Laboratoire PPSM – UMR CNRS 8531

Photochimie et Photophysique Supramoléculaires et Macromoléculaires

Séminaire PPSM

Mercredi 29 mars 2017 - 11h00 Auditorium D. Chemla - Bâtiment IDA

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«Colloidal Heterostructured Nanocrystals: Synthesis, Properties and Prospects for Applications»

Since the discovery of the size-dependent behavior of nanoscale matter, colloidal inorganic nanocrystals (NCs), wetchemically prepared crystalline particles made of a few hundred up to several thousand atoms, have developed more rapidly than other classes of nanomaterials owing to the high degree of control with which their properties can be tailored through geometric and compositional engineering in the synthesis stage, and to the versatility with which they can be processed and implemented into a number of technologically valuable applications [1, 2]. Two major reasons account for the exclusivity of NCs: the significant fraction of atoms residing at the surface, relative to the total number of atoms, and the restriction of charge carrier motion to a small space volume. By virtue of these contributions, NCs exhibit unique chemical–physical responses that, for a given material composition, systematically correlate with size and shape, a feature prohibited to their bulk counterparts. As of today, NCs with controlled sizes and shapes not only represent model systems for the study of new phenomena in nanostructured solids, but also serve as building blocks for the bottom-up development of artificial functional materials, key active elements in miniaturized devices, and novel platforms on which innovative concepts in magnetooptoelectronics, biomedicine, and catalysis are being founded [1, 2].

More recently, in response to the growing demand for “smarter” multifunctional colloidal objects with enhanced and/or diversified capabilities, nanochemistry research has devoted efforts toward the realization of brand-new hybrid nanocrystals (HNCs) with a spatially controlled distribution of their chemical composition and crystal structure [2, 3]. These can comprise all-inorganic multicomponent nanoheterostructures arranged in elaborate concentric/eccentric onion-like or oligomer-type architectures, in which domains of different materials are interconnected together via direct epitaxial interfaces. Their structural complexity makes HNCs “smart” encounter platforms, where various nonhomologous properties can coexist and exchange-couple, leading to increased functionality, modified or amplified chemical–physical responses, or even emergence of entirely new properties. The development of HNCs thus embodies a generic paradigm to multicomponent nanoscale entities, for which an increasingly higher level of structural-architectural sophistication opens access to enhanced and/or diversified functionalities by combining control over the geometry and composition of the constituent domains with the engineering of their relative spatial arrangement.

The synthesis of HNCs, the understanding of property-structure-functionality relations in such hybrid nanomaterials, and their exploitation in practical applications are all hot fields of research yet far from approaching maturity, which are continually attracting increasingly high attention. In this talk I will highlight progress made by our research group in the synthesis and advanced structural characterization of a rich selection of elaborate HNCs based on diverse associations of semiconductor, plasmonic and magnetic materials [3-8]. The mechanisms through which HNCs may be accessed in nonequivalent topological configurations with distinctive chemical-physical properties will be discussed. The technological potential prospected by such multifunctional HNCs will be highlighted.

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