Polymer-Based Nanowires and Nanotubes: nanosources, wave-guiding

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Abstract: One-dimensional polymer-based nanostructures such as nanowires (NWs) and nanotubes (NTs) are nowadays intensively investigated since they promote enhanced properties, as well as new paradigms for electronic, optical, optoelectronic, and photonic devices (Garreau *et al.*, 2014).

Here, we propose a review of recent developments achieved in our group with collaborations on polymer-based nanowires and nanotubes. Various polymer-based NWs and NTs were synthesized by template strategies with advanced architectures designed for improving their functionality (waveguiding, color control of photoluminescence, photoconductivity and mechanical reinforcement,…). Both conjugated polymers (CPs) and photoresists containing photoactive species (transition metal compound clusters, single-walled-carbon nanotubes SWCNTs) were involved. The focus is made on the emerging strategies for understanding and controlling the behavior of charges, excitons and photons, as well as light propagation in sub-wavelength nanostructures.

First, an original design was realized to control accurately the color of photoluminescence in organic nanostructures (Garreau *et al.*, 2013). It consists in minimizing the role of charge and energy transfer mechanisms between two types of luminophores. This was achieved by an optimized spatial separation at the nanoscale with nanowires in a coaxial geometry: a green polymeric emitter shell (poly-para-phenylene-vinylene PPV) and a red phosphorescent emitter core ($[Mo_6Br_8F_6]^{2-}$ clusters@poly(methyl methacrylate) PMMA). In addition, the choice of luminophores was motivated to get a spectral separation, i.e. distinct color of PL emission, as well as no overlapping of their absorption and emission spectral range. Thus, it is possible to anticipate and to control simply the color of the emitted light on the chromaticity diagram as an interpolation of the CIE coordinates of each luminophore. This design make possible to reach a very sharp color change within 10 nm scale. Additionally, unique proportion equal typically to 1:1 for the green and red luminophores are required.

Second, we report light injection and sub-wavelength propagation in nanotubes made of SU-8, a photoresist used for integrated photonics. Nanotubes have been rarely investigated as waveguides. However, it is a very promising geometry for highly integrated photonic devices, as shown by theoretical simulation by finite domain time-dependent (FDTD) method (Bigeon *et al.*, 2014). The features of direct light injection and subwavelength propagation regime within nanotubes were determined. The injection into nanotubes of SU8 was successfully achieved by using polymer microlensed fibers with sub-micronic radius of curvature. The propagation losses into single SU8 nanotube were determined. The attenuation coefficient has been evaluated at 1.25 dB/mm by a cut-back method transposed to such nanostructures. The mechanisms responsible for losses in nanotubes were identified in view of FDTD theoretical support.

These recent advances in polymeric based NWs and NTs contribute to open new ways for the next generation of optoelectronic and photonic integrated devices.

Keywords: Nanowires, Nanotubes, Polymer, Nano-optoelectronics, Nanophotonics.

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