Micro- and nano-scale soft matter photonics: molecules and polymers for lasers and nonlinear optics

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The field of molecular photonics is currently experiencing a significant revival of interest due to a number of reasons which will be outlined and exemplified in this talk. Current and future broadband telecommunication systems based on wavelength division multiplexing (WDM) schemes are hampered by limitations of inorganic technologies. Initially proposed in the mid- to late 1980s, electrooptic polymers have recently emerged as strategic contenders with a demonstrated potential for high frequency electrooptic modulation well above 100 GHz, unmatched by any other technology. The unlimited bandwidth of the non-resonant electronic hyperpolarizabilities at the root of the electrooptic effect and the favourable matching of optical refractive index with correspondingly low HF dielectric constants stand out as the main enabling features of polymers towards high speed operation. A number of passive and active functions such as filtering, switching or routing are now implemented in polymer devices benefiting from the increasing availability of low loss materials with high glass transition temperatures ensuring excellent stability and electrooptic coefficients comparable to or higher than lithium niobate. Based on the adaptation to organics of otherwise well established processing, a full-fledged polymer based technology is now available to implement practically any conceivable optical circuitry on top of any mineral (e.g. Si and GaAs) or organic substrate, including flexible ones.

Whereas initial work in polymer based photonics was mainly focusing on channel waveguide architectures, more advanced structures are being increasingly explored such as microcavities based on planar, ring or disk geometries and photonic crystals. Micro-laser sources with sizes in the range of 10 to 100 µm now span the full visible to near IR range based on the outstanding luminescence efficiencies and good stability of organic dyes and conjugated solid-state polymers.

Advanced structures at the micron and sub-micron scales based on laser induced reorientation and displacement effects is likely to have a significant. Indeed, quantum interference of different absorption pathways make it possible to engineer (without resorting to high temperatures) unlimited patterns of optical properties for such applications as high density optical storage, nonlinear holography, photonic crystals, *etc.* This domain is particularly illustrative of the virtues of soft matter photonics, whereby photosensitive molecules can be reoriented at will in condensed phases so as to allow for the local imprinting of desired optical properties.

Fascinating and relatively untapped possibilities at the nanometer scale are becoming accessible thanks to the increasing availability of advanced instrumentation techniques such as scanning tunneling, near field or confocal microscopy. The possibility to functionalize polymer spheres of submicrometer size with luminescent semiconductor shells and to further arrange them in pre-organized 2-D and 3-D arrays and stacks with photonic crystal-like periodicity will be discussed in this perspective.