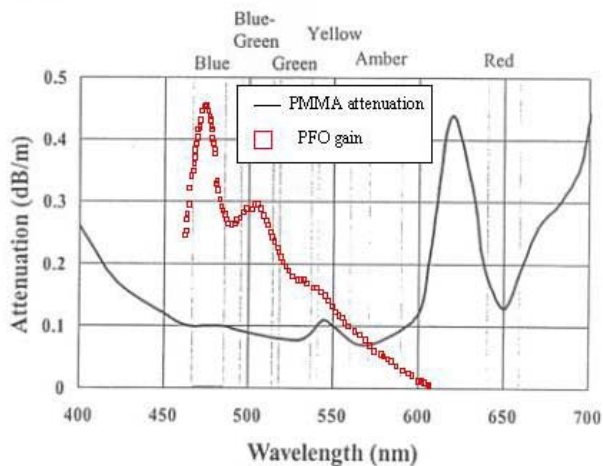


POLYCOM

The main objective of this project is the development of active Polymer Optical Fibers (POFs) and plastic waveguides for optical amplification to enhance the maximum communication distance, allowing, for example, supply chain management to be more readily implemented. Such active POFs will allow for subnanosecond all-optical as well as electro-optical switching inside the fibre. These two parameters provide the key to high-speed data transmission beyond 100 Gb/s, the maximum network speed achievable nowadays, and it is expected that polarization-independent operation may be achievable. Note that most conventional devices, based on electro-optics or non-linear optics, need polarized light beams, thus introducing further requirements to the system as a cause of failure. The proposed active device could have the same impact as Er⁺-doping had for Silica fibres, leading to a significant scientific, technological and economic impact in a number of present and future applications.

Our innovative approach to achieve amplification and switching in POFs is the inclusion of strands of highly fluorescent isolated conjugated polymers (ICPs) into host polymers (such as the commonly-used poly(methylmethacrylate), or PMMA). These ICPs can have unique photophysical properties with respect to non-isolated chains. Poly(9,9-dioctylfluorene), PFO, based ICP have shown wide optical gain windows (with peak enhancement of 10³ db/cm measured in normal film transmission geometry) in wavelength regions where POF attenuation is low. The reason for this behaviour is the suppression of charge carriers, that, in the case of condensed polymer films, with interacting neighboring chains, lead to undesired absorption in the gain region. In ICP, one-dimensional geminate recombination of photogenerated charges results in a very low stationary density of such charged states. Under these conditions the gain ($\sigma_{SE}N_S$) is given by the product of the cross-section for stimulated emission (σ_{SE}) and the population inversion (N_S). However, charged states can be generated deliberately if ultrashort laser pulses are applied to the ICPs under gain operation. In this case, the stimulated emission is reduced due to partial dissociation of singlets into two opposite charge carriers, and a strong charge absorption arises. The result is gain reduction given by $N_C(\sigma_{SE} + \sigma_C)$ where σ_C and N_C refer respectively to the charge absorption cross-section and the charge-pair population. The laser pulses can therefore be used to switch off the ICP gain and according to our reports, a gain reduction of more than 90% is achieved. The laser pulses can therefore be used to switch off the ICP gain and according to our reports a gain reduction of more than 90% is achieved, (see Fig. 1).

Typical Spectrum of PMMA Fiber



Switching principle

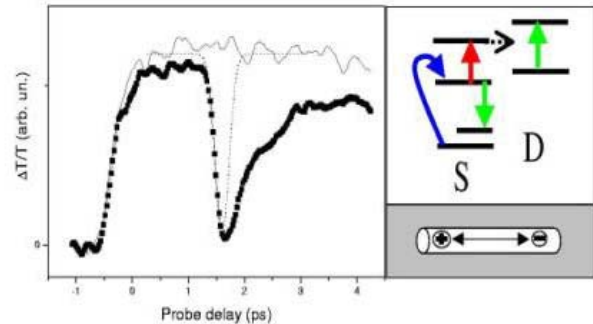


Figure 1

As geminate recombination of charge carriers in one-dimensional systems is ultrafast and complete, the gain will recover completely only 2 picoseconds after the switching pulse. This principle has been patented by one of the authors in 2003 and allows for picosecond to subpicosecond optical gain switching in ICPs.

Moreover, geminate charges can also be created by exciton dissociation under an electric field leading to electro-optical switching. Since the gain reduction is proportional to number of charges, the assistance of an electric field to the optically-induced dissociation process would surely contribute to enhance the switching efficiency inside the fibre.

We are investigating and synthesizing active materials with optimised properties for ICP: low aggregation tendency and optical gain and switching in different regions of the visible and near infrared.

The inclusion of ICP into host polymers is being achieved by a number of physico-chemical and chemical methods at various different laboratories around Europe. The morphology of the active polymers is being thoroughly studied and compared to their switching efficiency. These investigations are initially done in films, which are easier to handle under laboratory conditions and for which we have considerable experience. They are then performed on the POFs and waveguides. Different techniques such as ellipsometry and near field microscopy are employed as a probe for homogeneous distribution of ICPs.

POFs doped with ICP are produced by our industrial partner, LUCEAT Spa. These are benchmarked according to industrial requirements. Losses and gain as well as the switching efficiencies are quantified and optimized by a constant feedback loop between characterization and material synthesis/fibre production. A coupling demonstrator will be manufactured, where a carrier pulse is amplified and switched on and off directly in a short piece of fibre without any transceiver involved, (see Fig.2). Couplers are routinely produced by LUCEAT with typical excess losses of 1.5 dB.

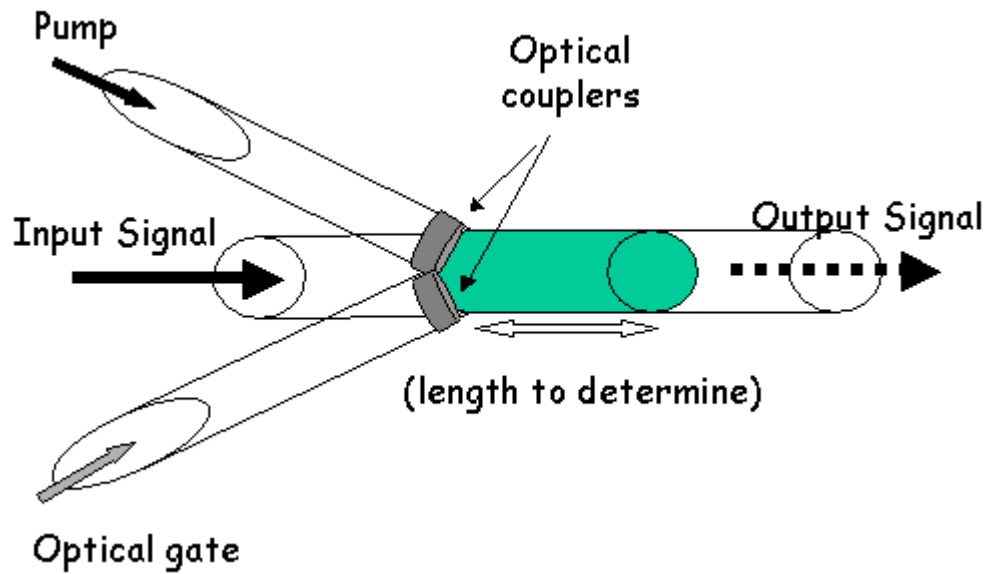


Figure 2

POLYCOM comprises a consortium of groups from Italy, Portugal, Germany and the United Kingdom containing experts in organic photonics, morphology, spectroscopy, synthesis and in producing and characterising POFs. We work closely together to achieve the goals of developing of low-loss polymer optical fibers and waveguides with integrated gain and ultrafast optical switching functionalities

- project the link to the project website.

<http://www.fisi.polimi.it/polycom/>