Doctoral study at TU Ostrava in the international context

Dalibor CIPRIAN, Jaromír PIŠTORA, Martin FOLDYNA, Kamil POSTAVA
Department of Physics, TU Ostrava, 17. listopadu 15, 708 33 Ostrava, Czech Republic, dalibor.ciprian@vsb.cz

KEYWORDS: *doctoral study, international collaboration*

ABSTRACT: *In the last ten years, as the international cooperation in every field is more and more important, the number of opportunities how to enhance the doctoral study has rapidly increased. One of the possibilities is the doctoral study supported by a research stay in foreign laboratory, for example, offered by foreign government or university, supported by an European project, or by the doctoral study covered by contracts between universities in different countries. We want to emphasize that not only the Ph.D. student profits from advance equipped laboratory, but also transfer of knowledge and intensifying the international research collaboration improves education and research in the domestic university. Also the optimisation of the research stay length is discussed. The contribution is devoted to summarization of the experiences of doctoral students affiliated with Department of Physics at Technical University of Ostrava. Particularly, the experience and other information considering the stay in France and Japan are considered. The authors try to present also some critical aspects connected with the study in foreign country that has to be understood and accepted by each possible candidate. This will include language-oriented problems as well as various aspects of the research carried out in foreign environment and culture.*

1 INTRODUCTION

As the rate of the industrial evolution increases, the demand on basic and applied research in science and engineering increases as well. In the same time, the time period for turning of the scientific discovery into a industrial product, which could successfully compete on the market, has been decreased. All these factors are heading to requests for highly educated people with flexible communication skills.

In order to attain a good starting position on such demanding job market, it is not enough to get just master degree in science or engineering, but the completion of doctoral course is necessary. During their study, the doctoral students have to pass the exams and take and active role in the research performed at their affiliated institution. Considering the research activities, they are often the very working force, who performs the research at some universities. Because the today research is very demanding and time consuming task, it is unavoidable to perform it in teams and the doctoral students have to learn how to perform well in such a team. There is no better way how to teach them such skills than send them to work in foreign institutions. If they are to learn some new things and improve their speciality, they should be send to the institution which is on higher level in the research area than their mother department and where you can expect some sources of motivation. Here we want to emphasize that not only the doctoral students can profit from the advance of well equipped laboratory or from direct contacts with the experts, but the transfer of the knowledge and future close research contacts help the domestic university as well.

2 SURVEY OF DOCTORAL STUDIES AT DEPARTMENT OF PHYSICS

In this part of the text, brief survey of main results achieved in the frame of doctoral study connected with the Department of Physics TU Ostrava (DPTUO) will be given. All of them are closely related to the topics of the research performed by the optic group at the department. Because the doctoral programme in physics or applied physics has not started yet at DPTUO, all doctoral students had to be incorporated into the doctoral study with either different university, or to take a part in some doctoral programme in engineering available at TU Ostrava. In all cases, the supervisor or consultant was a member of DPTUO. All the mentioned circumstances, although they seemed to be a handicap, resulted in the end into work in true global, international context bringing long term international collaboration.

At first, K. POSTAVA (1997) finished the thesis "Light propagation in magneto-optic multilayers, magnetization behaviour" in 1997. Part of his research included sophisticated experiments in magneto-optics and it was performed during his stay at Solid State Physics Laboratory, INSA Toulouse in France. The stay was divided in three parts (6, 6, and 3 months). Total length was 15 months and the work in France was partially supervised by Prof. A. Fert, head of the laboratory, who is an expert in thin film magnetism.

Main results of the work concerned the study of magneto-optic phenomena and magnetization behaviour in thin film system containing ferromagnetic metals. Author focused his attention on Fe ultrathin layers with the thickness varied from 2 to 50 nm deposited on MgO monocrystalic substrate using molecular beam epitaxy. Such structures exhibit so called in-plane magnetization. Magnetic properties were studied using Kerr vector magnetometry. For these purposes, the experimental setup based on differential intensity detection scheme was designed and built at INSA Toulouse. The method is based on the study of magnetization loops related to two components of the magnetization. The way, how to separate them was extensively discussed from the theoretical point of view. During the study, the role of higher order magneto-optic effects was revealed. The attention was paid mainly to the description of quadratic magneto-optic effect in magnetization. It was shown that such effect could significantly influence the experimental results. The method, how to suppress them and improve the interpretation of experimental data, is one of the significant results of the work. The author had the opportunity to exploit the technological and experimental background of INSA, where he brought his knowledge of optical methods to the benefit of accepting laboratory mainly oriented on magnetism. The thesis was defended in front of mixed Czech – French committee.

The second thesis, belonging to the person affiliated to DPTUO was defended by D. CIPRIAN (2000) in 1999. The work "Electromagnetic wave propagation in anisotropic layered media" was oriented on computer models of the optical response of anisotropic grating structures using rigorous coupled wave analysis. Great part of the research work was done during author's stay in Japan, where he was affiliated with the Laboratory Electromagnetic Waves and Communication, which is the part of Graduate School of Information Science and Electrical Engineering at Kyushu University in Fukuoka. During his stay there the author was supervised by Prof. K. Yasumoto. Total length of this stay was one and half of the year.

Main results of the work were computer models of the optical response of one dimensional grating structures containing anistropic materials – electro-optic and magneto-optic. Rigorous coupled wave analysis exhibits high demands on computational resources and the author had the possibility to use the scalar multiprocessor system at Kyushu University. The other advantage was the opportunity of direct contacts with one of the pioneer of the mentioned method – Prof. K. Rokushima as well as the discussion with Prof. Yasumoto, who belongs to top specialists in numerical methods for electromagnetic wave propagation. The computer models brought better insight into the optical behaviour of phase gratings, composite gratings and sandwich grating structures. The results obtained for the case of phase grating formed by magnetic domain stripe structure in magnetic garnet film were successfully compared with the older simple models. The quantitative discrepancies concerning the fill factor dependence of transmission diffraction efficiency was explained in detail. Because used method had some limits, the attempt to exploit new aspects of fast Fourier formulation was made. It helped to understand the behaviour of the method, although some questions are still opened. The author brought to the group of Prof. Yasumoto some new interesting topics related to the optic of periodic structures and layered media, whether he benefited from the sophisticated background of the team traditionally oriented on computational electromagnetics.

The last mentioned case is the thesis "Magnetic properties of multilayers for spintronics, studied by means of magneto-optical methods" by D. HRABOVSKÝ (2003), who finished his doctoral course in nanophysics, nanocomponents and nanomeasurements at Solid State Physics Laboratory, INSA Toulouse in 2003. At beginning, he started his Ph.D. programme at Faculty of Electrical Engineering and Informatics TU Ostrava (supervised by Prof. J. Pištora), then he was given the possibility to do part of his research at INSA Toulouse. He spent there together more then three years and entered INSA doctoral program being in the same time enrolled at TU Ostrava, where he changed his study to external form. His work in France was supervised by prof. A. Fert and dr. J. F. Bobo. It was oriented on the study of thin film magnetic structures for spintronics using magneto-optical measurement methods. Two measurement

methods were used: low temperature magneto-optical magnetometry and Kerr microscopy. During the work, the experimental setup built by K. Postava was improved and equipped with cryogenic facilities allowing the low temperature experiments. For the purposes of magnetic domain imaging, the Kerr apparatus for Kerr microscopy was built. Using both techniques, anisotropy relaxation field effects of exchange Co/NiO bilayer systems were studied. The attention was paid to the hysteresis loop shift. The influence of anisotropy of antiferromagnetic NiO film on the relaxation rate was successfully demonstrated. The other studied system contained diluted magnetic semiconductor (Ga,Mn)As. It was shown, that the system exhibited four-fold magnetic anisotropy. The experiments with the dynamics of magnetic reversal revealed strong dependence of coercive field on the applied sweep rate of magnetic field. The phenomena together with an abrupt reversal process indicate the presence of large magnetic domains in the structure.

In all cases, the knowledge obtained during the doctoral study was successfully transferred to DPTUO, where now the method of vector Kerr magnetometry is the main measurement method. As to the computer models – the description of the grating structures by rigorous coupled wave analysis was extended to two-dimensional structures. Such structures were experimentally investigated in the laboratory of DPTUO and the data were confronted with the theoretical prediction. Mutual collaboration was supported by KONTAKT and BARRANDE programs – M. Foldyna is currently pursuing his Ph.D. degree at DPTUO realized short stay at INSA Toulouse (one month) oriented on mathematical models of thin film structures.

3 IMPORTANT ASPECT FOR RESEARCH STAY PLAN

The most important point is the choice of the accepting institution. The research group where the doctoral student has to work should be at least at the same level as his mother department or team is. It is not necessary to find the team working exactly on the same research topic, but the orientation of the accepting team should be in the context with the theme of student's thesis. Also the level of the requested knowledge should be reasonable, otherwise the candidate will lack behind and that is totally demotivating. The stay should be granted with appropriate financial support for everyday living costs.

The question of the language knowledge and skills is important as well, especially when the stay is planned in the countries, where English is not commonly spoken as in France or Japan. In such case, the doctoral student should be given the opportunity to study the appropriate language in advance. Nowadays, the Department of Languages TU Ostrava offers classes in all mostly used languages, but Japanese. The knowledge of the language can also help a lot in the competition for a study position (for example: French or Japanese international student programs).The last aspect which the authors consider to be important is the optimisation of the stay length. The short stays up to two months do not bring usually any problem, but that is not the case of long term stays. During the doctoral course, the students have to pass approximately five exams (average on Czech universities). If we consider the usual three-year doctoral programme, the continual research stay longer than one year can lead to the time difficulties considering the mentioned duties. On the other hand, short stays do not give enough time for long term research, which is usually needed in order to obtain original results. The authors considered the optimum length to be approximately five or six month, twice during the doctoral study. The time periods longer than one year can lead to the necessity to extend the time of the programme, or to interrupt the study during the stay abroad and that is not good for the mother institution of the student. If the candidate has better condition in foreign institution, he is tempted to break his study at TU Ostrava and start new doctoral course there. On the other hand, proper choice of the length stay the mother institution and the student can profit from the transfer of the knowledge and change of research environment.

4 CONCLUSION

The survey of the main results achieved during the doctoral study of the persons affiliated with DPTUO was given, all of them could not be obtained without the help of foreign institution. It led us to the conclusion that the work in international context is not only an advantage, but it is necessary in current conditions. Some important aspects considering the plan of the research stay during the doctoral programme were discussed in details. As to the authors knowledge, this question has not been opened at TU Ostrava in the past.

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KONTAKT – International collaboration in research and development project, Czech ministry of Education. Available from web: <URL: http://www.msmt/cz>

BARRANDE – Bilateral Czech-French collaboration project in research and development, Czech ministry of Education. Available from web: <URL: http://www.msmt/cz>