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

Project title:

"Photovoltaic and nonlinear optical effects of the perovskites thin films".

1.1. Project goals:

I. To explore and examine the PVD and spin-coating techniques for the fabrication of perovskites thin films.
II. To determine the influence of structural characteristics on the optical and electrical properties.
III. To examine the applicability of the proposed materials for nonlinear optics.
IV. To examine the performance of solar cells using investigated materials and estimate other possible applications.

1.2. Outline

The main scientific goal of the project is to clarify the impact of the structural properties of perovskite thin films on their optical and electrical properties and the mechanisms of nonlinear optical phenomena. The research hypothesis assumes that the type of obtained structures strongly dependent on the process used to prepare them, primarily the composition and pressure of the surrounding atmosphere as well temperatures of the substrate and/or process heating. The change of the structural properties leads in turn to changes in optical and electrical properties.

In research, it will be demonstrated that the structures of materials, such as organic and inorganic perovskites, allow obtaining new generation multi-functional mixed structures. Such structures will be used in various fields such as photovoltaics - as photoactive layers inside photovoltaic solar cells and nonlinear optics – as optical limiters and thin layers that multiplicate the frequency.

Realization of the project will allow applicants to answer the following questions:

- how the fabrication techniques and their parameters affect the structural properties,
- how structural properties affect electrical and optical physical properties and assess their applications for photovoltaics and nonlinear optics.

1.3. Work plan

1. Initial studies of physical vapor deposition and spin-coating technique's conditions as a prerequisite for thin film formation.
2. Fabrication of thin films of the above-mentioned chemical compounds.
3. Measurements of structural, optical and electrical properties.
4. Deposition of multilayer structures – examination of the proposed materials as the active layer of solar cells.
5. Estimation of the nonlinear optical properties and applications.

6. Writing scientific papers and PhD thesis; auxiliary calculation.

1.4. References

1. A. Zawadzka "Cienkie warstwy i nanostruktury cienkowarstwowe - eksperymentalne metody wytwarzania i badania właściwości", ISBN: 978-83-231-3513-5
2. M. Petrović, V. Chellappan, S. Ramakrishna, *Solar Energy* **122** (2015), 768-699; DOI: 10.1016/j.solener.2015.09.041
3. Xu, J., Li, X., Xiong, J., Yuan, C., Semin, S., Rasing, T., Bu, X.-H., *Adv. Mater.* 2020, 32, 1806736. https://doi.org/10.1002/adma.201806736
4. Ch. Yuan, X. Li, S. Semin, Y. Feng, T. Rasing, J. Xu, *Nano Lett.* 2018, **18, 9**, 5411–5417, DOI: 10.1021/acs.nanolett.8b01616
5. G. Niu, X. Guo, L. Wang, *J. Mater. Chem. A*, 2015,**3**, 8970-8980

1.5. Required initial knowledge and skills of the PhD candidate

1. Thorough knowledge of the physics of solids and thin films.
2. Knowledge of PVD and Sol-Gel techniques.
3. Knowledge of phase transformations occurring in materials under the influence of temperature changes.
4. Experience in experimental work related to: transmission spectroscopy, Raman spectroscopy and photoluminescence, XRD and AFM, photovoltaics effect.
5. 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 used to study nonlinear optical and photovoltaic properties, as well as he/she will learn the fundamentals of processes occurring in thin films and their applications. He/she will improve his/her skills in data analysis and drawing conclusions from data.