All optical switching: towards an "optical transistor"

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Optics is an obvious choice for the transmission of the information, which is processed (e.g. header recognition prior to routing, error correction ...) using logical operations on signals whose bandwidth is constantly increasing. The current approach requires the conversion from the optical to the electrical (OEC) domain (and conversely), as these operations are performed in electronic circuits. The OEC is responsible for substantial energy consumption. Furthermore, the generalization of optical links, also to short distances (e.g. the optical cable) and considering the perspective of on-chip interconnections, makes signal processing at the optical level (without OEC) strongly desired. However, to be competitive with respect to electronics, all optical processing has to be performed with very low power consumption. Power consumption lower than 100fJ per bit has been recommended as prerequisite to any prospect of integration.

Few technologies are able to face these challenging specifications, one of them being Photonic Crystals. Their unique properties in terms of spatial and temporal confinement through nano-cavities are particularly interesting to enhance non-linear effects. A promising approach is based on two-dimensional photonic crystals. The implementation of these concepts in III-V semiconductor alloys, allowed TRT to demonstrate that the enhancement of carrier dynamics in such structure, results into an ultra-fast response (<10ps), which makes clear the advantage of nanotechnology over conventional photonic device fabrication. More recently, the group of M. Notomi at NTT has demonstrated the laser with the lowest energy consumption (about 1fJ/bit) based on photonic crystals. An all-optical memory has also been demonstrated by the same group.

In the discussion session, I will frame all the recent results in the context of integrated optics, a topic started forty years ago at Bell Labs. We will see how recent advances in nanofabrication, especially in the realization of structures exalting the light-matter interaction, make this old dream possible. I will conclude by commenting, from an applicative point of view, the perspectives of the integration of these advanced nonlinear functions on more complex photonic circuits.