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**Subject:** Report on the Habilitation Thesis “Fast-switching photonic crystal fibers infiltrated with ferroelectric and nematic liquid crystals” by Dr Daniel Budaszewski

Dear Scientific Council of the Physical Sciences Discipline Warsaw University of Technology,

Dr Daniel Budaszewski has submitted a Habilitation Thesis consisting of a cycle of eight articles [H1-H8] published most of them in leading journals with high impact factor. He is an experimental researcher who tackles the design, production and characterization of fiber components made up of specialty optical fibers functionalized by inserting in them different liquid crystals. For almost fifteen years since his thesis defense, he has studied different configurations (different photonic crystal fibers, different liquid crystals with different concentrations, adding different nanoparticles...) with the aim of improving the performance of this association combining optical fibers with holes close to the core (so that the guided light can be impacted by the liquid crystal) and the possible orientation of liquid crystals by the application of an external electric field. He was thus able to observe, analyze and interpret numerous experiments concerning in particular the evolution of electro-optical response time (rise times and relaxations times) as a function of the numerous aforementioned parameters.

First [H1] Dr Daniel Budaszewski did develop a method for effective photo-ordering ferroelectric liquid crystal molecules in a medium with cylindrical symmetry (as present in the cladding of photonic crystal fibers) by using ultraviolet light and SD1 material chromophores. He not only checked the quality of the generated photo-alignment of the ferroelectric liquid crystal molecules via this method but also demonstrated the possibility to get periodic orientation of the ferroelectric liquid by using a double UV light irradiation. Once this first step on a single capillary done, Dr Daniel Budaszewski tackled the problem to selectively fill air holes of a birefringent photonic crystal fiber (PCF made of about 100 holes with two larger ones than the others to get the birefringence) and adapt the method to insolate correctly these two holes. He demonstrated the possibility to modify the polarization state of the light at the fiber output by applying an electrical field [H2]. He then studied the impact of different concentrations of

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silver and gold nanoparticles (of 8 and 4 nm diameter respectively) on rising times and relaxation times [H3 and H4]. One of the important results brought by these studies is the demonstration of the decrease in rise times with the addition of nanoparticles (up to a certain concentration) but with an almost systematic increase in relaxation times. To overcome this limitation, Dr Daniel Budaszewski carried on new investigations [H6 & H7] with smaller gold nanoparticles (2nm of diameter) and succeeded in decreasing both rising and relaxation times (even if the effect is clearly less marked at the highest values of the applied field) for both nematic [H6] and ferroelectric [H7] liquid crystals. Similar behaviors have been demonstrated with titanium dioxide nanoparticles [H8]. In H5, Dr Daniel Budaszewski measured the impact of the addition of liquid crystal on the optical losses of the fiber (of the order of 3dB over 8mm of propagation) and experimentally highlights (using the so-called three -stage rectangular signal) much shorter rise times and relaxation times (by approximately 2 orders of magnitude) in its structure with ferroelectric liquid crystal than those obtained with nematic liquid crystal.

In conclusion, the work of Dr Daniel Budaszewski made it possible to master, using UV exposure, the arrangement of different liquid crystals in hollow capillaries of the order of few microns in diameter in photonic crystal fibers and to determine the influence of the size, concentration and composition of nanoparticles on the spectral and electro-optical properties of nematic and ferroelectric crystals. He has been once a supervisor of a Ph'D student but on a different subject (fiber Bragg sensors) from that presented here. He was the leader of 6 national projects (the importance of which I find difficult to assess in terms of finances and people involved) and investigators in 8 other projects including 2 internationals. Note that the candidate did a foreign internship at HKUST in Hongkong (few months with Prof. V. Chigrinow). Although I do not consider the candidate's achievement to be of an exceptionally high standard, I would nevertheless recommend the Habilitation Thesis to the Faculty for its acceptance.

Villeneuve d'Ascq, 20/03/2024



Prof. Géraud Bouwmans