FlexiL-NANO
FLEXIBLE, VERY LARGE-AREA, STAND-ALONE MEMBRANES OF ENVIRNONMENTALLY FRIENDLY NANOCRYSTALS FOR FLEXIBLE SURFACE LIGHTING

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Project context and objectives

The use of NCs not only in solution but also in solid-state host media is crucial from the application point of view. The film formation of such NCs using polymer blends is one of the examples to demonstrate the benefits arising from the polymers. NCs gain elasticity by using them in a composite form, and can then be processed i.e. for patterning purposes, unlikely to their as synthesized form. Till now, there are previous reports on polymer-NC composites mostly based on the Cd containing nanocrystals, and have been studied for their use in polymer matrix to benefit from the advantageous properties of these soft materials. Although the film formation is crucial from the application point of view, it is quite challenging and requires good understanding of the complex nature of the hybrid material to satisfy desired optical quality film. The optimal NC film should be able to stand alone; provide versatility, provide flexibility, and possess good mechanical strength; and be fabricated in large areas. However, to date, flexible and very large area membranes have not been implemented at all: neither for Cd-containing NC s nor for the Cd-free ones. Thus, as a game changer, the FlexiL-NANO seed project addresses the scientific challenge of developing very large area membranes of Cd-free InP/ZnS quantum dots, while sustaining superior mechanical properties of the film. Successful demonstration of these films are intended to be revolutionary for the fabrication of very large area NC devices)

The specific objectives for our innovative research work in the FlexiL-NANO seed project include:

(i) Development of very large area, optically uniform, flexible, mechanically outstanding films of quantum dot-polymer composites at tunable emission wavelengths,
(ii) Fabrication of bilayer-trilayer architectures in the membrane form and modeling and experimental studies of these layered structures exploiting the benefits of the flexible architecture to control their emission kinetics, and
(iii) White light generation on the LED platform for flexible surface lighting.

Brief description of the main results

In this project, we report on the first time demonstration of standalone, flexible films of InP/ZnS QDs-polymer composites fabricated over very large areas (over 50 cm × 50 cm). By using the fatty acids as the ligand of the nanocrystals, hydrophobicity of the polymer matrix have been enhanced, thus allowing for the formation of their standalone composite membranes. These flexible large area films demonstrate high optical quality, along with the homogenous distribution of QDs within the optical sheets.

As a device application point of view, we have fabricated and employed bilayer structures of those flexible optical sheets of QDs as remote color converters for the demonstration of high quality white LEDs. Our white LED consisting of green and red emitting optical sheets excited by a blue LED platform demonstrates a high color-rendering index (CRI) of 89.30, warm correlated color temperature (CCT) of 2,298 K and a large luminous efficacy of optical radiation (LER) of 253.98 lm/W_{opt}, thus producing high photometric performance.

Final results, potential impact and use

Closely following the goals of the project, we have fabricated the world's largest area sheets of quantum dots. The work has extensively been carried out in detail to achieve the superior scientific quality. As a result of the extensive efforts by the team, the results of the project have been disseminated in highly ranked journal (Nano Letters, 12, 5348 (2012)) as well as in international conference (25th IEEE Annual Photonics Society Meeting, San Francisco, CA, USA, 23-27 September 2012. Session: WH: Large-Area Nanophotonics and Novel Fabrication Techniques Paper: WH 1.)