DZIEKANAT WYDZIAŁU FIZYKI
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Report on the PhD thesis manuscript of Krzysztof Galkowski

Dear Colleagues and examination Committee,

The manuscript proposed by Mr. Krzysztof Galkowski is dedicated to an experimental study of halide perovskites materials, which appeared recently as a promising alternative to existing bulk and thin-film solar cell technologies. Besides photovoltaic applications, halide perovskites can be considered as a new class of semiconductors already showing additional optoelectronic applications. The work of Mr. Krzysztof Galkowski represents a major contribution toward a deeper physical description of these new materials. The long papers list of Mr. Krzysztof Galkowski also clearly demonstrates his potential for a scientific career that he certainly deserves.

Besides a huge activity on various topics, Mr. Krzysztof Galkowski also demonstrates an excellent ability to perform state of the art spectroscopy studies in the very competitive field of hybrid perovskites for photovoltaics. His contributions directly addressed key open questions for hybrid perovskites, leading to major steps forward in the understanding of their fundamental properties, as well as enhancements of device performances. The experimental work of Mr. Krzysztof Galkowski also shows that he was able to benefit from collaborations at the international level.

1) The fundamental question about the nature of charge carriers at room temperature (excitons versus free carriers) for this new class of semiconductors in operating devices was put forward as early as 2013 by most authors and the subject of intense debates in international conferences. Our team in Rennes predicted in 2014 a strong exciton screening at room temperature, due to phonons and molecular relaxation, but in apparent contradiction with very precise spectroscopy contributions from Japanese groups exhibiting clear excitonic features with strong binding energies at very low temperatures. Krzysztof Galkowski's contributions published in high impact journals definitively solved this important paradox, by carefully determining the exciton physical parameters. The ongoing extensive studies on both organic and inorganic halide perovskites further demonstrate that the chosen experimental approach was fruitfull.
2) Mr. Krzysztof Galkowski also addressed the question of halide perovskite structural instabilities and microstructuration with spatially resolved microphotoluminescence. This fundamental study is also at the center of intense scientific discussions, because halide perovskite materials are used

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for practical applications as thin-films. It is clearly demonstrated in this study that optical studies may yield useful informations on the lattice strain, phase coexistence and lattice defects. Temperature or light soaking effects are also considered.

Among the various questions opened thanks to this work and that might be further discussed by Mr Krzysztof Galkowski during the oral defence, one may consider:

1) the influence of the fine structure of the exciton on the measurements (manuscript p51), providing that the spin in the conduction band is not a real spin, but a pseudospin associated to a spin-orbit split-off state

2) a discussion about basic landau theory of the reconstructive tetragonal to orthorhombic phase transition, providing that the I4/mcm and Pnma space groups share a common supergroup (Pm3m) , especially in the context of strain/defect exciton localisation (manuscript p77)

3) the possible influence of the non-cubic structures on the exciton: besides screening and band gap shifts, what could be expected from anisotropy and symmetry breaking (manuscript p49) for the exciton.

In summary, Mr Krzysztof Galkowski, certainly deserves the title of Doctor from Toulouse and Warsaw universities. I am sure that Mr Krzysztof Galkowski will considerably extend and strengthen his scientific activities in the future. His PhD work on hybrid perovskites is a key contribution to this emerging field. This manuscript has my highest recommendation. The thesis fulfils conditions required in Poland from PhD thesis.

Rennes, 19th December 2016

Sincerely,
Jacky EVEN

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