1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

Project title:

"Modern thin-film solar cells with a perovskite photoactive layer".

1.1. Project goals:

I. Simulation and optimization of parameters of perovskite photoactive layers.
II. Application of the PVco-D (Physical Vapor co-Deposition) process to obtain prototype thin-film solar cells with increased efficiency and time stability
III. To determine the influence of structural characteristics on the optical and electrical properties.
IV. To examine the performance of solar cells using investigated materials and estimate other possible applications.

1.2. Outline

This project is dedicated to a new perovskite materials dedicated for photovoltaics and optoelectronics. Investigated materials will contain absorbent like perovskite materials with crystalline structure of ABX_3 (A - is an organometallic compound, B - transition metal and X - a halogen atom), and simple oxides.
Perovskites are minerals occurring in nature, but they may as well produce a by replacing different elements or chemical groups and maintaining a specific crystalline structure Possibility of choosing composition of the perovskites with a wide range of organic and inorganic materials leads to various properties.
A few years ago perovskites were not related great expectations, and today they are undoubtedly the hope of photovoltaics. They can replace the popular so far silicon within the solar cells, which in the final result is more expensive than perovskites. After three years from fabrication of the first perovskites solar cell were achieved - in laboratory scale - an efficiency of 20%. It is the fastest growing technology in the history of photovoltaics.
Research will be focus on the interrelationship that exists between the structure and optical as well as electrical properties, because mainly these properties determine the photo-physical processes responsible for the effective of the increase.
In research, it will be demonstrated that the structures of multiple materials, such as perovskites, organometallic compounds, etc. allow obtaining new generation multi-functional mixed structures. Such structures will be able to be used in various fields such as optoelectronic – as active layers of diodes, and photovoltaics - as photoactive layers inside photovoltaic solar cells.
Realization of the project will allow applicants to answer the following questions:

- how the fabrication techniques and their parameters affect the structural properties,
- how various forms of nanostructures inside thin films affect their physical properties and assess the ability of their applications for optoelectronics and photovoltaics.

1.3. Work plan

1. Initial studies of physical vapor co-deposition technique's conditions as a prerequisite for photoactive perovskite thin films formation.
2. Fabrication of complete solar cell structures.

3. Measurements of structural, optical and electrical properties.
4. Estimation of the other possible applications.
5. Writing scientific papers and PhD thesis; auxiliary calculation.

1.4. Literature

1. A. Zawadzka "Cienkie warstwy i nanostruktury cienkowarstwowe - eksperymentalne metody wytwarzania i badania właściwości", ISBN: 978-83-231-3513-5
2. R Anoua, S Touhtouh, M El Jouad, A Hajjaji, M Bakasse, B Sahraoui, et al., *Environ Sci Pollut Res* (2024). https://doi.org/10.1007/s11356-024-33461-0
3. A Marjanowska, H El Karout, D Guichaoua, B Sahraoui, P Płóciennik, Zawadzka *Nanomaterials* 2024, *14*(1), 50; https://doi.org/10.3390/nano14010050
4. M Lougdali, M Zazoui, R Anoua, Y Abboud, A Zawadzka, et al., *Journal of Alloys and Compounds* 2023, 921, 165947; https://doi.org/10.1016/j.jallcom.2022.165947
5. A Zawadzka, A Marjanowska, P Płóciennik, A Korcala, K Wiśniewski, et al., *Organic Photonic Materials and Devices* XXII 2020, 11277, 59-65
   Proceedings Volume 11277, Organic Photonic Materials and Devices XXII; 112770S (2020)
   https://doi.org/10.1117/12.2545957

1.5. Required initial knowledge and skills of the PhD candidate

1. Thorough knowledge of the physics of solids, thin films and nanostructures.
2. Knowledge of PVD and Sol-Gel techniques.
3. Knowledge of phase transformations occurring in materials under the influence of temperature changes.
4. Knowledge of basic electrical parameters of the solar cells.
5. Experience in experimental work related to: transmission spectroscopy, Raman spectroscopy and photoluminescence, XRD and AFM, photovoltaics effect.
6. Basic knowledge in electronics is also desired, since the student will carry on measurements using various experimental setups, all of them full of electronic items and devices.

1.6. Expected development of the PhD candidate's knowledge and skills

The student will master several experimental techniques for studying optoelectronics and photovoltaic properties. He/she will also learn the fundamentals of nanostructures and thin films' processes and applications. He/she will improve his/her data analysis and concluding data skills.