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Hybrid polymer-nanocrystal multilayered architectures for high-performance near-infrared LEDs

Xin Ma[1] and Sylvain G. Cloutier[2]
[1]University of Delaware, USA
[2]Ecole de Technologie Supérieure, Canada

The synthesis of exotic lead-chalcogenide nanostructures and their self-assembly into more complex nanocrystalline films using dithiol-based ligand-exchange has created an entirely new paradigm in low-cost and high-performance optoelectronic materials research, largely due to the facile solution-based processing and the large versatility of these structures. High structural quality and excellent electronic transport properties have propelled these self-assembled nanocrystalline lead-chalcogenide film structures to the forefront of cutting-edge research in the area of low-cost photovoltaic and photodetector platforms.

We report an all solution-based processing method used to produce efficient hybrid polymer-nanocrystal multilayered heterostructures for electroluminescence in the near-infrared. We employ the benzenedithiol linker to produce high-quality PbS nanocrystalline films acting both as an electron-transporting and electroluminescent layer within a near-infrared polymer-based light emitting diode (LED) architecture. Due to superior carrier-transport properties within the cross-linked nanocrystalline films, this new architecture yields high emission powers and good quantum efficiencies. Using cascaded multilayered superstructures, we demonstrate that efficient exciton energy funnelling can occur, leading to dramatically improved luminescence. Controlled experiments including absorption, photoluminescence, and time-resolved photoluminescence spectroscopy measurements demonstrate that the recycling of trap state-bound excitons is primarily responsible for this significant efficiency enhancement.

This facile, robust, low-temperature and substrate-independent all solution-processed architecture provides a scalable method of producing near-infrared LEDs allowing integration on flexible substrates and amorphous silicon active matrix backplanes. In the future, this approach could be potentially extended to other optoelectronics, biological imaging and sensing, photovoltaics and lab-on-a-chip platforms and to potentially extend their operation further in the near- and mid-infrared ranges.

Biography

Sylvain G. Cloutier obtained his Ph.D. from Brown University in 2006. He then joined the University of Delaware as Assistant Professor of Electrical & Computer Engineering, where he received the DARPA Young-Faculty Award. In 2011, he moved to the Ecole de Technologie Supérieure, where he currently holds the Canada Research Chair on hybrid optoelectronic materials and devices. He has published over 60 scientific articles and is also a member of the editorial board of Semiconductor Science & Technology.

xinma@udel.edu, SylvainG.Cloutier@etsmtl.ca