Registration form for Polish research institution

1. Research institution data (name and address):

   Institute of Physics, Polish Academy of Sciences,

   Al. Lotników 32/46
   PL-02-668 Warsaw, Poland

2. Type of research institution[1]

   1) research unit of the Polish Academy of Sciences

3. Head of the institution:

   Prof. dr hab. Roman Puźniak

4. Contact information of designated person(s) for applicants and the NCN: first and last name, position, e-mail address, phone number, correspondence address):

   Prof. Dr. hab. Magdalena Załuska-Kotur

   Deputy Director for Scientific Affairs

   projects@ifpan.edu.pl

   (+48 22) 116 3515

   Institute of Physics
   Al. Lotników 32/46
   PL-02-668 Warszawa, Polska

5. Research discipline in which the strong international position of the institution ensures establishing a Dioscuri Centre:

Natural Sciences and Technology

■ Condensed matter physics

1 As specified in "Addressees of the call"

6. Description of important research achievements from the selected discipline from the last 5 years including a list of the most important publications, patents, other (*up to one page in A4 format*):

Institute of Physics, Polish Academy of Sciences (IF PAN). Selected important research achievements (2013-2018):

Topological insulators in lead chalcogenides. Demonstration that the metallic topological surface states wrap on all sides the three-dimensional topological crystalline insulator SnTe [1]. Discovery of 1D topological conducting channels adjacent to surface step edges in (Pb, Sn)Se with scanning tunneling microscopy [2] (in collaboration with the group at Wurzburg).

MBE growth of low dimensional structures of II-VI semiconductors. Achieving high degree of control of ZnTe nanowires, allowing to insert into them CdTe inclusions, either axial or radial [3]. Employing quantum Hall ferromagnetic transitions in (Cd, Mn)Te quantum wells to achieve electrostatic control of a single helical domain wall. This is a milestone on the path to creation of a new, scalable semiconductor platform for topological quantum computer [4] (collaboration with the group at Purdue University).

Physics of dilute magnetic semiconductors. Recent review of this field has been published in [5]. Doping of gallium nitride by Mn resulting in a semi-insulating material apt to sustain electric fields as high as 5 MV/cm. Inverse piezoelectric effect controls the magnitude of the single-ion magnetic anisotropy specific to Mn^3 ions in GaN [6].

Molecular spectroscopy used to study interdisciplinary areas at the boundary between physics and chemistry and/or molecular biology. **C**ombined spectroscopic measurements and theoretical calculations bring to light an ultrafast excited-state deactivation process in peptides that may contribute to the ultraviolet photostability of proteins [7]. Characterizing and understanding the photophysics of single molecules in condensed matter [8]

Theoretical studies of ultracold gases: from Bose-Einstein condensates to many-body correlated systems. One recent achievement is using optical lattices as ‘‘toy models’’ for solving problems in solid-state physics [9].

Research in biological physics. The topics deal with bio-nanotechnology, molecular aspects of life processes in a cell, such as protein biosynthesis and mechanical manipulation of biomolecules and virus capsids. One important result concerns searching for molecular origins of Alzheimer’s disease [10].

Important publications:

1. K. Dybko, M. Szot, A. Szczerbakow, M. U. Gutowska, T. Zajarniuk, J. Z. Domagala, A. Szewczyk, T. Story, W. Zawadzki, *Phys. Rev* **B 96**, 205129 (2017).
2. P. Sessi, D. Di Sante, A. Szczerbakow, F. Glott, S. Wilfert, H. Schmidt, T. Bathon, P. Dziawa, M. Greiter, T. Neupert, G. Sangiovanni, T. Story, R. Thomale, M. Bode, *Science* **354**, 1269 (2016).
3. P. Wojnar, J. Płachta, W. Zaleszczyk, S. Kret, A. M. Sanchez, R. Rudniewski, K. Raczkowska, M. Szymura, G. Karczewski, L. T. Baczewski, A. Pietruczik, T. Wojtowicz, J. Kossut, *Nanoscale* **8**, 5720 (2016)

4. A. Kazakov, G. Simion, Y. Lyanda-Geller, V. Kolkovsky, Z. Adamus, G. Karczewski, T. Wojtowicz, and L. P. Rokhinson, *Phys. Rev. Lett.* **119**, *4*, 046803 (2017).
5. Tomasz Dietl and Hideo Ohno, *Rev. Mod. Phys.* **86**, 187-251 (2014).
6. D. Sztenkiel, M. Foltyn, G. P. Mazur, R. Adhikari, K. Kosiel, K. Gas, M. Zgirski, R. Kruszka, R. Jakiela, Tian Li, A. Piotrowska, A. Bonanni, M. Sawicki, & T. Dietl, *Nature Comm.* **7**, 13232 (2016).
7. Wolfgang Domcke and Andrzej L. Sobolewski, *Nature Chemistry* **5** 257 - 258 (2013).
8. Bolesław Kozankiewicz and Michel Orrit, *Chem. Soc. Rev*. **43**, *4*, 1029 (2014) .
9. T. Sowiński, M. Łącki, O. Dutta, J. Pietraszewicz, P. Sierant, M. Gajda, J. Zakrzewski, and M. Lewenstein, *Phys. Rev. Lett.* **111**, 215302 (2013).
10. Mai Suan Li (co-author), *Chem. Rev.* **115**, 3518 (2015).

7. List of no more than 3 important research projects from the selected discipline awarded in national and international calls to the institution in the last 5 years (title, name of PI, source of funding, amount of funding):

Presently 98 different research projects are realized in the Institute. They are awarded by National Science Centre, The National Centre for Research and Development, Foundation for Polish Science, EU Research & Innovation Programs, Simmons Foundation and other sources. Among others, exemplary projects are:

a) **"International Centre for Interfacing Magnetism and Superconductivity with Topological Matter** – MagTop" operates within the International Research Agendas Programme of the Foundation for Polish Science, supported by the European Regional Development Fund under Smart Growth Operational Programme (SG OP), Priority Axis 4: Increasing the research potential, Measure 4.3: International Research Agendas (IRAs).

The grant, awarded to MagTop Leaders **prof. dr hab.Tomasz Dietl and prof. dr hab. Tomasz Wojtowicz**, provides funding of 10 M€ for initial 5 years 2017-2022.
The strategic partner of MagTop is the University of Würzburg

b) **TECHMATSTRATEG1 INNDEX "Technologies of obtaining X and gamma detecting plate using homogeneous (Cd, Mn)Te crystals resistant to radiation caused defects"- Nr TECHMATSTRATEG1/346720/8/NCBR/2017**

Founded by The National Centre for Research and Development"
PI : **prof. dr hab. Andrzej Mycielski**
Amount of funding: 12 403 732 zł
Duration 2018 - 2021

c) **Topological Aspects of Superconductivity and Ferromagnetism Phenomena in Chalcogenides IV – experimental approach**

Founded by National Science Centre
PI **prof. dr hab. Maciej Sawicki**
Amount of funding 2 467 700 zł
Duration: 2018-2021

8. Description of the available laboratory and office space for the Dioscuri Centre (*up to one page in A4 format*):

Institute of Physics, Polish Academy of Sciences (IF PAN). Description of the available laboratories:

Laboratory of Electron Microscopy is equipped with a transmission electron microscope FEI Titan 80-300 Cubed and a dual beam scanning microscope Helios-NanoLab. The Helios-NanoLab 600 is used for FIB sample preparation for transmission electron microscopy as well as for other tasks. The Laboratory performs two test procedures covered by the accreditation of the PCA. Contact persons: assoc. prof. Piotr Dłużewski, e-mail: dluzew@ifpan.edu.pl, tel: (+48) 22 116 33 83

Laboratory of growth and physics of low-dimensional crystals.
Two MBE chambers connected via UHV transfer chambers - in vacuum transfer of substrate holders possible. Growth of II-VI tellurides: Diluted Magnetic Semiconductors „Normal": QWs, SL, QDs including single Mn, sophisticated: parabolic QWs, in-plane graded QWs, DMS nanowires, high mobility 2DEG in DMS. Contact: Prof. dr hab. Tomasz Wojtowicz, wojto@ifpan.edu.pl

Universal Technological Line for Studies of Fabrication Processes of Nanostructures and Prototypes of Semiconductor, Superconductor and Metallic Devices:
Facilities: Reactive Ion Etching (RIE); Atomic Layer Deposition (ALD); UHV Sputtering; Mask Alignment, Wire Bonding, and other processes.
Contact: Dr. Tomasz Wojciechowski: twojcie@ifpan.edu.pl.

Optics Laboratory: IR - VIS - UV optical detection system**;** Microluminescence setup - resolution 2 microns, temperature range 5 - 300 K **;** Raman spectrometer; HeCd laser **;** Coherent Argon ion laser; Coherent dye laser; White light sources. Contact: Dr.Łukasz Kłopotowski, lklopot@ifpan.edu.pl, Dr. Piotr Wojnar, wojnar@ifpan.edu.p

Atomic physics laboratory. Magneto-optical trap for Rb atoms consists to large extent of components designed and built at IF PAN.
Contact: prof. dr hab. Włodzimierz Jastrzębski, jastr@ifpan.edu.pl.

Laboratory of Group of Oxide Crystals Growth. The main subject of research is growth of pure and doped single crystals for various aplications. Crystal growth is performed using Czochralski method, TSSG, Floating Zone and Bridgeman method.
Contact: prof. dr hab. Andrzej Wiśniewski, wisni@ifpan.edu.pl

Laboratory of X ray/UV photoelectron spectroscopy and low energy electron diffraction (LEED). X-Ray Photoelectron Spectroscopy (XPS) provides elemental and chemical information on surface layers or thin film structures. It is of value in many industrial applications including: semiconductor, dielectric materials, electronics, catalysis, corrosion, polymer surface modification, adhesion, etc.
Contact: prof. dr hab. Krystyna Jabłońska jablo@ifpan.edu.pl

Laboratory of Biological Physics. Interdisciplinary research - interface of physics, chemistry, biology and bioinformatics - uses both experimental and theoretical methods. The research belongs to the main trends of fundamental studies of modern biophysics and molecular biology and yet it also aims at generating applications. The topics studied at the Laboratory deal with bionanotechnology, molecular aspects of life processes in a cell, such as protein biosynthesis

and mechanical manipulation of biomolecules and virus capsids. Contact: prof. dr hab. Anna Niedźwiecka, annan@ifpan.edu.pl.

Laboratory of Nanostructures. The Nanostructures Laboratory provides capabilities for the fabrication of advanced submicrometer-size electronic devices. Research activities are focused on design and fabrication of semiconductor, metallic, and superconductor nanostructures by electron beam lithography, and investigations of quantum effects at subkelvin temperatures.
Contact: prof. dr hab. Jerzy Wróbel, wrobel@ifpan.edu.pl

9. List of the available research equipment for the Dioscuri Centre:

Institute of Physics, Polish Academy of Sciences. Available research equipment.

Growth facilities:

- ✓ 3 MBE growth chambers for II-VI, IV-VI and metallic nanostructures growth
- ✓ Newly installed dual growth chamber GENXplor MBE system from VEECO
- ✓ Dual chamber molecular beam epitaxy (MBE) Compact-21 system from Riber, for growth of (InAlGa)N and ZnO, each equipped with up to 11 source cells. Both chambers are interconnected enabling sample transfer under ultrahigh vacuum.
- ✓ Three ALD reactors: F-120 from Microchemistry, TSF200 from BENEQ and Savannah-100 from Cambridge NanoTech for growth of thin II-VI films. The latter enables ultra-low temperature growth (substrate temperature below 200^{o}C).
- ✓ Standard and high pressure Bridgman, as well as vapor transport techniques for single crystals growth of Bi, Sb, Pb, Sn, Zn, Cd chalcogenides and Cd, Zn arsenides, all doped with transition metal

Equipment for nanostructurization and for making devices:

- ✓ Electron beam lithography (EBL), focused ion beam (FIB) lithography, and photolithography
- ✓ ZEISS Auriga – CrossBeam Workstation
- ✓ Reactive Ion Etching (RIE) Inductive Coupled Plasma (ICP) Source (Chlorine) and ICP-RIE with deposition PECVD (Fluorine)
- ✓ Atomic Layer Deposition (ALD) – Remote plasma & thermal ALD FlexAL Oxford
- ✓ UHV Sputtering System with electron gun sources.

Equipment for characterization and advanced studies of various materials and devices:

- ✓ High resolution X-ray and UV photoelectron spectrometer based on VG Scienta R3000 XPS/UPS/ARPES analyzer
- ✓ Dry Dilution Refrigerator Triton 400 Oxford Instruments (temperatures down to 10 mK and magnetic field up to 6 T)
- ✓ 100 microW Oxford dilution refrigerator with measuring apparatus for charge transport, magnetic (SQUID and mutual inductance), and optical properties (fiber glass) down to 25 mK, up to 9 T and under hydrostatic pressure of 6 kbar
- ✓ Cathodoluminescence and Electron Beam Innduced current (EIBC) down to 5 K
- ✓ Set up for quantum transport characterization
- ✓ Set up for Optical characterization
- ✓ SQUID magnetometers Two SQUID magnetometers Quantum Design MPMS XL, 1.9 – 400 K (800 K with added apparatus), up to 5 T in AC, DC, RSO modes.

- ✓ Scanning electron microscope ZEISS Auriga – CrossBeam Workstation (Ion imaging resolution of 2.5 nm at 30 kV, electron imaging resolution 1 nm at 15 kV).
- ✓ Ultra-high vacuum setup equipped with an Auger spectrometer and low energy electron diffraction (LEED) system for surface atomic structure studies.
- ✓ High resolution Fourier Transform Infrared Spectrometer from BOMEM
- ✓ Photoluminescence and photoluminescence excitation setup covering the wavelength range from ultraviolet to infrared (pulsed OPO system in the range of 210-2300 nm, Ti:sapphire cw laser in the range of 700-1100 nm).
- ✓ Photoluminescence under high hydrostatic pressure in a diamond anvil cell.
- ✓ Holographic setup for four wave mixing.
- ✓ Electron spin resonance X- band spectrometer.
- ✓ Optically detected magnetic resonance at 40 and 60 GHz.
- ✓ Laplace/conventional deep level transient spectroscopic (DLTS) systems, enabling Minority Carrier Transient Spectroscopy (MCTS), Photo Induced Current Spectroscopy (PICS), application of uniaxial stress, and VIS-NIR illumination continuous and pulsed.
- ✓ And many others….

10. List of the additional benefits (other than listed in call text) that the Institution declares to provide for the Dioscuri Centre (i.e.: additional funds, personal benefits, other) (*up to one page in A4 format*):

Institute of Physics has very good collaboration with Faculty of Physics University of Warsaw, Faculty of Physics Warsaw University of Technology, Institute of Physical Chemistry, Institute of High Pressure Physics and other Institutes of Polish Academy of Sciences. We realize grants together, attend seminars in these institutions and organize conferences together. All our scientists are welcome to join this collaboration.

We conduct doctoral studies in the Institute and offer to our employees a the opportunity to lecture for students.

All social packets available for employees are offered. We also organize polish language lessons and interested persons can take part in the work of editorial board of Journals we publish in the Institute.

We offer a good atmosphere, many discussions at seminars and in the Labs, at lunches and corridors.

11. Other information about the internationalisation of the research institution, international researchers employed at the institution, the availability of English language seminars etc. (*up to one page in A4 format*):

In the Institute of Physics 36 foreigners are employed at different positions and there are 20 PHD students from abroad. Most or documents inside Institute have their English version.

There are over 10 different seminars each week. All of them are English language i.e.

Monday	10.30	Photophysics and Molecular Spectroscopy Seminar
Tuesday	10.30	Roentgen Seminar

12.00 Theoretical physics seminar

12.00 Seminar of Optical Characterization of Micro- and Nano Objects

14.00 Condensed Matter Physics Seminar

Wednesday 10.00 Magnetism and Superconductivity Seminar

12.00 Fundamentals of Physics

15.15 Biological physics and bioinformatics seminar

Each month we organize COLLOQUIUM of Institute of Physics Polish Academy of Sciences. It is the formal colloquium of the Institute of Physics, Polish Academy of Sciences, the main ongoing periodic series of lectures in physics and related science, of interest to members of the Institute. It is held from 1977.

Additionally we organize seminars, short conferences, meetings devoted to some special subjects and with special guests.