Funded Ph. D. thesis proposition

Title: Photonic Crystal Fibers for high power/energy lasers: beam transportation/generation and high quality spatial shaping

Host laboratory

This Ph. D. thesis is co-funded by University of Lille and CEA CESTA (Bordeaux), within the framework of the SYLFE laboratory [1] that gathers the Photonic team of PhLAM laboratory (UMR8523) and the laboratory Opto-Electronique du Département Lasers de Puissance at CEA CESTA. The work will take place at IRCICA (USR3380) in Villeneuve d'Ascq (France) within the PhLAM's Photonic team. The research activities of this team are structured around the Fibertech technological platform dedicated to studies and realization of innovative optical fibers. This group (~ 40 people) generates scientific production of about 30 publications per year and constitutes one of the first main research centers in France in its field.

The retained person will benefit from skills and means in modelling, realization and characterization of optical fibers, thanks to Fibertech platform. This platform is a unique center in France gathering in a single entity 3 complementary methods of high quality glass manufacturing (MCVD, OVD, Sol-Gel) and 3 capillary and fiber drawing towers.

Description of the Ph. D. thesis topic

For fifteen years, fiber amplifiers and lasers have greatly developed. They are of course an essential part of the current very high speed telecommunications but they also play a very important role in various fields of physics, biology and health as well as industrial markets such as material machining (etching, cutting…). This growth is related to intrinsic benefits of the fiber (compactness, robustness, beam quality...) and the continuous increase of fiber laser optical power.

Nevertheless, main industrial applications (machining, biology...) as well as laser facilities like Megajoule laser will greatly benefit from fiber lasers delivering *flattened single-mode beam* (homogeneous intensity) with high energy/power and with controlled polarization. In this context, the PhLAM laboratory, closely with the CEA/CESTA, has designed and realized *two world firsts:* a single-mode air-silica microstructured fiber delivering a flat mode [2] and an extended version preserving the light polarization [3].

Moreover, it is also important to design an all-fiber system that could transport high power and high spatial quality beam free from deleterious effects (non-linear effects, FM/AM modulations...).

The proposed thesis will carry on this work (accredited by *Equipex Flux [4] and CPER Photonics for society*) aiming, firstly, at increasing the diameter of the fundamental mode to amplify at higher energies/powers and, secondly, at amplifying directly in the polarization maintaining fiber delivering the flat mode. ***Different original strategies to increase the effective area*** of the fundamental mode while eliminating other modes, deleterious to the spatial quality and stability of the laser, ***will be studied theoretically and experimentally***. ***The work will also aim at a better understanding of the impact on the modal properties of the fiber of various manufacturing steps, bends and thermal effects*** generated in

use. A second issue concerns the design and realization of high power transmission fibers free from non-linear effect over tens of meters: a thorough study of different fiber designs including photonic bandgap hollow core fiber will be undertaken. The ultimate goal is an implementation on the front-end of Mega-Joule laser [5].

The applicant for the thesis will rely on the knowledge and skills of members of the laboratory SYLFE (PhLAM-CEA CESTA), as well as on Fibertech platform. The applicant will have the opportunity to work on the entire project (***theoretical models and simulations, realizations and optical characterization*** of the realized fibers) according to his preferences and skills.

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Location: IRCICA/PhLAM, 59658 Villeneuve d'Ascq, France

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