainly Mn^{3+}-O-Mn^{4+}, Mn^{3+}-O-Mn^{3+} i Co^{2+}-O-Mn^{4+}) and antiferromagnetic (mainly Mn^{4+}-O-Mn^{4+}, Co^{2+}-O-Co^{2+} i Mn^{3+}-O-Co^{2+}) exchange interactions forming a complex ground state, that is strongly dependent on microstructure, ionic ordering, and oxygen stoichiometry.(**Błąd! Nie zdefiniowano zakładki.**)

The goal of research reported in the paper [1] was to determine, which of the above-mentioned interactions is dominant. To answer that question the Mn and Co valence states were systematically probed by means of Mn and Co *K*-edge XANES on the $LaMn_{1-x}Co_xO_3$ series (x=0÷1) obtained from solid state reaction synthesis. An evolution of the Mn and Co valences that vary almost linearly with cobalt doping was observed. A comparison of the spectra of doped compounds with weighted average of the reference spectra suggests that the mixed-valent ions form two interpenetrating sub-systems Co^{2+}+Co^{3+} and Mn^{3+}+Mn^{4+}. Quantitative comparison of the derived average valence states to the magnetic properties of the compounds revealed that at intermediate values of x the transition metal ions are in their high spin states. This surprising result, especially in terms of Co^{3+} spin state, motivated us to perform another experiment, that is reported in the paper [3]. It was performed by means of Kβ XES - a direct method to probe the localized spin moment and effective charge of 3*d* transition metals. The energy and shape of $K\beta_{1,3}$ and $K\beta'$ lines ($3p\rightarrow1s$ decay) is mainly sensitive to the 3*d* spin revealed in multiplet structure due to exchange interaction between the 3*p* hole and the 3*d* orbitals.[13] The measurements performed at room temperature on the same set of samples revealed nonlinear evolution of the effective charges and spin states of Co and Mn. The effective spins, <S>, obtained from XES transformed with x=0→1 as $<S_{Mn}>$=2→3/2 and $<S_{Co}>$=3/2→1/2. Comparison of the latter to charge evolution determined from XANES spectra resulted in conclusion that the Co^{3+} ions persist in low spin configuration for x <0.6. At higher Co content, where the structural phase transition to rhombohedral symmetry is observed, the effective spin of Co^{3+} is raised. These results lead to qualitative explanation of the differences in magnetic properties of the samples synthesized with unlike methods – depending on the microstructure the different relative distribution of Co (low and high spin) and Mn (high spin) ions and their magnetic couplings, thus net moment, is observed. Results of the paper [3] were selected for *ESRF Highlights 2007*.[14]

Recently the same methodology was applied to probe charge and spin distribution in x ~0.5 samples synthetized using sol-gel method. They are dominated by well-ordered Mn^{4+}+Co^{2+} phase (both ions in high spin configurations) of double perovskite structure,

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[10] I.O. Troyanchuk et al., *Magnetic and magnetotransport properties of Co-doped manganites with perovskite structure*, Journal of Magnetism and Magnetic Materials **210**, 63 (2000), DOI:10.1016/S0304-8853(99)00620-4.

[11] J. B. Goodenough et al., *Relationship Between Crystal Symmetry and Magnetic Properties of Ionic Compounds Containing Mn^{3+}*, Physical Review **124**, 373 (1961), DOI:10.1103/PhysRev.124.373.

[12] G. Blasse, *Ferromagnetic interactions in non-metallic perovskites*, Journal of Physics and Chemistry of Solids **26**, 1969 (1965), DOI:10.1016/0022-3697(65)90231-3.

[13] F. de Groot, A. Kotani, *Core Level Spectroscopy of Solids*, (CRC Press, Boca Raton, 2008), ISBN:9781420008425.

[14] M. Sikora et al., *Evolution of charge and spin state of transition metals in the $LaMn_{1-x}Co_xO_3$ perovskite series*, ESRF Highlights 2007, 20 (ESRF, Grenoble, 2008).

which confirms the hypothesis of strong influence of the ionic ordering on the bulk magnetic properties of such a multi-elemental magnetic materials.

The ordered double perovskite structure, $A_2BB'O_6$ (A is alkali metal, while B,B' are transition metals), is usually observed when the ionic radii of B and B' are considerably different – a scenario realized in the series A_2FeReO_6 (A=Ca,Sr,Ba). These compounds are characterized by T_C that is much higher than room temperature as well as half-metallic electronic structure with a finite density of minority spin band at the Fermi level [15] – properties, that are desirable for application in spin electronic devices. Unfortunately, Re-based double perovskites are magnetically hard and reveal large magnetoelastic effects, which wERE attributed to a substantial magnetocrystalline anisotropy due to the anisotropy of an unquenched orbital moment of Re. The aim of the experiments described in the paper [2] was to find out whether a significant Re orbital moment exists in Re–Fe double perovskites and how the lattice distortion influences its value. XMCD spectra measured at Re $L_{2,3}$ edges revealed unusual shape, that was analyzed by means of sum rules,[6,7] that confirmed the hypothesis of large unquenched orbital magnetic moment. It is parallel to the net magnetization of the compound and opposite to Re spin moment. The m_L magnitude is approximately a third part of m_S. The average Re magnetic moment was estimated at m_{Re}~0.75 μ_B/f.u. The magnitude of the orbital contribution increases with the lowering of local symmetry of the compounds, while the effective spin moment of Re scales linearly with Curie temperature, which suggests its high importance in the mechanisms leading to high magnetic ordering temperatures in ferrimagnetic double perovskites.

Soon after publication of the paper [2] the intriguing phenomena were observed in the series $Ca_xSr_{2-x}FeReO_6$. High-field experiments revealed large negative magnetoresistance and magnetostriction that do not saturate at low temperatures up to 45 Tesla. It was attributed to spatial phase separation into two phases of different magnetotransport properties.[16] The relative amount of the two phases was field dependent - a behavior known from manganite perovskites. The purpose of the experiment reported in the paper [4] was to investigate the role played by the Re orbital moment in the mechanism of the structural phase transition in Ca_2FeReO_6 and how it impacts the changes observed in magnetocrystalline anisotropy. To achieve this goal, we studied the magnetic field and temperature evolution of the orbital and spin moments of rhenium by means of XMCD using pulsed high magnetic field installation.[17,18] The measurements were performed at magnetic field up to 30 Tesla in the temperature range 10÷250 K. The temperature dependence of m_L/m_S ratio evidenced that the two phases observed are characterized by different spin-orbit coupling. A gradual increase in the absolute m_L/m_S ratio was attributed to the expansion of the metallic phase that is induced by a strong magnetic field at low temperature. Comparison of the field and temperature dependences of the Re and bulk magnetization[19] revealed that the former one is significantly higher in the insulating phase. This gives evidence that the phase transition is accompanied by the evolution in the population of Re 5d(t_{2g}) orbitals. It was the first XMCD experiment performed under pulsed magnetic field reported in the literature and, therefore, it was selected for *ESRF Highlights*

[15] D. Serrate, J. M. De Teresa, M. R. Ibarra, *Double perovskites with ferromagnetism above room temperature*, J. Phys.: Condens. Matter **19**, 023201 (2007), DOI:10.1088/0953-8984/19/2/023201.

[16] D. Serrate et al., *Colossal magnetoresistance in $Ca_xSr_{2-x}FeReO_6$ double perovskites due to field-induced phase coexistence*, Phys. Rev. B **75**, 165109 (2007), DOI:10.1103/PhysRevB.75.165109.

[17] O. Mathon et al., *XAS and XMCD under high magnetic field and low temperature on the energy-dispersive beamline of the ESRF*, J Synchrotron Rad. **14**, 409 (2007), DOI:10.1107/S0909049507030099.

[18] P. J. E. M. van der Linden at al., *Miniature pulsed magnet system for synchrotron x-ray measurements*, Rev. Sci. Instrum. **79**, 075104 (2008), DOI:10.1063/1.2949873.

[19] J. M. Michalik et al., *Temperature dependence of magnetization under high fields in Re-based double perovskites*, J. Phys.: Condens. Matter **19**, 506206 (2007), DOI:10.1088/0953-8984/19/50/506206.

2009.[20] Measurements of this kind can be routinely performed nowadays at the new branch of ID24 beamline, that is optimized for XAS studies under extreme conditions and equipped with dedicated pulsed electromagnet setup.[21]

In order to perform quantitative analysis of XMCD spectra by means of sum rules the exact value of effective occupancy of (or number of holes in) valence orbitals of probed element must be known. Usually, application of the parameter value as derived from band structure calculations provides a satisfactory agreement of the measured and calculated magnetic moments of 3*d* transition metals in oxides and intermetallics. However, a significant discrepancy is observed in the case of heavy elements, especially 5*d* transition metals. In the case of double perovskites the results of calculations provide the correct distribution of rhenium valence electrons among the 5*d* orbitals, but the integrated occupancy of n_{5d}~4.5[22] is significantly higher than expected by phenomenological model of ferrimagnetic double-exchange-like interaction based on ionic picture (n_{5d} ~ 1÷2). Moreover, the value of Re magnetic moment derived using the calculated occupancy and sum rules applied to the XMCD spectra is significantly lower than the theoretically predicted moment as well as observed by other experimental techniques like neutron diffraction[23] and nuclear magnetic resonance.[24]

Among the possible sources of that discrepancy the most likely seem to be the incorrect values of the input parameters of calculations or an incomplete probing of the delocalized 5*d* orbitals in the resonant absorption at $L_{2,3}$ edges. In order to determine, which of them is more significant, I proposed to performed the research project, which outcomes are described in the paper [6]. The goal was to simultaneously probe occupied and unoccupied 5*d* orbitals of the compounds of the well-known electronic structure by means of X-ray spectroscopy, namely valence band emission upon resonant excitation at $L_{2,3}$ edges (2*p* RXES). The results of experiments were fitted by theoretical spectra generated using simplified Kramers-Heisenberg equation. Satisfactory agreement between experiment and theory was achieved without including core hole–induced multiplet splitting and multielectron transitions. The atomic charges on W and Re atoms in simple oxides obtained using Bader charge analysis were significantly different of expectations of the ionic model, but lower than expectations of the first iteration of calculations, performed with default parameters. At the end of year 2010 I was able to acquire the valence band 2*p* RXES spectra of A_2FeReO_6 samples. Comparative analysis of the spectra with the outcomes of the paper [6] revealed that the Re occupation in double perovskites 'spotted' by $L_{2,3}$-edge X-ray spectra is of the order of n_{5d}~2÷3. Quantitative analysis is in progress. The approach reported in the paper [6] allows the study of the electronic structure near Fermi level in bulk materials with delocalized valence states and large spin-orbit coupling. It provides a powerful tool to study valence band electronic structure of a large number of relevant systems with bulk sensitive hard x-rays. As such it might become an alternative to X-ray photoelectron spectroscopy of 'difficult' systems.

Magnetic moment of rhenium in ordered double perovskites may also be derived by simple subtraction of iron moment from the bulk value. However, the results of application

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[20] M. Sikora et al., *Field-induced magnetostructural phase transition in Ca_2FeReO_6 studied via XMCD under 30T pulsed magnetic field*, ESRF Highlights 2009, 77 (ESRF, Grenoble, 2010).

[21] *UPBL11 Conceptual Design Report, UPBL11: Time resolved and extreme conditions X-ray absorption spectroscopy*, (ESRF, Grenoble, 2009), www.

[22] H. Wu, *Electronic structure study of double perovskites A_2FeReO_6 (A=Ba,Sr,Ca) and Sr_2MMoO_6 (M=Cr,Mn, Fe,Co) by LSDA and LSDA+U*, Phys. Rev. B **64**, 125126 (2001), DOI:10.1103/PhysRevB.64.125126.

[23] K. Oikawa et al., *Structural Distortion on Metal–Insulator Transition in Ordered Double Perovskite Ca_2FeReO_6*, J. Phys. Soc. Jpn. **72**, 1411 (2003), DOI:10.1143/JPSJ.72.1411.

[24] Cz. Kapusta et al., *NMR study of A_2FeMO_6 (A=Ca,Sr,Ba, M=Mo,Re) double perovskites*, J. Magn. Magn. Mater. **272-276**, E1619–E1621 (2004), DOI:10.1016/j.jmmm.2003.12.475.

of Fe $L_{2,3}$-edge XMCD cannot provide unambiguous results[25] due to short probing depth (of ~20 Å)[26] as compared to average grain size. Thus, the comparison to the results of volume magnetometry is not allowed. Probing depth of several microns is achieved at the K-edge, but XMCD signal is much weaker (by almost three orders of magnitude) and the spectra are sensitive to the orbital moment only.[27]

In a quest for a sensitive technique suitable for investigation of magnetic moments of 3*d* transition metals with hard X-rays, I proposed to endeavor detection of magnetic circular dichroism in 1*s*2*p* RIXS – a photon-in photon-out process, that final state is identical to $L_{2,3}$-edge absorption spectra as long as photon-in energy is tuned to the *K* pre-edge region dominated by quadrupole transitions.[28] Preliminary calculations performed for the $3d^5$ ion in the octahedral crystal field predicted a remarkable effect, which was soon confirmed in a pioneer experiment performed on a polycrystalline sample of magnetite at room temperature. The magnitude of the effect, that is close to 15%, is of the order of the XMCD effect observed at L_3-edge. Results of the experiment and the quantitative simulations performed by means of the crystal field multiplet approach are reported in the paper [5]. In this work, also the origin of the high sensitivity of the technique as well as its possible unique applications are discussed, namely the bulk sensitivity and potential site-selective measurements in mixed valence and multisite compounds. The latter properties are desirable for high pressure measurements using diamond anvil cells providing not only spin moment value usually known from *K*β XES,[29] but also information on the orientation of magnetic moments and their coupling. The technique was also described in the reports published in *ESRF Highlights 2010*[30] and *ESRF Spotlight on Science*.[31]

The high resolution emission detection, that is applied for the measurements of RIXS-MCD spectra, is typically utilizing bent crystal analyzers. It offers a strong suppression of the background radiation from other emission lines and scattering channels.[32] Thus, it is possible to explore magnetic ordering of low level dopants and deeply buried thin films. In the paper [7] the results of preliminary experimental assessment of the sensitivity of the technique as a probe of the magnetization of buried thin films is presented. Magnetic field dependence of the spectral features associated with tetrahedral site of iron in thin magnetite layers buried under gold and/or platinum capping layers as well as biased by cobalt was probed. The results obtained prove that 1*s*2*p* RIXS-MCD can be applied as a quantitative probe of element and site specific magnetization. Moreover, it allows for a separation of the

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[25] C. Azimonte et al., *Investigation of the local Fe magnetic moments at the grain boundaries of the Ca_2FeReO_6 double perovskite*, J. Appl. Phys. **101**, 09H115 (2007), DOI:10.1063/1.2714317.

[26] Absorption length of soft X-rays at this photon energy range (E_γ ~ 700 eV) is of the order of 0.5μm. However, $L_{2,3}$-edge spectra acquired in fluorescence yield are strongly distorted due to self-absorption effects - see F. M. F. de Groot et al., *Distortions of X-ray absorption spectra measured with fluorescence yield*, Physica B **208-209**, 84 (1995), DOI:10.1016/0921-4526(94)00638-C. Therefore, for the bulk samples total electron yield detection (of reduced information depth) is routinely used.

[27] G. Y. Guo, *What does the K-edge x-ray magnetic circular dichroism spectrum tell us?*, J. Physics: Cond. Mat. **8**, L747 (1996), DOI:10.1088/0953-8984/8/49/005.

[28] W. A. Caliebe et al., *1s2p resonant inelastic x-ray scattering in α-Fe_2O_3*, Phys. Rev. B **58**, 13452 (1998), DOI:10.1103/PhysRevB.58.13452.

[29] J. Badro et al., *Electronic Transitions in Perovskite: Possible Nonconvecting Layers in the Lower Mantle*, Science **305**, 383 (2004), DOI:10.1126/science.1098840.

[30] M. Sikora et al., *Strong K-edge magnetic circular dichroism in 1s2p RIXS*, ESRF Highlights 2010, 18 (ESRF, Grenoble, 2011).

[31] *Strong K-edge magnetic circular dichroism observed in photon-in/photon-out spectroscopy*, ESRF Spotlight on Science **118**, (ESRF, Grenoble, 2010).

[32] Signal-to-background ratio of the spectra acquired with bent crystal analyzers is related to the intensity of the Bragg peak of given indexes. It is possible to further increase the sensitivity of the technique using grazing emission detection. See e.g. J. Szlachetko et al., *Application of the high-resolution grazing-emission x-ray fluorescence method for impurities control in semiconductor nanotechnology*, J. Appl. Phys. 105, 086101 (2009), DOI:10.1063/1.3086658.

signals that origin from metallic and oxide layers of the same element. Thus it may be applied for a systematic magnetic characterization of complex multilayer systems, for instance the spintronics devices.

Besides the application of X-ray spectroscopy to the exploration of the element selective magnetic properties of complex oxides and multilayer systems, that are mentioned in the previous paragraphs, the outcome of the research papers presented do contribute to the development and promotion of high resolution X-ray emission spectroscopy as well as to better understanding of the microscopic mechanisms of exchange interactions and their competition. I hope that the experience acquired while performing these research projects will be useful for design and construction of experimental stations at polish synchrotron as well as for investigations to be performed there.

5. Other scientific achievements.

I started high profile research activity in the Spring of the year 1997, when Professor Czesław Kapusta invited me, a 6th semester student, to perform experiments in the nuclear magnetic resonance laboratory of AGH. Over the next six years I was involved in the research of hard permanent magnets of the Nd_2Fe_{17} type as well as colossal magnetoresistive (CMR) manganese oxides, especially in terms of the phase segregation phenomena. Over these years I co-authored several manuscripts, among them one published in *Physical Review Letter*, one in *Journal of the American Chemical Society* and two in *Physical Review B*.

Also in the year 1997 I did participate in my first synchrotron experiment. It was an XMCD session performed at Hasylab/DESY in collaboration with the research group of Professor Gisela Schütz from Würzburg University. Since, the mainstream of my research activity is associated with X-ray spectroscopy. Both, my master thesis (1999) and my PhD thesis (2002) were devoted to the magnetic phase segregation in the CMR compounds of the $La_{2/3-y}RE_yCa_{1/3}MnO_3$ perovskite series.

In the year 1999 I participated in the *DESY Summer Students Program* contributing to the activity of the research group of Dr Jacek Krzywiński from Instytute of Physics of the Polish Academy of Science, that constructed the experimental chamber for the investigation of ablation process using the *Tesla Test Facility* free electron laser. I collaborated with that group over the next two years working on simulations of the ablation process as well as on the software for experiment control and data acquisition. As a result of this activity I co-authored two FEL Conference Proceedings and one paper published in *Review of Scientific Instruments*.

After PhD viva, in the years 2002-2005, I was involved in the activity of the FP5 *SCOOTMO Research Training Network*. At first I was responsible for synchrotron projects and training of the young scientists visiting Kraków on the X-ray spectroscopy techniques. I was also contributing to the magnetic resonance activity of the group. Then, in the year 2004, I left for Zaragoza for one year Post-Doc fellowship at *Instituto de Ciencia de Materiales de Aragon* (ICMA-CSIC), where I was working in the group of Professor Ricardo Ibarra. The activity there involved characterization of the structural and magnetic properties of single crystalline YVO_3 i $HoVO_3$ by means of thermal expansion, magnetisation and magnetostriction under pulsed magnetic fields.

From March 2005 until December 2008 I was hired as Post-Doc and Junior Scientist in the group of Dr Pieter Glatzel (beamline ID26) at European Synchrotron Radiation Facility in Grenoble. My activity there was devoted to development of the high resolution X-ray spectroscopy techniques and their application to the investigation of:

- local order and phase transitions in magnetic materials,
- microstructure of coating materials for nuclear fusion reactors,
- local structure and magnetic interactions in molecular magnets,
- microstructure and charge distribution in metallo-organic complexes,

- electrochemical and catalytic processes,
- microstructure of minerals,
- morphology of magnetic thin films and nanoparticles.

I am still involved in many of these projects, that are performed under close collaboration with the scientists from Poland, France, Germany, Spain, Czech Republic, United Kingdom, The Netherlands, Russia, Belorussia, Austria, Switzerland and USA. As a result of common research projects a tens of papers were published, for instance in *Physical Review Letters*, *Physical Review B*, *Journal of Physical Chemistry B* i *C*, *Electrochimica Acta*, *Nanotechnology*, *Catalysis Today*, *Journal of Analytical Atomic Spectrometry* oraz *Journal of Synchrotron Radiation*.

Within my scientific career I co-authored 64 papers listed in *Web of Science*, that were citated 440 times. Total *impact factor* is about 154 and Hirsch index is equal to 12.[33]

I was a project leader of fourteen projects performed at synchrotron radiation facilities (one at BESSY II in Berlin, one at Elettra in Triest, four *user* and eight *in-house* projects at ESRF in Grenoble). Moreover, I was the co-proposer of fifteen other synchrotron projects (performed at BESSY II, Elettra, ESRF, Hasylab/DESY and SLS/PSI in Villigen) as well as one research project at high pulsed magnetic field laboratory (LNCMP) in Toulouse.

I was team member within three european grants: *PHIL (Polarised 3He for Imaging of Lungs)*, 5FP (2000-2004); *RTN SCOOTMO (Spin Charge and Orbital Ordering in Transition Metal Oxides)*, 5FP (2002-2005); *MUNDIS (Competitive contact-less position sensor based on magnetoresistive nano-contacts)*, 6FP (2005-2008).

Currently I lead the Polish Ministry of Science and Higher Education grant N202 071539 and work as R&D coordinator of the grant POIG.02.01.00-12-001/09-00 (*Academic Center of Materials and Nanotechnology AGH*). I was also a team member in the grant 2 P03B 082 23 of the State Committee for Scientific Research Poland (2002-2005).

I am laureate of the 9th edition of POLITYKA's *Zostańcie z nami* scholarship (2009) and the laureate of the outstanding young researchers scholarship from Minister of Science and Higher Education of Poland (2010-2013)

I reported the results of my research in the form of oral presentation during 23 conferences and workshops. Among them I gave five invited talks:

- *Field induced phase transition in Ca_2FeReO_6 double perovskite: an XMCD study in 30T pulsed magnetic field*, EDXAS Workshop, Grenoble, February 2009,
- *Study of magnetism with XMCD and XES* (in Polish), VIII KSUPS, Podlesice, September 2009,
- *Magnetic circular dichroism in resonant inelastic X-ray scattering and under high pulsed magnetic field*, XFEL Workshop, Budapest, December 2009,
- *Spin and orbital magnetic moments in magnetic double perovskites probed by X-ray magnetic circular dichroism under high magnetic fields*, CIMTEC 2010, Montecatini, June 2010,
- *Strong K-edge magnetic circular dichroism in 1s2p RIXS*, ESRF Users Meeting 2011, Grenoble, February 2011.

My recent activity is still focused on the investigation of magnetic properties of complex oxides (core/shell nanoparticles and composites) as well as on the application of 1*s*2*p* RIXS-MCD to the new class of materials. Moreover, I collaborate in the investigation of magnetic properties of adatoms on the surface of topological insulators and in the studies of valence band electronic structure of photocatalysts derived from TiO_2 and WO_x.

Marcin Sikora

[33] Impact factors of the year of publication were used for calculation of the total impact factor. In the case of papers published in 2012 the value of *JCR Science Edition 2011* was used. Citation metrics were obtained from *Web of Science* on 26 June 2012. The most up-to-date are available at *ResearcherID.com* (F-9998-2010).