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**Research on specialty optical fibers: tribute to Indian-French academic collaborations.**

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*Abstract: Because this symposium is also organized to mark the establishment of Optics and Photonics at IIT-Delhi, this talk will aim at paying a tribute to the collaboration between our two institutes in the field of fiber optics, and evoke recent and present investigations carried out in our institute, which are the consequences of this fruitful collaboration.*

Research and development in the field of fiber optics has seen such an incredible activity since the first proof of applicability in the 60's that our every-day life has been immensely changed. Thanks to continuous efforts in fundamental and applied research, key technologies have led to the development of optical telecommunications. Among key technologies, optical fiber technologies have allowed this revolution in only few decades, from the 60's (first objective proposal by Charles K. Kao [1]), through the 70's (first 'modern' silica fibers and systems), the 80's (fabrication of Rare-Earth-doped fibers [2], and light amplification in Erbium-doped fibers [3]), the 90's (first submarine transcontinental optical telecommunications cables). From the turn of the millennium up to now, overcoming technological barriers one by one made it possible to continuously increase the capacities of telecommunications systems. More recently, alternative fields of application have diversified from telecommunications to the fields especially since the beginning of this millennium, for example, fiber laser sources in an extreme variety of characteristics, and multi-factor fiber sensors organised in networks,.

In this race for performance, the design and manufacture of original and dedicated optical fibers have been taken to very strict limits, precision, as well as diversity [4], in terms of materials composition, waveguide concepts, microstructure and even nanostructure. In this context, many research groups have collectively contributed to the deepening of knowledge, which is crucial for technological and industrial developments. The community involved in research in the field of specialty optical fibers is today very rich, varied and globally distributed around the world.

In this exciting mood, our institute [5] has established a collaboration with the IIT-Delhi Physics Department. This fruitful meeting was led initially by Profs. D.B. Ostrowsky (LPMC) and K. Thyagarajan (IITD) on integrated optics components, thanks to the support of IFCPAR [6], shortly followed by a collaboration on Dispersion Compensating Fibers (DCF) by Prof. B.P. Pal (IIT-D) and Prof. G. Monnom (LPMC) from 1999 onwards. In particular, very efficient DCF and Er-doped DCF (ErDDCF) were successfully demonstrated (Fig. 1) [7,8].

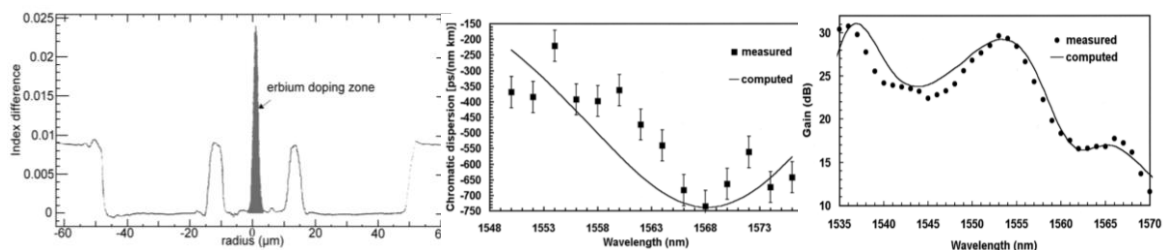


Fig. 1: Er-doped DCF: (left): refractive index profile of the fiber, (center) its chromatic dispersion, (right) its partially compensated gain across the C-band. From [8]. Note that Ref [7] had shown a record negative dispersion to -1800 ps/nm/km

Following the great success on DCF compensators, a Joint Network Research Project involving both Indian and French funding bodies, has linked four french Institutes and four Indian institutes from 2004 to 2010 [9], to investigate original ideas to flatten the gain from EDFA for metro applications. The approach was transdisciplinary (optical engineering, material engineering, glass science, micro- and nano-structuration of the waveguides and materials, etc). From this joint work, new ideas emerged that were not initially foreseen on the scope of the program. They initiated investigations on topics and ideas that emerged from this collaboration. Some present investigations in our institute are still inspired from that Indian-French collaboration. For example, fully solid and 1-D Large Mode Area fibers were proposed for powerful laser transversally singlemode delivery [10], as well as intrinsically gain flattened Erbium doped fiber amplifier for telecommunications [11], and more recently complex few-mode EDFA with equalized gain [12]. Exploration toward 2  $\mu\text{m}$ , using Thulium doping was also investigated, using optical engineering [13] as well as materials investigations to the nano scale [14]. In all these investigations, we express our tribute to the members of the Physics Dept at IIT-D, and to their former students whom are now active in other academic and industrial positions. Collaborations with other Indian institutes, as well as with Indian collaborators from all over the world have been engaged.

During our talk, some salient results of these collaborations will be presented or recalled. They will be linked to recent and current investigations in specialty optical fibers carried at INPHYNI. Perspectives toward short and longer terms in the design and fabrication of future and innovative optical fibers will be discussed.

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