ERASMUS+ Mobility 2014/2015

Andrei Avdonin Max-Lab Lund University, Sweden:

Traineeship has started on February the 2^{nd} 2015 with a tour around Max II storage ring and its beamlines. A number of samples brought by the trainee were selected and mounted into the back chamber of D1011 beamline (energy range of 3 – 1600 eV). While waiting for the beam-time trainee was instructed about the structure of the end station, operation of different elements of the apparatus and was familiarized with the rules of measurement. With the users of the beam-time, which, at the time, were studying the chemical reactions of organic molecules on the metal surfaces, trainee took part in actual measurements in the front chamber of D1011, and was shown what kind of data is collected during NEXAFS measurements and what kind of information can be extracted from such data, regarding the changes of chemical bonding. Between the measurements of the users of beam-time, when users had deposited their samples or had to “baked out” the apparatus, during two sessions, trainee had possibility to perform measurements of his own samples. The preliminary interpretation of the results was made.

For two days, during the maintenance time, trainee had possibility to perform also EXAFS measurements of his samples on the I811 beam line, which is built for measurements in the range of higher energies (of 2.5 - 21 keV). Here trainee was also instructed on how to operate the measurement apparatus in order to collect spectra. EXAFS spectra of several samples, for several chemical elements were collected. An introduction was made regarding the software used for the simulation of the EXAFS spectra, in order to be able to extract the distances to the closest neighbors of atoms of the studied element.

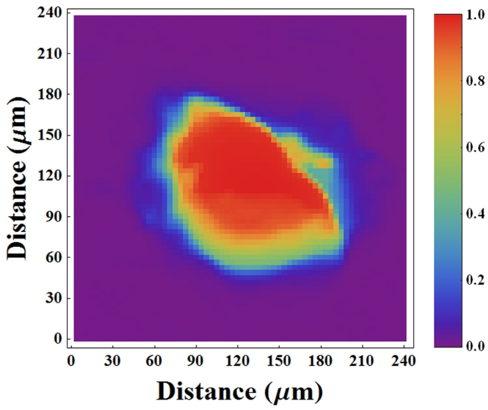
The most important knowledge obtained, is the awareness of the possibilities and limitations of investigations with such techniques as EXAFS and NEXAFS, understanding of the apparatus involved in the measurements, experience regarding preparation of samples and understanding of which samples are appropriate for such measurements.

On the other hand the experimental data, gathered during the visit, will provide valuable information about the measured samples and will help to plan the future studies.

Michał Głowacki, University of La Laguna, Spain:

From 17 November 2014 to 26 November 2014 I was visiting Faculty of Physics, Department of Fundamental and Experimental Physics, Electronics and Systems at the University of La Laguna. It was my second visit at this University. My host was Dr. Inocencio R. Martín Benenzuela – head of the Group of Laser Spectroscopy. The main research topics of this group are optical properties of crystalline and vitreous matrices doped with optically active ions (Lanthanides and Transition Elements), investigation of energy transfer and IR-Vis conversion processes, and inducing laser action.

I went to La Laguna University with samples prepared by me and my co-workers in my home institution – glass samples of SrB_4O_7 doped with 1at% of samarium. Strontium tetraborate is a compound with high mechanical strength, high optical damage threshold and excellent non linear properties. Doped with lanthanide ions SBO can be used as visible light emitting material. The oxidation state of dopant ion (thus also the emission spectra) depends on the form of the obtained material (crystal/glass) as well as on the crystal growth method. During my stay at ULL we managed to create and investigate microcrystalline SrB4O7 : Sm^{2+} dots in SBO glass. In the glass of SBO:Sm one can observe only Sm^{3+} emission lines, but due to the crystallization process carried out using 3,5 W Ar laser beam focused in one spot on the surface of the SBO:Sm glass the emission peaks coming from Sm^{2+} ions in a crystalline environment can be detected. Therefore, presence and intensity of Sm^{2+} luminescence spectral lines became an indicator for microcrystalline dot formation. Series of spectral measurements allowed us to determine size and the shape of the dot.



Obtained results were presented as an poster presentation on the Fifth European Conference on Crystal Growth (ECCG5), Bolonia, Italy, 9-11 September 2015 (M. Głowacki, I.R. Martín, C. Pérez-Rodríguez, M. Berkowski, *Formation of microcrystalline* SrB_4O_7 *:*Sm^{2+} *dots in SBO glass-ceramic*).

Marta Sobańska, Paul-Drude-Institut für Festkörperelektronik, Berlin, Germany:

During two stays in Paul-Drude-Institut für Festkörperelektronik in Berlin I successfully carried out all the experiments that had been planned. In particular, I grew a series of samples of GaN nanowires on Si substrates with amorphous Al_xO_y buffer. QMS and RHEED data were acquired in-situ during growths in order to analyse a mechanism of self-induced nucleation and PAMBE growth of GaN nanowires. After experimental part of the work I made numerical analysis of QMS data. Currently I am preparing publication of received results. The idea of second project was to check optical quality of GaN NWs grown at high temperature on silicon substrates with various thicknesses of amorphous buffer and to compare it with similar NWs grown on silicon which are known to suffer from silicon uptake from the substrate. After photoluminescence measurements I will prepare final results for publication.

During the traineeship period I got experience in using Quadrupole Mass Spectrometer for in-situ analysis of PAMBE growth process of GaN nanowires. Discussions of experimental results with team members from PDI allowed me to deepen my knowledge and understanding of physical processes taking place during spontaneous growth of semiconductor nanowires by PAMBE. The knowledge and skills I gained there will help me to improve the growth procedures I use in my home Institute as well as will speed up preparation of my PhD thesis.

Marta Witkowska-Baran, University of Surrey, Guildford, Surrey, United Kingdom:

I am involved in the growth and characterisation of the semiinsulating (Cd,Mn)Te crystals for X- and gamma radiation detectors, and we are going to start the Time-Of-Flight measurements of the parameters of the current carriers in these crystals.

I was acquainted with this technique during the visit in the University of Surrey, FEPS, Department of Physics, Guildford, Surrey, UK. The group is known for the world-highest achievements in this field. The values of the parameters (drift mobility and lifetime) and mapping of them, which can be obtained from the TOF measurements, are extremely important for selection of the crystal plates for radiation detectors. Moreover, I am interested in broadening my knowledge in preparation of the pixellated detector plates
Numerous discussions and conversations with Dr. Annika Lohstroh and people from her group gave me extended knowledge and experience in the area of time-of-flight measurement techniques and preparation of the crystal plates for the X- and gamma radiation detectors (particularly - pixellated detectors)

The acquired knowledge allowed for construction of the experimental setup for the time-of-flight measurements and introduction of this type of measurements in the IP PAS for characterisation of the crystals for the X- and gamma radiation detectors.
According to the plan, we are going to continue scientific cooperation between IP PAS and Department of Physics, South East Physics Network (SEPnet), in particular – the exchange of crystals, experimental data and their interpretation.

Filip Krzyżewski, Institute of Physical Chemistry, Bulgarian Academy of Sciences, Sofia, Bulgaria:

Erasmus+ travel to Sofia broadened my knowledge about new surface pattern analysis technique. It is used to characterize step bunches which emerge at surfaces of semiconducting crystals during growth or annealing processes. The key element of this method is to find universality classes of step bunching process which will be useful to investigate such structures during their evolution. It is expected that different bunching mechanisms and conditions in which system develops lead to differences of crucial parameters describing time evolution of the surface.

I also learned new simulation techniques and broadened my experience in the field of crystal growth modeling. In Sofia I practiced cellular automata modeling method. Such a technique uses fast and simple algorithms and will help me in the future while tuning parameters for more complex simulations In Sofia I also had an occasion to practice dimensional analysis of step motion equations. For me it was a new tool of analytical investigation of surface evolution and will certainly be useful during my further scientific work.

Finally, travel to Bulgaria was the beginning of cooperation between Bulgarian group which develops the universal bunch analysis method and the Polish group which has experience in the field of crystal growth simulations. Such a partnership will lead to broadening present knowledge about step bunching phenomenon which is commonly observed during growth of semiconducting devices.

One can conclude that my travel to Sofia was a fruitful and developing activity which will result in further cooperation with Bulgarian group I visited. It is expected that scientific manuscripts will be written as the result of that trip.

Janusz Daniel Fidelus, University of Duisburg-Essen, Duisburg, Germany:

Research activity of the Department of Nanoparticle Process Technology (NPPT) at the University of Duisburg-Essen concentrates on the synthesis and characterization of particles and nanomaterials for variety of applications. The aim of the visit at the NPPT was to obtain ZnO:Mn continuous layers/films for water splitting applications. Research direction in the proposed project results from search of better material solutions (anode) and is based on knowledge gained during research conducted in our group in IP PAS in this field in project realized under the POIG 1.1.2 project entitled "Modern Materials and Innovative Methods of Conversion and Monitoring of Energy".

During the traineeship period I had the opportunity to broaden my knowledge and gain experience in (i) chemical vapour synthesis (CVS) (ii) optimization of stable solutions containing oxide nanoparticles, (iii) experience in EPD method for the deposition of ZnO, ZnO(0.5)Mn and ZnO(1)Mn films and (iv) widening of experience in films characterization.

As a final result I successfully obtained (and characterized) stable dispersions of ZnO/ZnO(0.5, 1)Mn nanoparticles in PAA solution and deposited (by EPD) them on Si-wafers in the continuous and homogeneous layers/films.

Preliminary results of the joint work were presented at 11th Conference for Young Scientists in Ceramics, SM-2015 in Novi Sad, Serbia, October 21-24, 2015.

A. Kompch, J.D. Fidelus, C. Notthoff, M. Winterer, "Synthesis and structural analysis of Mn-doped ZnO nanoparticles".

Marcin Stachowicz, Ewa Przeździecka, University of Minho, Centro de Fisica, Campus de Gualtar Portugal:

From 22nd to 28th of March 2015 we took part in ERASUS+ training, which was conducted at University of Minho, Centro de Fisica, Campus de Gualtar Portugal.

The training was about getting familiar with new experimental technique, which is temperature dependent Hall Effect measurements in the van der Pauw configuration. The van der Pauw Method is a technique commonly used to measure the resistivity and the Hall coefficient of a sample. Its power lies in its ability to accurately measure the properties of a sample of any arbitrary shape, so long as the sample is approximately two-dimensional (i.e. it is much thinner than it is wide), solid (no holes), and the electrodes are placed on its perimeter. There are five conditions that must be satisfied to use this technique: the sample must have a flat shape of uniform thickness, the sample must not have any isolated holes, the sample must be homogeneous and isotropic, all four contacts must be located at the edges of the sample, the area of contact of any individual contact should be at least an order of magnitude smaller than the area of the entire sample.

From the measurements made, the following properties of the material can be calculated:

- The resistivity of the material,
- The doping type (i.e. whether it is an N-type or P-type material),
- The sheet carrier density of the majority carrier (the number of majority carriers per unit area). From this the charge density and doping level can be found,
- The mobility of the majority carrier.

In our case the main goal was to determine the conductivity type. The samples which were studied are II-VI semiconductors, especially ZnO doped with different p type dopants. The goal of the training was to get familiar with the van der Pauw Method and to conduct temperature dependent measurements. Temperature dependent van der Pauw Method measurements allow to determine electrical parameters of the samples in temperature range from 10 to 300K. It also allows to observe conductivity type change (if any) from **p** to **n** in the temperature.

The Hall Effect in the van der Pauw Method measurement setup, which is at the University of Minho, Cetro de Fisica, Campus de Gualtar Portugal, consists of electromagnet, which gives magnetic field up to 1.2T, Keithley 6220 power supply and 6514 digital multimeter. Samples are placed in a closed circuit Hellium cryostat equipped with proper electrical probes.

The training began from OSH training and getting familiar with all measurement protocols in the lab. Next the sample preparation process began under supervision of the inviting professor. During the training four samples were measured. All measured samples were grown with plasma assisted molecular beam epitaxy in the laboratory of Institute of Physics Polish Academy of Sciences in Warsaw as the part of the NCN nº P414/S grant. All specimen were effused on sapphire c- plane substrates and doped with As, N or Sb elements during the growth process. After the growth process, samples were annealed at temperatures in range from 500 to 700ºC in various atmospheres (O_2, Ar_2, N_2) . The omic TiAu contacts also were made at the IP PAS in Warsaw. The obtained results were further analyzed and even at early stage of analysis they were very promising. The first conclusions were included into collaborative presentation “*The UV detectors based on p-n and p-i-n heterostructures (p-ZnO, n-GaN, and i-Al22O3) electrical and optical properties”,* shown during the 44th “Jaszowiec” International School & Conference on the Physics of Semiconductors 2015.

Michał Ławniczak, University of Hradec Králové in Czech Republic

The purpose of the visit was cooperation regarding the analysis of the experimental results connected with the distributions of the power spectrum of discrete and finite series obtained for microwave networks simulating the chaotic quantum graphs. During the stay the software has been developed which allowed to obtain the distributions and verify their compliance with different theoretical predictions. Some of those predictions have been developed together with the hosts.

The hosts of my stay were theoretical physicists with some experience in the analysis of chaotic quantum systems. Collaboration with them allowed me for better and more precise analysis of the experimental results. The stay also allowed me to gain knowledge and skills in the development of new theoretical models.

Walery Kołkowski, Technical University Dresden, Dresden, Germany

During my visit at the Technical University in Dresden I gained experience in operation of the DLTS and high-resolution Laplace DLTS techniques which are not accessible in our laboratory at the Institute of Physics PAS. Nitrogen doped P-type ZnTe/n-type GaAs junctions with different nitrogen concentration were grown by the molecular beam epitaxy technique at the Institute of Physics Polish Academy of Sciences. Ohmic contacts to ZnTe layer were obtained by thermal evaporation of gold and silver. The quality of the Au and Al cotacts were found to be similar. The Ohmic contact to GaAs were obtained by InGa alloy. Some of the samples were annealed in air at 300 °C. For the electrical characterization of the contacts capacitance-voltage (CV) and current-voltage (IV) measurements were performed at diffferent temperatures in the range of 77-400 K. The IV curves shows that the thermionic mechanism is not dominant in these samples and the tunneling of carrier through a thin insulating layer between ZnTe and GaAs or barrier inhomogeneity should be taken into account. The carrier concentration in N-doped p-type ZnTe is about 2x1017 cm-3 as obtained from the CV measurements at room temperature. In order to investigate the electrical properties of defects introducing deep levels in ZnTe DLTS measurements were carried out. Two deep levels were detected in the band gap of ZnTe. The activation energy of the dominant trap is 0.88 eV and it can be correlated with the vacancy of zinc or an oxygen-related defect.