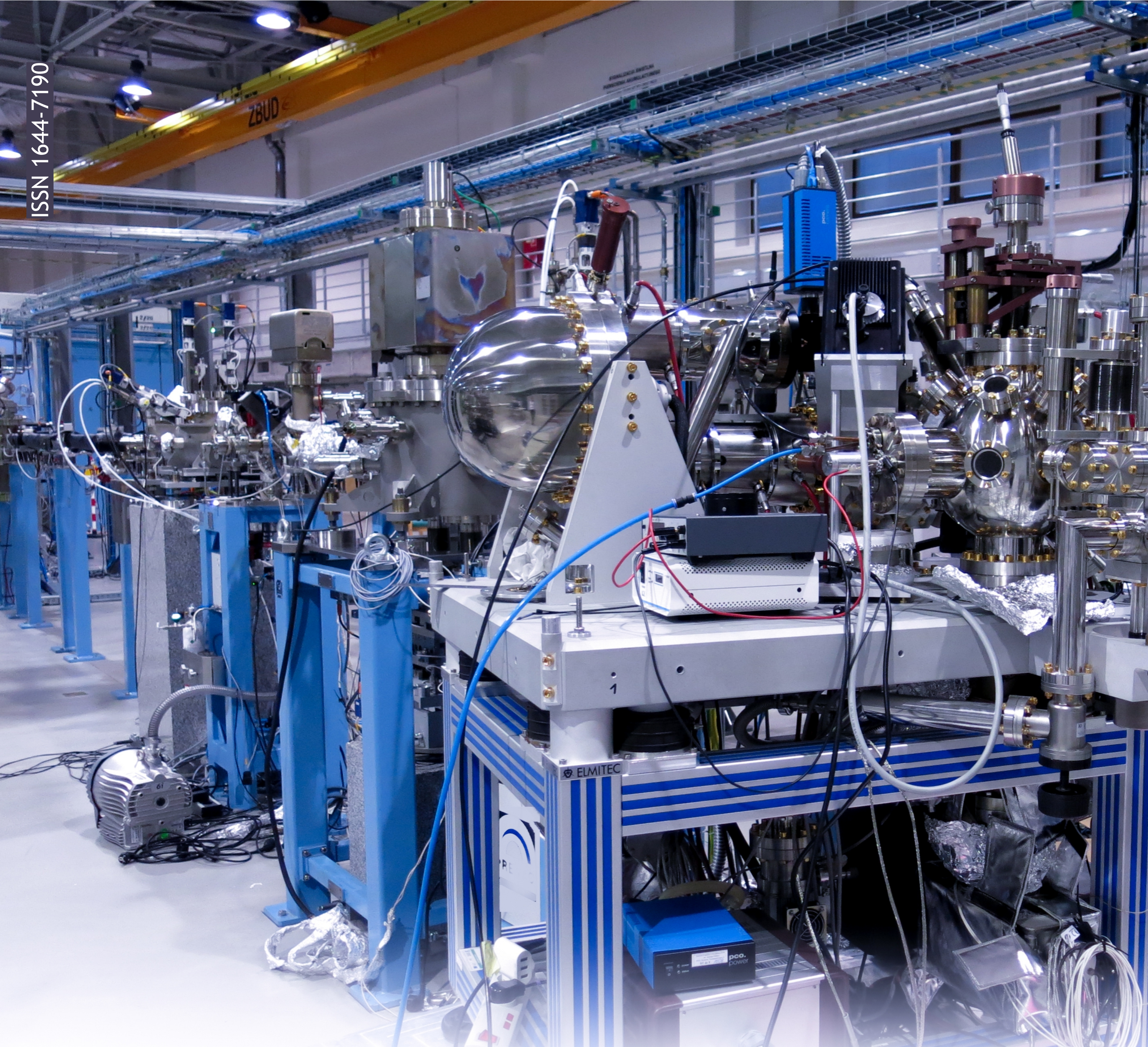
ISSN 1644-7190



Bulletin of Polish Synchrotron Radiation Society
Vol. 19, May 2020

SYNCHROTRON RADIATION IN NATURAL SCIENCE

Dear Readers,

On behalf of the Editorial Team, it is my pleasure to deliver a remastered issue of Synchrotron Radiation in Natural Science. Since the year 2002 Polish Synchrotron Radiation Society publishes the journal with content covering recent developments in instrumentation related to synchrotron radiation and X-ray Free Electron Laser sources. It also provides a forum for reporting the most recent achievements in fundamental and applied research, such as novel applications in physics, chemistry, materials science, biology, and medicine.

The release of the recent issue aims at enhancing the platform for knowledge exchange within Polish as well as the international scientific community. Our objective is to deliver bi-yearly issues with short scientific reports and flash-like news from synchrotron and related sources. We were focused on enhancing complementarity between scientific reports and popular science news, all enclosed in a compact and refreshed appearance. We would like to introduce to readers the current edition with the hope that the present issue will be regarded as a valuable and complementary alternative option to the other scientific journals.

On behalf of Editorial Team,

Editor-In-Chief
Jakub Szlachetko
jakub.szlachetko@ifj.edu.pl
Institute of Nuclear Physics
Polish Academy of Sciences
Radzikowskiego 152
31-342 Kraków, Poland

Editorial board

Layout and cover design by Z. Piertalik-Molińska and A. Moliński

Cover photo PEEM RESEARCH STATION IN THE SOLARIS SYNCHROTRON by A. Chrześcijanek

ISSN 1644-7190

Synchrotron Radiation in Natural Science

Synchrotron Radiation in Natural Science **19**, 1-4 (2020)

The soft X-rays spectroscopy beamline at the National Synchrotron Radiation Centre Solaris

M. Zając[1]*, T. Giela[1], K. Freindl[2], J. Korecki[2,3], E. Madej[2], M. Sikora[4], N. Spiridis[2], M. Stankiewicz[1], J. Stępień[4], J. Szade[1], M. Ślęzak[3], T. Ślęzak[3], D. Wilgocka-Ślęzak[2]

[1]*National Synchrotron Radiation Centre Solaris, Jagiellonian University, 30-392 Kraków, Poland*
[2]*Jerzy Haber Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences, 30-239 Kraków, Poland*
[3]*AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, 30-059 Kraków, Poland*
[4]*AGH University of Science and Technology, Academic Centre for Materials and Nanotechnology, 30-055 Kraków, Poland*

*e-mail: mar.zajac@uj.edu.pl

DOI:10.36184/SRNS.2020.19.001
Received: 07 April 2020
Published: 13 May 2020
PACS/topics: synchrotron radiation, beamline, soft X-ray spectroscopy

The recently commissioned national synchrotron source in Poland has opened the possibility for comprehensive sample characterization in the soft X-ray photon energy regime. The PEEM/XAS beamline dedicated both for spectroscopy and microscopy offers two well-equipped end stations in the UHV standard that enable advanced sample preparation and synchrotron experiments in divers sample environments.

Introduction

The bending magnet (04BM) PEEM/XAS beamline has been constructed and operates at the National Synchrotron Radiation Centre Solaris. It is dedicated to microscopy and spectroscopy in the absorption of soft X-rays. The beamline is equipped with two end stations: a photoemission electron microscope (PEEM), and a universal station for X-ray absorption spectroscopy (XAS)[1]. The beamline is designed to study chemical and electronic, structural and magnetic properties exploiting X-ray absorption spectroscopy (XAS) with polarized X-ray: X-ray natural linear dichroism (XNLD), X-ray magnetic circular dichroism (XMCD) and X-ray magnetic linear dichroism (XMLD). The methods are suitable for probing element-specific properties of surfaces, interfaces, thin films and nanomaterials. The photon energy range (200–2000 eV) covers the absorption K edges for light elements, from carbon to silicon, L edges of elements with Z between 20 and 40, including 3d elements, and also M edges of many heavier atoms, including 4f elements.

The beamline parameters

The optical design of the beamline based on the plane grating monochromator working in the collimated light (cPGM) has been optimized for the soft X-ray photon energy range. The optical concept used is common at other facilities and gives the opportunity to reduce the contribution from the higher-order radiation and to optimize flux versus energy resolution during the experiment. The cPGM is equipped with two gratings to obtain energy resolution (ΔE/E) in the order of 2.5×10^{-4} or better in the accessible energy range and for the available linear horizontal and elliptical left and right polarizations. A summary of the beamline parameters is shown in Table 1.

The PEEM/XAS beamline is operated under the cooperation of Solaris with the Jerzy Haber Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences and the AGH University of Science and Technology. The consortium partners are involved in the beamline operation and take care of the beamline development.

Source	Bending magnet (1.31 T)
Available (optimal) energy range	150–2000 eV (250–1700 eV)
Energy resolution ΔE/E	2.5 x 10^{-4} and better
Beam size at sample (H x V) [mm x mm]	At PEEM: 0.200 x 0.050 At XAS: 2.5 x 2.5
Photon flux at sample	10^9 – 10^{10} [ph/s/0.1 A]
Polarization	Linear (horizontal) and elliptical
The photoemission electron microscope	XPEEM, µ-XAS, µ-XPS, variable sample temperature (100 - 1200 K)
The X-ray absorption spectroscopy chamber	The XAS, XMCD, XMLD in applied field (200 mT) and variable sample temperature (20 - 660 K)

Table 1. The summarized main beamline parameters, as determined during commissioning.

The PEEM end station

The PEEM instrument (PEEM III with energy analyzer from ELMITEC Elektronenmikroskopie GmbH) is an electron microscope that uses low energy electrons emitted from a sample after excitation with photons to form an image with a spatial (lateral) resolution of a few dozen nanometres. With a tunable X-ray source (XPEEM), elemental sensitivity is accomplished by tuning of the exciting photon energy to the absorption edge of the studied element. In this case, secondary electrons are efficiently used to form an image. Alternatively, with the energy analyzer the excited photoelectrons can be energy-selected, which gives the additional image contrast (also chemical) resulting from characteristic electron binding energies, in analogy to X-ray photoelectron spectroscopy (XPS). Magnetic domain structure is accessible with polarized photons using XMCD or XMLD effects. By taking image series as a function of energy, spectroscopic information can be retrieved with a spatial resolution of the image (micro-spectroscopy: µ-XAS and µ-XPS). Another way to accomplish µ-XPS is to use the dispersive properties of the energy analyzer, so that a photoemission spectrum in the energy bandwidth of approximately 10 eV can be taken in a single shot from a preselected micrometre-sized sample area.

The PEEM end station is a fully equipped “surface science laboratory”. It includes a load-lock and an entrance chamber for a fast sample transfer from air into the ultrahigh vacuum (UHV) environment, a preparation chamber, the main microscopic chamber. The preparation chamber includes LEED and Auger spectrometers, several evaporation sources, an ion sputtering source, and a gas dosing system. An additional evaporation source is mounted in the main chamber for real-time microscopy during the deposition.

When planning your XPEEM experiment, consider that:

- Samples must be UHV compatible, flat and should not charge under illumination;
- Samples must fit a sample holder that limits their dimensions to 14 mm in diameter and 3 mm in height;
- Typical information depth is a few nm;
- Typical image acquisition time can vary from the video rate to hours;
- Accessible field of view is from 1.5 to 150 µm;
- Available temperature is from 120 K to 1200 K (imaging) or from 300 K to 2200 K (preparation).

An example of the XPEEM application is shown in Fig. 1. An epitaxial (111)-oriented magnetite film, 10 nm thick, was grown in the preparation chamber by reactive deposition of iron on a Pt(111) single crystal. Then the sample kept at the preparation temperature of 250°C was exposed for half an hour to molecular oxygen at 8*10^{-6} mbar. The following XPEEM analysis revealed a chemically inhomogeneous surface with dendritically spreading hematite embedded in the magnetite matrix. The both phases are distinct in respect of magnetic properties, as shown in the XMCD image in Fig. 2c; sub-micrometre magnetic domains are characteristic for ferromagnetic magnetite, whereas antiferromagnetic hematite does not reveal any XMCD contrast.

The XAS end station

The XAS in the soft X-ray energy range is often termed NEXAFS (Near Edge X-Ray Absorption Fine Structure). This spectroscopy provides element and chemical specificity, as well as sensitivity to polarization effects related to magnetic and crystal structure of the materials by means of XMCD and XMLD effects. The main signal detection mode is total electron yield (TEY) realized by measurement of the sample drain current. For low-conductive samples two other modes are available - the partial electron yield detection using electron multiplier (channeltron) and a fluorescence detection realized with the use of silicon drift detector type. The XAS end station is a two-chamber UHV system equipped one chamber for spectroscopy and another one for preparation. It features:

- Sample (powder or bulk) stations fitting a standard flag-style sample holder (so-called "Omicron plate");
- Beam spot on the sample (h x v): 2.5x2.5 mm^2; may be reduced using slits;
- High vacuum or UHV sample environment;
- Spectroscopic measurements in a broad temperature range of 20–660 K and external magnetic field of 0–2 kOe; sample rotation about the vertical axis;
- Fully equipped preparation chamber (comparable to that of the PEEM end station).

Results of three accomplished experiments is presented in this section. The recently explained antiferromagnet (AFM)/ferromagnet (FM) magnetic moment structure in an exchange bias CoO/Fe(110) system[2] is the first example. It was proved that the FM layer with strong uniaxial magnetic anisotropy determines the interfacial spin orientations of the neighbouring AFM layer and rotates its easy axis. The following successful study aims at determining the structure of conduction band of a TiO_2 based system. Figure 2 shows the Ti L-edge and O K-edge XAS spectra collected for metal titanium disc (before and after sputtering of Ti disc) and Ti disc thermally oxidized at 800°C. In the measured Ti XAS spectra, two main regions attributed to the dipolar excitations of $2p_{3/2}$ electron (L_3-edge) and $2p_{1/2}$ electron (L_2-edge) into unoccupied Ti 3d states are observed. The difference between the spectra of metallic titanium and oxidized Ti-species lies in the edge shift and spectral shape change. As the metal surfaces relatively easily undergo oxidation in an ambient environment with the depth of the oxide layer in the range of few to tens of nanometers, the ability of surface sputtering is of importance for measurements of reference metal materials. The unprocessed sample shows a clear Ti-oxide signal that vanishes after 3h of sample sputtering.

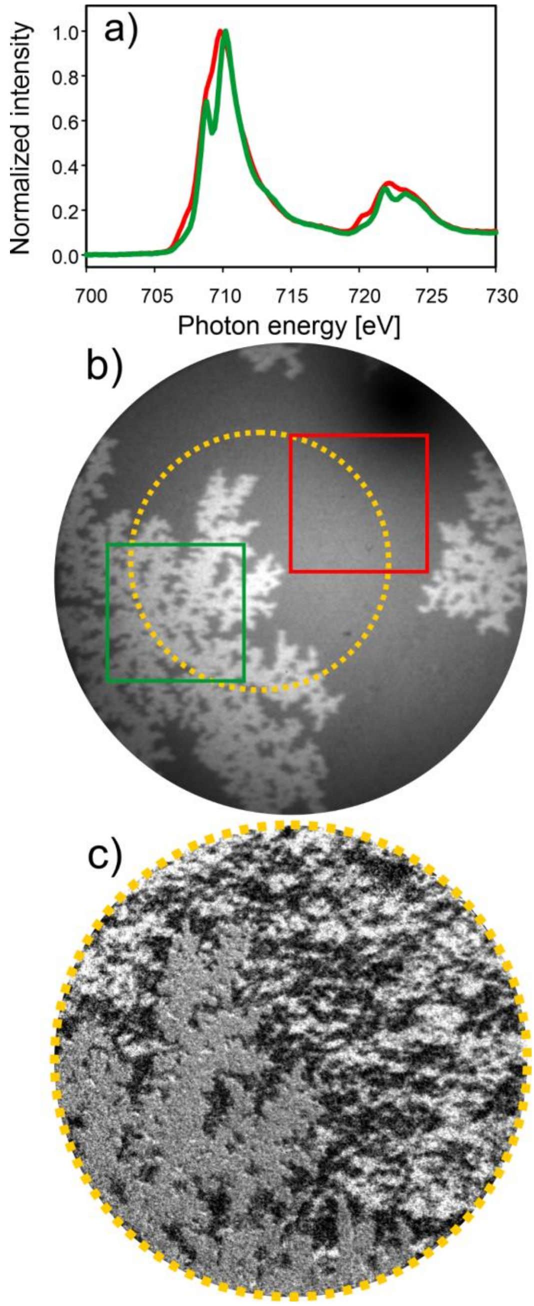


Fig. 1. XPEEM analysis of an epitaxial magnetite 10-nm Fe_3O_4(111) film on Pt(111) that was partially oxidized by exposing *in situ* to an oxygen dose of app. 10^4 langmuir at 250°C: a) selected-area XAS spectra that expose magnetite (red) and hematite (green) stoichiometry. The spectra were collected on the colour-corresponding squared areas marked in an XPEEM image (b), FoV 20 μm, taken at an X-ray energy of 710 eV. c) XMCD image at 708.5 eV of a selected area (FoV 10 μm), marked yellow in (b).

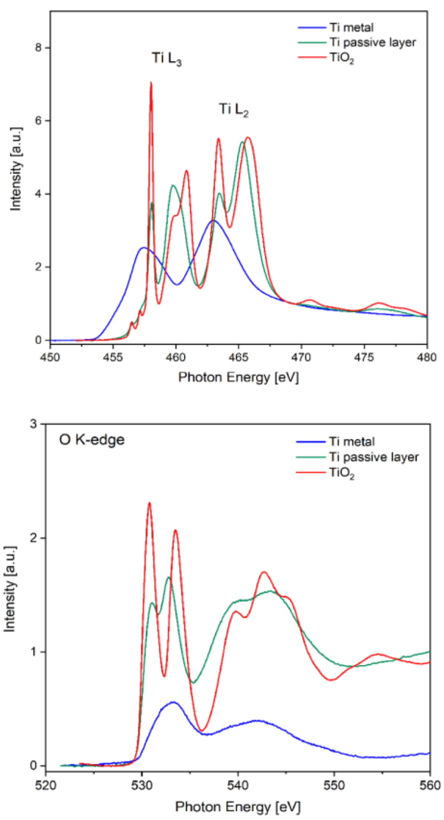


Fig. 2. Example of application. The Ti L-edge and O K-edge XAS spectra collected for TiO_2 based system (courtesy of Dr A. Wach, INP PAN, Kraków).

Multiplet effects revealed in XAS is often used as a fingerprint of the local structure of ions in semiconductors. For instance, it shows that Mn dopants in InSb nanowires produced by pulse electrodeposition, have a strong tendency to clustering, which results in ferromagnetic response at room temperature[3]. Even more subtle structural effects can be probed if polarization analysis is involved, for instance in the experiments performed on anisotropic monocrystals. The difference between XAS probed at two distinct orientations between linearly polarized incident photons and main crystal axes, which is often termed as XNLD (X-ray natural linear dichroism), may be used to assess the evolution of structural distortions. Such an experiment performed on a single crystal of Bi_2Te_3 shows the evolution of surface atomic structure *in-situ* upon Au deposition (Fig. 3). Local anisotropy of surface Te ions, revealed in strong XNLD oscillation beyond Te M_{45} edge, is enhanced at, a low thickness (up to 5 monolayers) and relaxed at thicker Au cap layers. Robustness of the surface structure is a prerequisite for the preservation of topological insulator properties of Bi_2Te_3.

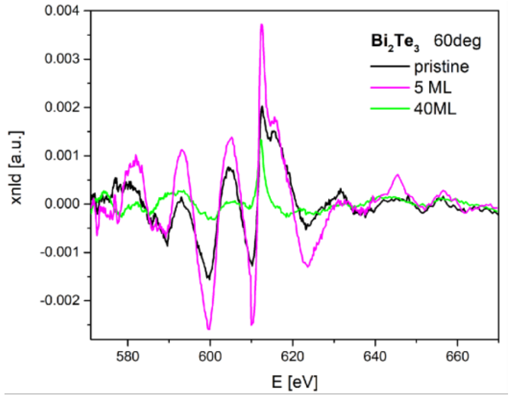


Fig. 3. XNLD at Te M_{45} edge collected from pristine and Au covered Bi_2Te_3 single crystal. The amplitude of the oscillations is a measure of anisotropy in the local structure of surface Te.

Summary

The PEEM/XAS beamline is fully operational and available for users at the National Synchrotron Radiation Centre Solaris. The experimental setup is dedicated for soft X-ray spectroscopy and microscopy. Moreover, the two available end stations provide separate chambers for the state-of-the-art surface preparation and characteri-zation. The access to the Solaris infrastructure is open for the users via Solaris' or CERIC's call for proposals[4].

Acknowledgements: Authors would like to thank A. Bianco, E. Busetto and I. Cudin from Synchrotron Elettra, Trieste for beamline optical design optimization and support during the design period.

References

1. The PEEM/XAS beamline: https://synchrotron.uj.edu.pl/en_GB/linie-badawcze/peem-xas
2. Ślęzak, M. et al. How a ferromagnet drives an antiferromagnet in exchange biased CoO/Fe(110) bilayers. Sci. Rep. **9**, 889 (2019).
3. Hnida, K. E., Żywczak, A., Sikora, M., Marciszko, M. & Przybylski, M. Room-Temperature Ferromagnetism in InSb-Mn Nanowires. *Nano Lett.* **19**, 7144–7148 (2019).
4. Solaris' call: https://synchrotron.uj.edu.pl/en_GB/uzytkownicy/nabory-wnioskow
   Ceric's call: https://www.ceric-eric.eu/users/call-for-proposals/

Synchrotron Radiation in Natural Science **19**, 5-7 (2020)

Laboratory for high energy resolution X-ray spectroscopy at the Institute of Nuclear Physics of the Polish Academy of Sciences

W. Błachucki[1]*, A. Wach[1], J. Czapla-Masztafiak[1], W. Kwiatek[1], J. Szlachetko[1]

[1]*Institute of Nuclear Physics, Polish Academy of Sciences, 31-342 Kraków, Poland*
*e-mail: wojciech.blachucki@ifj.edu.pl, wojciech.kwiatek@ifj.edu.pl, jakub.szlachetko@ifj.edu.pl

DOI:10.36184/SRNS.2020.19.005
Received: 25 March 2020
Published: 13 May 2020
PACS/topics: laboratory X-ray spectroscopy, von Hámos X-ray spectrometer, liquid jet target

The technological progress in the X-ray instrumentation made nowadays possible the development of efficient laboratory X-ray spectroscopy setups. The new excitation sources, optics and detectors allow constructing cost-effective and robust X-ray spectroscopy stations which, unlike large-scale facilities where the access is infrequent and not guaranteed *a priori*, are permanently available enabling the realization of entire research projects as well as giving more flexibility in the preparation of experiments at synchrotrons and X-ray free-electron lasers. At the Institute of Nuclear Physics of the Polish Academy of Sciences a new X-ray laboratory has been opened.

Introduction

The Department of Applied Spectroscopy (NZ53) has been recently established at the Institute of Nuclear Physics of the Polish Academy of Sciences. It covers well-equipped chemistry and biology laboratories, an X-ray laboratory specialized in the application of X-ray absorption and emission spectroscopy (XAS/XES) [1,2], X-ray microscopy and tomography setups as well as a particle-induced X-ray emission (PIXE) facility. The experimental setups and supporting preparation laboratories are commonly employed in research devoted to both fundamental and applied research. Particularly, high energy resolution X-ray spectroscopy methods are a part of the department's in-house activity and are focused on *in-situ* time-resolved X-ray studies on electron dynamics of atoms and molecules and in particular surveying the role of metals in biological complexes, photo-chemical systems and materials important for renewable energy.

X-ray spectroscopy laboratory

The X-ray lab's equipment is split into two independent X-ray hutches (10 m^2 each) located close to each other. The rooms' walls are shielded with a 5 mm-thick lead layer and the access to them is through shielded sliding doors. Each room has a heavy-duty optical table where the experiments are carried out and are well equipped with all the equipment arranged in lab cabinets as well as movable racks which makes the lab works very flexible. The X-ray hutches have interlock safety systems installed which prevent applying a high voltage on the X-ray tubes without prior safety check (confirmed with a badge reader by the room entrance) and disconnects the X-ray tubes' power supplies whenever the door is open while the X-rays are on.

Von Hámos spectrometers

The X-ray equipment allows setting up two in-air crystal X-ray spectrometers in the von Hámos geometry[3] (see Fig. 1). In this geometry the measured X-ray beam first falls on an analyzing crystal which, as described by the Bragg's diffraction law, diffracts at different angles photons of different energies. Thus spatially dispersed radiation beam reaches a positon-sensitive X-ray detector, such as a charge-coupled device (CCD), whereas photons of different energies fall on the detector at different channels or pixels along the dispersion axis. Fig. 1 shows an exemplary arrangement of spectrometers sharing one X-ray source[4]. In this arrangement the unit collinear with the excitation beam captures the radiation exiting the X-ray tube and, with the sample in the beam focal point, the radiation transmitted through it, thus allowing measurement of absorption spectra. Simultaneously, the unit placed aside records spectra of the radiation emitted in fluorescence induced in the sample by the excitation beam.

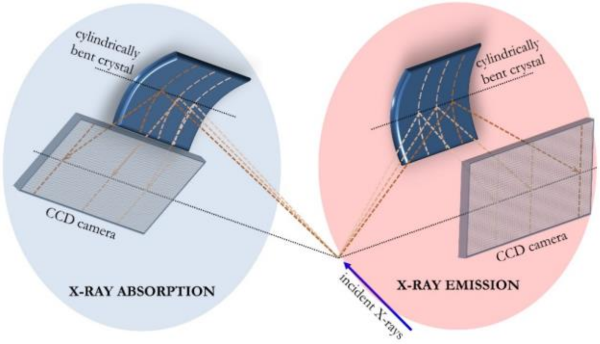


Fig. 1. Scheme of two von Hámos spectrometers sharing the same excitation X-ray source. In this arrangement one spectrometer measures the X-ray absorption spectrum and other measures simultaneously the X-ray emission spectrum.

In the X-ray lab available are 2 X-ray tubes XOS X-Beam Superflux PF, 2 X-ray cameras Andor Newton 920 and a number of different cylindrically bent X-ray crystals. The X-ray tubes are equipped with Mo anodes and polycapillary optics focusing the exit beam to the divergence of about 3°. The sources can operate at the maximum voltage and current of 30 kV and 1 mA, respectively, and are cooled with an integrated fan. The X-ray cameras are based on front-illuminated CCDs composed of 1024 × 256 26 μm-sized pixels. The cameras have 250 μm-thick Be windows and are vacuum sealed which allows cooling the sensors down to -70 °C with the integrated thermoelectric coolers. The use of the front-illuminated type sensor allows for energy discrimination of X-rays falling onto the detector, and thus resolving different diffraction orders given by the X-ray crystal used. The available X-ray crystals' cuts are: Si(111), Si(110), Si(100), Si(310), Si(531). Some of the crystals[5] are bent to a radius of 25cm and others are segmented and glued on a curved frame with the radius of curvature of 25 cm. Each spectrometer can be adjusted to measure radiation in the energy range ~ 5 – 12 keV covering ~ 50 – 200 eV during one measurement at the relative energy resolution of ~ 1 – 2 ×10^{4}.

The available equipment gives large flexibility in the preparation of experiments. For example, the spectrometers can be arranged not only independently, as two separate setups, but can share the same X-ray source, thus allowing simultaneous XAS and XES measurements[4] or two XES measurements in different energy domains (the so-called *two-color mode*). Also, the spectrometers can be oriented horizontally or vertically according to the specific needs of an experiment, as e. g. in XES measurements on liquid jet target the jet wiggling strongly affects the data collected with the horizontally aligned spectrometer but it has no observable effect on the data recorded with the vertical orientation.

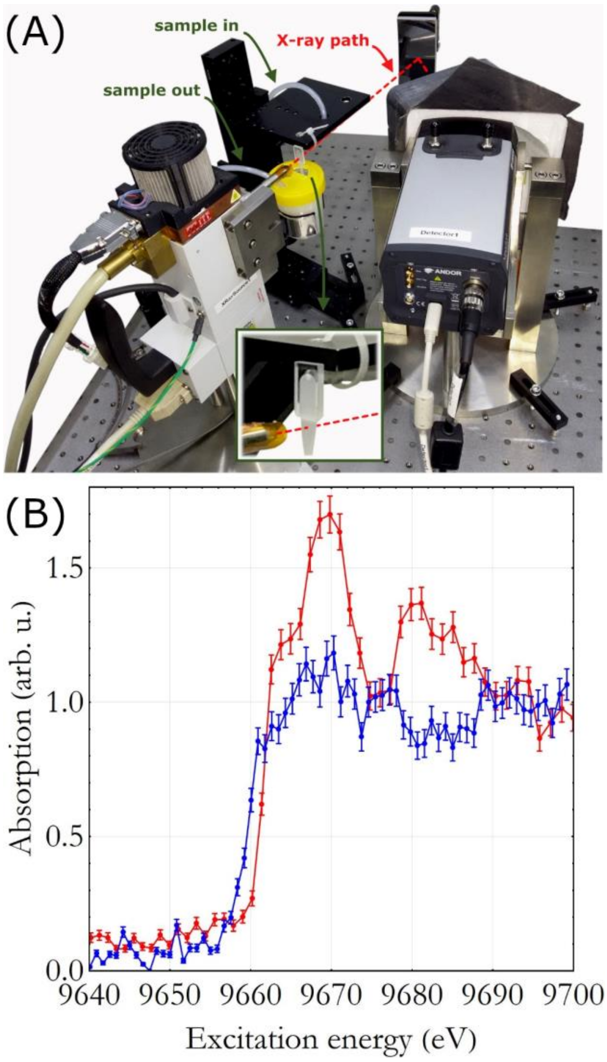


Fig. 2. (A) View on the experimental setup used. The X-ray tube was operated at the voltage of 30 kV and the current of 0.9 mA. (B) The Zn *K*-edge XAS spectra measured for the ZnO aqueous solution in the form of a jet (red) and for a Zn metal foil (blue).

Liquid jet sample delivery system

One of the recent activities in the lab has been the development of a liquid jet sample delivery system Fig. 2(A). We connected a plastic nozzle to a micro-gear pump through a supply tube. The liquid after exiting the nozzle flew through the X-ray beam and was collected by a catcher and sucked back to the circuit through another tube. The nozzle was fixed to a platform equipped with two linear stepper motors capable of positioning the target spot with micrometer precision. The jet was irradiated horizontally in its middle and vertically just below the nozzle's exit. Lead shielding was applied to the detector to diminish the contribution of the scattered photons to the recorded signal.

We tested the jet sample system during Zn *K*-edge XAS measurement on 1 M aqueous solution of ZnO nanoparticles with the jet thickness of 0.5 mm. The measured spectrum is shown in Fig. 2(B). Because of the sharing of valence Zn electrons to the bonding with O, Zn oxidation state increases and in consequence the *K*-edge binding is increased resulting in the shift of Zn *K*-edge XAS spectrum towards higher energy as compared to the spectrum measured for Zn metal. The stronger white line in the ZnO spectrum reflects the higher unoccupancy of the Zn valence states due to chemical bonding.

Summary

Laboratory for X-ray spectroscopy is available at the Institute of Nuclear Physics of the Polish Academy of Sciences. It serves in applied X-ray absorption and X-ray emission measurements on complex samples both in chemistry and biology. The lab is used in the realization of entire research projects and also provides an excellent workspace for the preparation of experiments at synchrotrons and X-ray free-electron lasers.

Acknowledgements: This work was supported by the National Science Centre (Poland) under grant numbers 2017/27/B/ST2/01890, 2016/21/D/ST4/00378, 2019/03/X/ST3/00035, and 2019/03/X/ST2/00949.

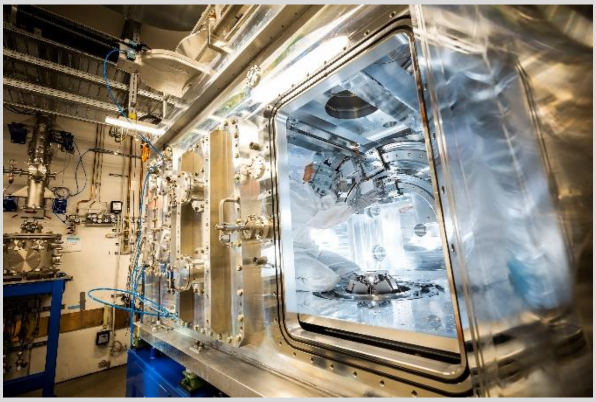
References

1. Yano, J. & Yachandra, V. K. X-ray absorption spectroscopy. *Photosynth. Res.* **102**, 241–254 (2009).
2. Bergmann, U. & Glatzel, P. X-ray emission spectroscopy. *Photosynth. Res.* **102**, 255–266 (2009).
3. v. Hámos, L. Röntgenspektroskopie und Abbildung mittels gekrümmter Kristallreflektoren. *Naturwissenschaften* **20**, 705–706 (1932).
4. Błachucki, W., Czapla-Masztafiak, J., Sá, J. & Szlachetko, J. A laboratory-based double X-ray spectrometer for simultaneous X-ray emission and X-ray absorption studies. *J. Anal. At. Spectrom.* **34**, 1409–1415 (2019).
5. Szlachetko, J. *et al.* A von Hamos x-ray spectrometer based on a segmented-type diffraction crystal for single-shot x-ray emission spectroscopy and time-resolved resonant inelastic x-ray scattering studies. *Rev. Sci. Instrum.* **83**, 103105 (2012).

SCIENTIFIC HIGHLIGHTS

Super laser delivered to European XFEL

The European XFEL is a 3.4 km long X-ray Free Electron Laser that generates extremely intense (>10^{12} photons per pulse and up to 27000 pulses per second) and ultrashort (<100 fs) X-ray flashes. The X-ray pulses are produced in underground tunnels and allow researchers from all over the world to map atomic details of viruses, film chemical reactions, and study the processes in the interior of planets. At present, a long-awaited piece of high-tech equipment has been delivered to European XFEL, namely the high repetition rate, high-energy laser DiPOLE 100-X. This unique laser, developed by scientists and engineers at the Science and Technology Facilities Council's Central Laser Facility (CFL, UK), will be used at the instrument for High-Energy Density (HED) science at European XFEL to generate extreme temperatures and pressures in materials. The High Energy Density (HED) scientific instrument is a unique platform for experiments combining hard X-ray FEL radiation and the capability to generate matter under extreme conditions of pressure, temperature or electric field using the FEL, high energy optical lasers, or pulsed magnets. Major science applications at the HED instrument include high-pressure planetary physics, warm- and hot- dense matter, laser-induced relativistic plasmas and complex solids in pulsed magnetic fields. Thanks to the unique combination of DiPOLE laser radiation with the XFEL beam it will be possible to transform laboratory astrophysics and the study of matter in extreme conditions. This experimental set-up will enable scientists to create conditions similar to the interior of exoplanets with temperatures of up to 10 000°C, and pressures of up to 10 000 tons per square centimetre. DiPOLE's high repetition rate will deliver a step-change in the speed of data collection, producing orders of magnitude improvements in the accuracy of measurements and the ability to detect previously unobservable effects.



The High-Energy Density (HED) instrument at European XFEL. Copyright: European XFEL/Jan Hosan

Read more on the European XFEL website:
https://www.xfel.eu/news_and_events/news/index_eng.html?openDirectAnchor=1757

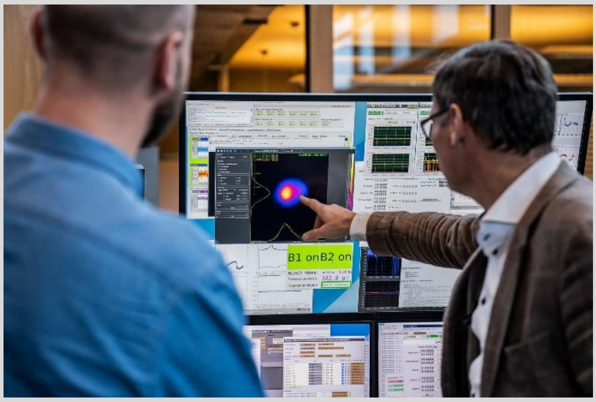
SCIENTIFIC HIGHLIGHTS

Athos is making great strides

SwissFEL is a free electron laser facility for hard and soft X-rays at the Paul Scherrer Institut in Switzerland. The hard X-ray beamline, Aramis covers a photon energy range from 2.0 to 12.4 keV and is operational for users since 2018. The second SwissFEL beamline called Athos is designed to provide photon pulses in the soft X-ray range from 250 to 1900 eV, with pulse energies up to 8 mJ. The Athos beamline will offer the combination of peak intensity, wavelength tunability and femtosecond pulse length required to perform dynamic soft X-ray spectroscopy.

Athos will soon be ready for action, as completion works are proceeding according to schedule. On 17th of December 2019, the PSI researchers made a first attempt to see if Athos could produce X-ray laser light. Even though there were only two working undulators with one chicane in between (in the final stage there will be 16 undulators with 15 chicanes) the Athos delivered laser light for the first time. This "first lasing" was a crucial milestone and the next milestone will be the arrival of the laser beam in the experimental station. The two experimental stations of Athos, Furka and Maloja, will be ready for the first experiments in 2021. Maloja is dedicated to atomic and molecular physics as well as nonlinear spectroscopy, whereas Furka is dedicated for condensed matter physics studies.

Read more on the PSI website:
https://www.psi.ch/en/media/our-research/athos-is-making-great-strides



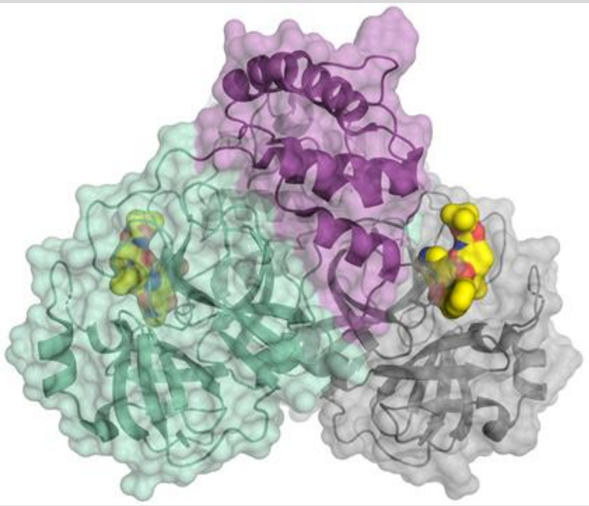
This is how Athos appeared on 17 December 2019 on the control room screen: as a compact X-ray laser beam. Copyright: Paul Scherrer Institut/Markus Fischer

SCIENTIFIC HIGHLIGHTS

Coronavirus SARS-CoV2: BESSY II data accelerate drug development

Coronaviruses have been known to cause problems for a long time. Some of them are known to trigger common colds, but their impact was mild. Recently, two types, such as severe acute respiratory syndrome (Sars) and Middle Eastern respiratory syndrome (Mers), have initiated epidemics of deadly illnesses. A spiky sphere of genetic material covered with lipids that measures 80 billionths of a meter in diameter, known as coronavirus Covid-19, in just a few months has caused blockages all over the world and influenced all nations. Humanity has been brought down low by a very modest attacker and global ravages caused by the coronavirus Covid-19, which caused the pandemic.

Scientists over the world are trying to understand severe acute respiratory syndrome-coronavirus 2 (SARS-CoV-2) that caused coronavirus disease 2019 (COVID-19). Among other things, work is carried out at the BESSY II, a third-generation synchrotron radiation source in Helmholtz-Zentrum Berlin (HZB). A group from the University of Lübeck and from Helmholtz Centre for Infection Research (HZI) has been using the high-intensity X-ray light at the synchrotron source BESSY II to study the x-ray crystal structure of the most important protein in the virus' life cycle - the main protease. The function of a protein is closely related to its 3D architecture. If this 3D architecture is known, it is possible to identify specific points of attack for active substances. The results obtained by the Prof. Dr. Rolf Hilgenfeld group can be a starting point for development of anticoronaviral drugs, which may inhibit the reproduction of the virus.



Schematic representation of the coronavirus protease. The enzyme comes as a dimer consisting of two identical molecules. A part of the dimer is shown in colour (green and purple), the other in grey. The small molecule in yellow binds to the active centre of the protease and could be used as blueprint for an inhibitor. Copyright: H.Tabermann/ Helmholtz-Zentrum Berlin (HZB)

The results were published in Science 2020: Crystal structure of SARS-CoV-2 main protease provides a basis for design of improved α-ketoamide inhibitors.
Authors: L. Zhang, D. Lin, X. Sun, U. Curth, C. Drosten, L. Sauerhering, S. Becker, K. Rox, R. Hilgenfeld
DOI: 10.1126/science.abb3405

Read more on the HZB website:
https://www.helmholtz-berlin.de/pubbin/news_seite?nid=21204;sprache=en

SCIENTIFIC HIGHLIGHTS

X-rays show birth of semiconductor for blue LEDs

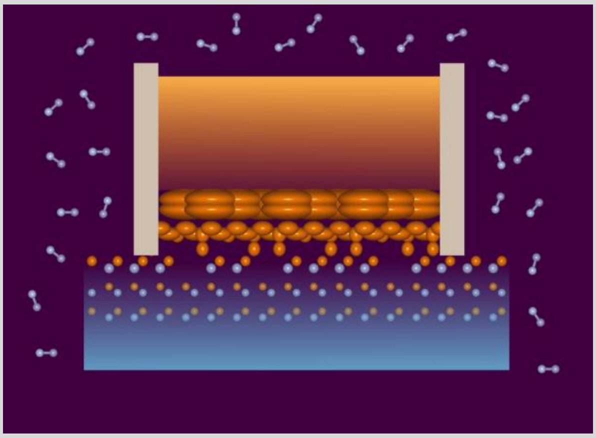
Gallium nitride has become the most important semiconductor material with exceptional optical and electrical properties. The GaN band gap of about 3.4 eV enables a range of applications, most prominently blue light-emitting diodes and power electronics. The X-ray light from the European Synchrotron Radiation Source ESRF in Grenoble, France, has been used to study the surface of the gallium nitride disk in the hot pressurized furnace. The research has been done in collaboration of Radboud University, the European Synchrotron Radiation Facility ESRF, the Institute for High-Pressure Physics PAS in Warsaw and DESY-Nanolab.

The research group used a tailor-made pressurized furnace to study the growth interface of a gallium nitride crystal with atomic precision using X-ray light. It was shown that the uppermost crystal layer had many point defects, in the form of vacancies at both sides of the solid-liquid interface. Furthermore, it was revealed that in the liquid gallium above the semiconductor crystal, layers form in which the gallium atoms of the liquid are located closer and closer to the gallium atoms of the crystal as they approach the boundary layer. This order and layering has never been observed before. For the first time, the atomic structure of the interface of the semiconductor material with liquid gallium was observed.

The observations are important from technological point of view. They can help to understand the growth of this semiconductor material and optimize a way to a simpler and more controllable production process. From the scientific point of view the observation contribute to a better fundamental understanding of the processes at interfaces between liquid and solid phases of a metal.

Related publication: Complex geometric structure of a simple solid-liquid interface: GaN(0001)-Ga; A.E.F. de Jong, V. Vonk, M. Boćkowski, I. Grzegory, V. Honkimäki, and E. Vlieg; Physical Review Letters, 2020; DOI: 10.1103/PhysRevLett.124.086101

Read more on the DESY website: https://www.desy.de/news/news_search/index_eng.html?openDirectAnchor=1788



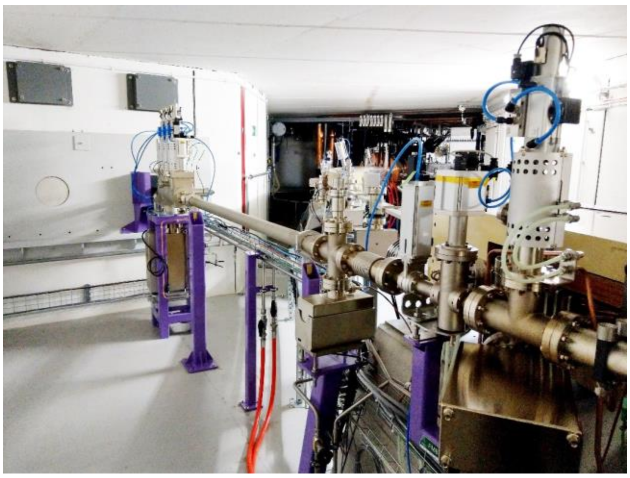
In the lower layers of the liquid gallium (centre), the atoms are located closer and closer to the horizontal position of the atoms in the crystal lattice (dots), as the X-ray investigation has shown. It also revealed surprisingly many defects in the upper layer of the crystal. Copyright: DESY, Vedran Vonk

News from SOLARIS

Construction of SOLABS (XAS-HN) beamline

The first SOLABS (XAS1Z-HN) beamline devices were installed in the storage ring in December 2019. The second part of the front end was delivered to SOLARIS in March 2020 and will be installed in a synchrotron tunnel during the upcoming spring shutdown.

The SOLABS beamline will allow research in materials science, physics and chemistry (investigation of alloys, oxidic systems and catalysts, probing of dynamic processes etc.); biomedicine (investigation of metalloproteins, investigation of the stability, uptake and therapeutic mechanism of action of inorganic and bio-inorganic drug); environmental protection (including tracking the degree and rate of toxic elements bioaccumulation). Research techniques to be made available: X-ray absorption spectroscopy, XANES, EXAFS.



Second electron cryo-microscope for SOLARIS

The SOLARIS Centre and the Malopolska Centre of Biotechnology will purchase a second cryo-electron microscope. The new equipment will be complementary to the Titan Krios G3i microscope. Moreover, it will be used not only for scientific research, but also for commercial ones. The purchase of the microscope will be financed under the European Union Smart Growth Operational Programme.

Installation of XMCD beamline

In May 2019, the SOLARIS team installed the XMCD beamline front end in a synchrotron tunnel. In July 2019, the team transported a photon source (an undulator) to the storage ring. On December 6, 2019, the first beam of photons was taken out of the synchrotron through one of the branch of the beamline (from the mirror chamber in the hutch to exit slits). Behind the slits a scanning X-ray transmission microscope (STXM) will be installed in 2020.

Potential application of the XMCD beamline include: magnetic order research; domain structure research; imaging of the chemical composition; biomolecular spectroscopy; fluorescence detection. Research techniques to be made available: scanning transmission X-ray microscopy (STXM), XMCD, XMLD, XPEEM, μXAS, μXPS.

News from SOLARIS

PHELIX beamline commissioning

In October 2019, the SOLARIS team observed the first light on the PHELIX beamline. Since the first photon beam delivery, the calibration of all beamline components, including X-ray optics, has been being intensively performed. An electron energy analyser and a spin detector will be delivered to SOLARIS as soon as possible (the delivery was postponed due to the COVID-19 closure of the Polish borders). Installation of these components will allow first test measurements to be started. The first research are planned to be carried out by friendly users at the end of 2020.

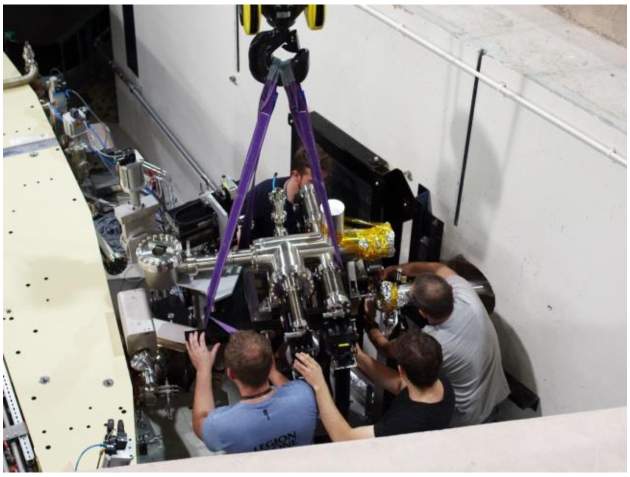
The PHELIX beamline will allow research on new materials for spintronics and magnetoelectronics, topological insulators; thin films and multilayers systems including samples obtained in-situ; surface of bulk compounds; surface magnetism, spin polarized surface states; chemical reactions taking place on the surface; biomaterials. Research techniques to be made available: photoemission spectroscopy (ResPES, ARPES, SX-ARPES, SR-ARPES, XPS, UPS, CD-ARPES), XAS (TFY, TEY).

More beam time for users

From March 1, 2020, the SOLARIS Centre went into a 24/6 operational mode (24 hours a day, 6 days a week). The beam is delivered to beamlines from Tuesday to Saturday, between 9:00 a.m. to 8:00 p.m. and between 9:00 p.m. to 8:00 a.m. The maximum duration of the experiment was extended twice (up to fifteen shifts), which corresponds to five days.

LUMOS diagnostic beamline

The LUMOS diagnostic beamline was launched in spring 2020. It enables systematic monitoring of the stability and transversal and longitudinal profiles of the electron beam. This knowledge help correct beam instabilities, and a stable beam improves the quality of measurements that are carried out on beamlines. LUMOS uses synchrotron radiation in the range of visible and UV light.



Rapid access to beamlines

A rapid access to operating beamlines was made available for SOLARIS users in November 2019. Researchers can use the procedure when they need to quickly conduct an experiment with a potentially high scientific value or when they need to supplement the results of the experiment previously carried out at SOLARIS. The rapid access is also meant for people who want to assess feasibility of planned measurements.

CALL FOR PROPOSALS
COMING SOON!

deadline: October 1st, 2020

SOLARIS

NATIONAL SYNCHROTRON RADIATION CENTRE

more information **www.synchrotron.pl**

Accepted experiments will be carried out at SOLARIS from March till August 2021
Scientists will be able to apply for beam or research time on:

PEEM/XAS beamline

Source: a bending magnet
Photon energy range: 150–2000 eV
Radiation polarisation: linear (horizontal) and elliptical

Research techniques:
PEEM end station – XPEEM, μ-XAS, μ-XPS. These techniques allow for surface imaging of chemical, electronic and magnetic properties of samples.
XAS end station – XAS, XMCD, XMLD. The X-ray absorption spectroscopy provides information on a chemical state and the local sample structure with element selectivity. Thanks to the control of radiation polarization, the XMCD and XMLD phenomena allow study of magnetic and crystal structure of the materials.

UARPES beamline

Source: a quasi-periodic undulator
Photon energy range: 8–150 eV
Radiation polarisation: linear vertical, linear horizontal, circular, elliptical, linear skewed

Research techniques:
ARPES. The technique allows for electron energy and momentum measurements, that is research on electronic band structure of the materials in three dimensions including the effects of electron correlations.

TITAN KRIOS G3i

Cryo-Electron Microscope
Optimum accelerating voltage: 200 and 300 kV
Detectors: Gatan K3 BioQuantum, Falcon 3EC, Ceta 16M Camera 300 kV
Research techniques: single particle analysis (SPA), electron tomography in structural biology

CONFERENCE INVITATION

JOINT MEETING OF POLISH SYNCHROTRON RADIATION SOCIETY AND SOLARIS USERS

KRAKÓW, POLAND, SEPTEMBER 9 - 11, 2020

polish sychrotron radiation society

Polish Synchrotron Radiation Society
Radzikowskiego 152, 31-342 Kraków, Poland

SOLARIS National Synchrotron Radiation Centre
Czerwone Maki 98, 30-392 Kraków, Poland

SOLARIS
NATIONAL SYNCHROTRON RADIATION CENTRE

Krakow, 4th May, 2020

On September 9-11, 2020, the first joint meeting of the Polish Synchrotron Radiation Society (PSRS) and users of the SOLARIS National Synchrotron Radiation Center (NCPS) will be held.

This meeting is the result of a very close, long-term cooperation between PSRS and NCPS SOLARIS.

The Polish Synchrotron Radiation Society has been organizing the National Symposium of Synchrotron Radiation Users (KSUPS) every two years since 1991. It was thanks to the efforts of the scientific community associated in the Polish Synchrotron Consortium that the construction of the National Synchrotron Radiation Center - the SOLARIS synchrotron in Krakow began in 2010. Since 2018, research groups from various centers, not only from Poland, have been conducting experiments on beamlines of the SOLARIS synchrotron, which has become a unique research center in Poland. SOLARIS is constantly expanding its research offer and recently, apart from the synchrotron, the most advanced electron cryomicroscope in Poland is also available to scientists.

This meeting is an evolution of the National Symposium of Synchrotron Radiation Users, and begins with a new tradition. The PTPS board decided to change the KSUPS format and extend it to a meeting of synchrotron users, which became possible thanks to the close cooperation of PTPS with the SOLARIS Center.

- adds prof. dr hab. Wojciech M. Kwiatek, president of PSRS.

The purpose of the meeting is to present achievements and exchange scientific experiences related to conducting research using synchrotron radiation. Such annual user meetings are good practice in other synchrotron centers, and also allow the promotion of research techniques available in a given center.

- says prof. dr hab. Marek Stankiewicz, director of the SOLARIS Center.

Discussions and lectures will also be accompanied by a poster session and visiting opportunities at SOLARIS. Coming soon to the event it will be possible to register to the vent and send abstracts. Being aware of the current situation related to the SARS-CoV-2 epidemic, we would like to emphasize that if the existing restrictions will be maintained; the planned event will be implemented in a videoconference mode. All information will be updated on a regular basis on the conference website at: https://synchrotron.uj.edu.pl/joint-meeting

Chairman	&	Co-Chairman
dr hab. Jakub Szlachetko		**prof. Marek Stankiewicz**

Organizing Committee:

Wojciech Błachucki	**Agata Chrześcijanek**	**Joanna Czapla-Masztafiak**
Sebastian Glatt	**Alicja Górkiewicz**	**Emilia Król**
Marcin Klepka	**Janusz Lekki**	**Anna Wach**

In cooperation with

JAGIELLONIAN UNIVERSITY IN KRAKÓW

THE HENRYK NIEWODNICZAŃSKI INSTITUTE OF NUCLEAR PHYSICS POLISH ACADEMY OF SCIENCES

Polish Synchrotron Radiation Society Board
The term of office: 2017 – 2020

Chairman:
Wojciech Kwiatek
Institute of Nuclear Physics PAS
Radzikowskiego 152
31-142 Krakow
wojciech.kwiatek@ifj.edu.pl

Vice Chairman:
Maciej Kozak
Faculty of Physics
Adam Mickiewicz University
Uniwersytetu Poznańskiego 2
61-614 Poznan
mkozak@amu.edu.pl

Vice Chairman:
Jakub Szlachetko
Institute of Nuclear Physics PAS
Radzikowskiego 152
31-142 Krakow
jakub.szlachetko@ifj.edu.pl

Treasurer:
Joanna Czapla-Masztafiak
Institute of Nuclear Physics PAS
ul. Radzikowskiego 152
31-142 Krakow
joanna.czapla@ifj.edu.pl

Secretary of the Board:
Agnieszka Witkowska
Faculty of Applied Physics and Mathematics
Narutowicza 11/12
80-233 Gdańsk
agnieszka@mif.pg.gda.pl

Board Member:
Marek Stankiewicz
National Synchrotron Radiation Centre SOLARIS
Jagiellonian University
Czerwone Maki 98
30-392 Kraków
m.j.stankiewicz@uj.edu.pl

Board Member:
Wojciech Paszkowicz
Institute of Physics PAS
al. Lotników 32/46
02-668 Warsaw
paszk@ifpan.edu.pl

Board Member:
Ryszard Sobierajski
Institute of Physics PAS
al. Lotników 32/46
02-668 Warsaw
ryszard.sobierajski@ifpan.edu.pl

Board Member:
Marcin Klepka
Institute of Physics PAS
al. Lotników 32/46
02-668 Warsaw
mklepka@ifpan.edu.pl

Board Member:
Paweł Piszora
Faculty of Chemistry
Adam Mickiewicz University
Uniwersytetu Poznańskiego 2
61-614 Poznan
pawel@amu.edu.pl

Board Member:
Zuzanna Pietralik-Molińska
Faculty of Physics
Adam Mickiewicz University
Uniwersytetu Poznańskiego 2
61-614 Poznan
zuzannap@amu.edu.pl

We are pleased to introduce you to the new Polish Synchrotron Radiation Society logo

ptps

polskie towarzystwo
promieniowania
synchrotronowego

polish sychrotron
radiation society

Bulletin of Polish Synchrotron Radiation Society

SYNCHROTRON RADIATION IN NATURAL SCIENCE