

Architectures of quantum dots for nanophotonics

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Stable and strongly light-emitting colloidal quantum dots (QDs) of various semiconductor materials can successfully be obtained in both polar and unpolar solvent media [1]. Due to quantum confinement, the photoluminescence (PL) and absorption of the QDs are dependent on their size and shape, which in most cases can be controlled by the preparative conditions. After synthesis, the QDs can be additionally treated to improve their size distribution, PL quantum efficiency (QY), solvent compatibility and stability. The PL QYs of state-of-the-art QDs that will be discussed in this presentation reach 50–90 %.

Surface design of QDs.

The design of surface ligand shells of QDs is of great importance for their applications [2]. Nowadays, the variety of successful examples of all-inorganic capping is known. This kind of ligand exchange is a key step in the QDs design necessary for their applications in solution processable (e.g. printable) electronics. These ligands provide very short interparticle distances in QD solids, which is desired for the efficient coupling and charge transfer. These solids outperform organic semiconductors in many critical parameters, such as carrier mobility and chemical stability. Moreover, all-inorganic shells can play a role of dopants thus ensuring the fine-tuning of carrier concentration. Nevertheless, the formation of 2D or 3D ordered nanostructures from the all-inorganic-capped QDs appears to be extremely challenging. The introducing of hybrid capping approach by utilizing short chain amines allows not only efficient ordering of the QDs but also extends their processability to common solvents such as chloroform [3]. In addition to applications in electronics, our method can be extended to achieve phase transfer of organically soluble QDs into aqueous media, including biologically relevant buffers [4]. The procedure is quantitative, widely applicable and it significantly preserves original PL QY of the QDs.

Assembly of QDs.

Assembly approaches have been nowadays recognized as main working tool of bottom up chemical nanotechnology [5]. The assembly of strongly emitting semiconductor QDs can be performed on flat, porous and spherical surfaces, thus being important for thin-film technologies, doping of mesoporous materials, modification of pre-patterned substrates, creation of microshells and cavities, forming processable bulk composites, etc. Self-assembly approaches or the use of removable templates make possible the formation of nanowires or nanoporous 3D materials created solely from the assembled nanoparticles.

Hierarchical assembling and assembling of QDs with other organic or inorganic entities open up a possibility to achieve architectures with literally unlimited functionalities.

QDs in matrices.

The recent advances in preparation of QDs embedded into the robust ionic salt matrices will be briefly overviewed. Making various QDs compatible with the saturated salt solutions is a challenging task, especially for the QDs originally synthesized in the unpolar organics. To assure embedding of the unpolar QDs into salts, the methods based on the liquid-liquid diffusion assisted crystallization as well as “cold flow” approach are recently introduced. Salt matrices may also be considered as a media for the efficient solid state anion exchange as demonstrated on the example of perovskite QDs. The resulting QD-salt composites are exceptionally stable and well processable emitters.

All mentioned QD architectures have already secured, and will secure in the future, a wide field of applications, ranging from life sciences to photonics and (opto)electronics. In particular, applications in (opto)electronics cover the light-emitting diodes, displays, photovoltaic windows, field effect transistors and optical sensors.

References

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Физико-химические процессы, индуцированные кавитацией

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Известно, что влияние ультразвуковой кавитации на протекание физико-химических процессов сопровождается сочетанием ряда факторов – интенсификацией массопереноса, механическим разрушением (эрозией поверхности и диспергированием твердых частиц, эмульгированием), ускорением лимитированных диффузией химических и электрохимических реакций, а также вызывает сонолюминесценцию, звукокапиллярные эффекты и сонохимические реакции. Нами установлено, что импульсная