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Report on the manuscript submitted by Mrs Agnieszka Marjanowska to obtain the PhD degree

This manuscript titled “*Photovoltaic and nonlinear optical effects of thin films based on perovskites*” submitted by Mrs Agnieszka Marjanowska describes her research work in the fields of non-linear optical and photovoltaic properties of perovskites-based materials. The manuscript is overall well written in English and well organized which makes it easy to read and to follow. There are several minor typographical and layout errors that need to be adjusted. The references are always highly relevant. This research work has been led in cotutelle between Université d’Angers and Nicolaus Copernicus University, Torun.

The dissertation begins with a very short general introduction (two pages) to give an overview and organization of the manuscript followed by two chapters 1 and 2 as more specialized introduction to the two different topics studied in this work.

The first chapter (18 pages) that describes the general and fundamental aspects of photovoltaic properties and applications. Chapter 1 describes the energy band models and the semiconductor *p-n* junction in organic and inorganic materials for applications in solar energy conversion. This chapter also explains the electrical descriptor of photovoltaics and gives the classification of photovoltaic cells including perovskite photovoltaic cells, as well as the recent advances in photovoltaic technology.

Chapter 2 (27 pages) describes the nonlinear optical effects and their physical origin. This chapter discusses the physical equations that describe light propagation in various media and the second/third-order nonlinear optical effects are presented. In particular the nonlinear absorption and changes of the refractive index are discussed. Finally, nonlinear optical applications in several fields such as telecommunications, photonics, medicine, and quantum technologies are accurately reviewed. Chapters 1 and 2 give a complete and useful introduction for the understanding of the content of the subsequent chapters 3 and 4.

Chapter 3 (34 pages) is dedicated to the description of the experimental techniques and set-up of the different measurements in this research work. The chapter describes the preparation of

perovskite-based thin films and the techniques to study the structural, optical and photovoltaic properties. A detailed description of the physical vapor co-deposition (PVco-D) technique used in this work is provided. Then description of AFM technique, standard UV-VIS-NIR spectroscopy, PL measurements, are explained. This chapter also provides a detailed description of the measurement equipment used to investigate nonlinear optical effects with the theoretical models. Chapter 3 concludes with an explanation of the electrical measurement technique used to determine the photovoltaic parameters of solar cells.

The last and longest chapter 4 (70 pages) presents the results obtained during this research work. Chapter 4 starts with a general description of the studied perovskites materials followed by details on the preparation of thin films of hybrid perovskites using the PVco-D technique. 14 samples were prepared and tested. Chapter 4 provides the results of AFM structural studies, UV-VIS-NIR spectroscopic studies, aging tests, phase transition studies, and nonlinear optical effects (SHG, THG, and Z-scan). The chapter finishes with description the prepared photovoltaic materials and the resulting electrical properties with determination of the key parameters characterizing these photovoltaic cells. Chapter 4 compares a given property across all the samples studied.

A concise (2 pages) summary and final conclusions of the dissertation is given. Perspectives for future research directions on perovskite materials in the context of photovoltaics and nonlinear optics applications are also presented.

In summary, the manuscript presented by Mrs Agnieszka Marjanowska is of high scientific quality. This work has already been disseminated in several publications and communications that are listed at the end of the manuscript, which is remarkable. Mrs Agnieszka Marjanowska also attended several conferences providing 8 oral and 3 poster presentations. The results are well presented and discussed, the manuscript is made easily readable even to non-specialized scientist besides the high diversity of analytical techniques that were well described in chapters 1 and 2.

I am extremely favorable to the defense of this dissertation by Mrs Agnieszka Marjanowska.

Dr. J. Moussa (Prof. Assoc.)