Organic and Hybrid Materials for Photonics and Electronics

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Polymethine dyes are promising materials for all-optical signal processing (AOSP) but efforts to utilize these dyes at high concentrations have been impeded by aggregation and other effects that have deleterious effects on the optical nonlinearity and optical absorption loss. We are researching strategies to block polymethines from aggregating by substitution with rigid, bulky groups that project out of the plane polymethine. This approach has lead to high-number-density films with macroscopic nonlinear optical properties and high two-photon figures of merit close to those needed for AOSP. The polymethines developed also exhibit a negative $\mathrm{Re}|\chi^{(3)}|$ that is useful in the compensation of spectral broadening in optical fibers.

Dielectric materials possesing high energy density are are of great interest for energy/power storage applications. Charge injection into the dielectric is undesirable as it leads to poor energy extraction efficiency. Bilayer capacitors based on silica-organic hybrid sol-gel materials exhibit high dielectric constant and breakdown strength through incorporation of nanoscale charge-blocking layers. Blocking layers with thicknesses in the range of 100 nm to ~1 nm deposited between have been the dielectric film and the metal (Al) electrodes have led to large improvements in energy density and extraction efficiency. Our investigations provide insights into the development of high-performance dielectric materials/devices from organic/inorganic hybrid materials.

Theory of Transfer Processes in Nano-Hybrid Systems

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The talk reviews recent work on photoinduced processes in hybrid systems formed by metal nano-particles, supramolecular systems, and semiconductor nano-crystals. In a first part a brief overview is given on metal nano-particle induced transient enhancement effects on molecular emission spectra [1,2]. Work related to a nano-laser is emphasized [3]. Then, studies are presented on excitation energy transfer among semiconductor nano-crystals and single molecules [4] as well as molecular aggregates [5,6].
Finally, current computations on metal-core semiconductor-shell systems are presented. The talk is closed with an outlook on planned work.

References

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