**Questionnaire**

Project: Development of experimental techniques and applied research with slow monochromatic positron beams (PAS)

 **PART A: Achievements**

**1.   Contributions of the JINR group:**

 Group members are responsible for the research and development of positron annihilation spectroscopy methods at JINR and collaborate with the following institutions:

* Institute of Nuclear Physics PAS, Kraków, Poland (P. Horodek, E. Dryzek, K. Skowron)
* Tomsk Polytechnic University, Tomsk, Russia (R. S. Laptev, A. M. Lider)
* Center for Nuclear Techniques, Ho Chi Minh City, Vietnam (Luu Anh Tuyen)
* Northern (Arctic) Federal University named after M.V. Lomonosov, Arkhangelsk, Russia (M. K. Eseev, I. V. Kuziv)
* Institute of Electrophysics & Radiation Technologies NAS of Ukraine,
Kharkiv, Ukraine (V. Klepikov, V. Lytvynenko)

**2.   Publications since 2020:**

* K.Siemek, M.K.Eseev, P.Horodek, A.G.Kobets, I.V.Kuziv *Defects studies of nickel aluminum bronze subjected to cavitation*, Applied Surface Science 546 (2021) 149107. Measurements and analysis of the results obtained by the positron annihilation method were performed at JINR by corresponding author K.Siemek;
* K.Siemek, A.P.Yelisseyev, P.Horodek, S.I. Lobanov, A.A.Goloshumova, A.V.Belushkin, L.I.Isaenko, *Optical and positron annihilation studies of structural defects in LiInSe2 single crystals*, Optical Materials 109 (2020) 110262. Measurements and analysis of the results obtained by the positron annihilation method were performed at JINR by corresponding author K.Siemek;
* K.Siemek, J.Dryzek, M.Mitura-Nowak. A.Lomygin, M.Schabikowski, *Positron annihilation studies of long range effect in Ar, N and C-implanted silicon*, Nuclear Instruments and Methods in Physics in Physics Research B 456 (2020) 73. Measurements and analysis of the results obtained by the positron annihilation method were performed at JINR by corresponding author K.Siemek;
* W. Nowak, K. Siemek, K. Ochał, B.Kościelniak, B. Wierzba *Consequences of different mechanical surface preparation of Ni-base alloys during high temperature exposure*, Materials 13 (2020) 3529. Measurements and analysis of the results obtained by the positron annihilation method were performed at JINR.

Additionally group participated in studies of nuclear materials and were responsible for measurements and analysis of the results obtained by the positron annihilation method in the following works:

* R.Laptev, A. Lomygin, D. Krotkevich, M. Syrtanov, E. Kashkarov, Y. Bordulev, K. Siemek, A. Kobets, *Effect of Proton Irradiation on the Defect Evolution of Zr/Nb* *Nanoscale Multilayers*, Metals 10 (2020) 535;
* E. Demir, M.N. Mirzayev, E.P. Popov, P. Horodek, I.G. Genov, K. Siemek, D.M. Mirzayeva, V.A. Turchenko, M. Bulavin, A.I. Beskrovnyi, A.H. Valizade, H.V. Akhundzada, S.I. Karaaslan*, Effects of high-energetic 3He+ ion irradiation on tungsten-based composites*, Vacuum 184 (2021) 109934;
* M.N.Mirzayev, A.Abdurakhimov, E.Demir, A.A.Donkov, E.Popov, M.Yu.Tashmetov, I.G.Genov, T.T.Thabethe, K.Siemek, K.Krezhov, F.Mamedov, D.M.Mirzayeva, M.V.Bulavin, V.A.Turchenko, T.X.Thang, T.Z.Abdurakhmonov, P.Horodek, *Investigation of the formation of defects under fast neutrons and gamma irradiation in 3C-SiC nano powder,* Physica B Condens. Matter. 611 (2021) 412842;
* R. Laptev, L. Svyatkin, D. Krotkevich, E. Stepanova, N. Pushilina, A. Lomygin, S. Ognev, K. Siemek, V. Uglov, *First-Principles Calculations and Experimental Study of H+-Irradiated Zr/Nb Nanoscale Multilayer System*, Metals. 11 (2021) 627.

**3.   PhD theses:**

 PhD 24.09.2020 Kobets A. G. “Development and creation of a source of low-energy positrons and electrons for diagnostics of point defects in condensed matter.”

**4.   Talks since 2020:**

Last year, due to the pandemic, most of the conferences were canceled.

* K. Siemek *Positron annihilation spectroscopy in studies of defects in solid materials*, lecture, Seminar of Solid State Physics Department, IFJ PAN, Kraków, Poland, 07.07 2020
* K. Siemek *Fundamental studies of irradiation effects in nanostructured titanium,* lecture*,* LNF JINR, Dubna, Russia, 02.10 2020

**PART B: Plans and requests**

**5.   Plans**

 In the following years, a planned positron annihilation experiments will concentrate on defect engineering and related to defects investigations as, i.e., modification of materials (by ion implantation, mechanical processing) and studies on destruction process (irradiation damages, cavitation, friction). Together with performed material studies, also improvement of the positron beam into the ordered beam is continued. In the past year, a three-frequency cavity was mounted to the positron channel, and a new chamber for samples was designed and constructed. This will allow conducting coincidence Doppler broadening of annihilation line measurements on the beam. The final project plan aims to create a modern stand for positron annihilation spectroscopy measurements which include beam measurements of positron lifetime and coincidence Doppler broadening of annihilation line.

**6.   Group size, composition and budget**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| № | Name | Position | Tasks | FTE |
| 1 | Meshkov I.N. | chief researcher | Theory, setting up and carring out an experiment, result analysis | 0,25 |
| 2 | Kobets A.G. | research scientist | R&D, assembling, discussion of the results | 0,25 |
| 4 | Sidorin А. А. | engineer | Carring out an experiment, result analysys | 0,85 |
| 5 | Siemek К. | head of sector | Setting up, preparing, carring out an experiment, result analysis | 1,0 |
| 6 | Akhmanova Е. V. | senior engineer | Numerical simulation of the positron dynamics | 0,7 |
| 7 | Yakovenko S. L. | DLNP chief engineer | Experiment setup, the discussion of the results | 0,1 |
| 8 | Orlov О. Yu. | engineer | Carring out an experiment, result analysis | 0,85 |
| 9 | Hilinov W. I. | engineer | Design, manufacturing, mounting of the PAS equipment | 0,85 |
| 10 | Soboleva L. V. | senior engineer | Documentation, preparation and formation of reports | 0,85 |

Schedule and necessary resources for the project

“DEVELOPMENT OF THE EXPERIMENTAL TECHNIQUES AND APPLIED RESEARCHES WITH SLOW MONOCHROMATIC POSITRON BEAMS”

|  |  |  |
| --- | --- | --- |
| Names of costs, resources, and funding sources | Cost(thousands of dollars).Resource requirements | Proposal of the laboratory for the distribution of funding and resources |
| 1 year | 2 year | 3 year |
| Costs | 1. Measuring equipment2. RF components3. Vacuum equipment4. Materials | 70171815 | 20785 | 25555 | 25555 |
| Funding source | Budgetary funds | Budget costs, including foreign exchange funds | 120 | 40 | 40 | 40 |

Cost estimates for the project “DEVELOPMENT OF THE EXPERIMENTAL TECHNIQUES AND APPLIED RESEARCHES WITH SLOW MONOCHROMATIC POSITRON BEAMS”

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NN | Name of cost items | Full cost | 1 year | 2 year | 3 year and so on |
|  | Direct Project Costs |  |  |  |  |
| 1. | Materials | 15 thousands of dollars | 5 | 5 | 5 |
| 2. | Equipment | 105 thousands of dollars. | 35 | 35 | 35 |
| 3. | Travel expenses, includingа) to non-ruble zone countriesб) to cities of the ruble zone countries | 30 thousands of dollars | 82 | 82 | 82 |
|  | Total direct expenses: | 150 | 50 | 50 | 50 |