

Process & Manufacturing

MIT: Scalable processing of LEDs with tunable colors based on inorganic/organic nanomaterials

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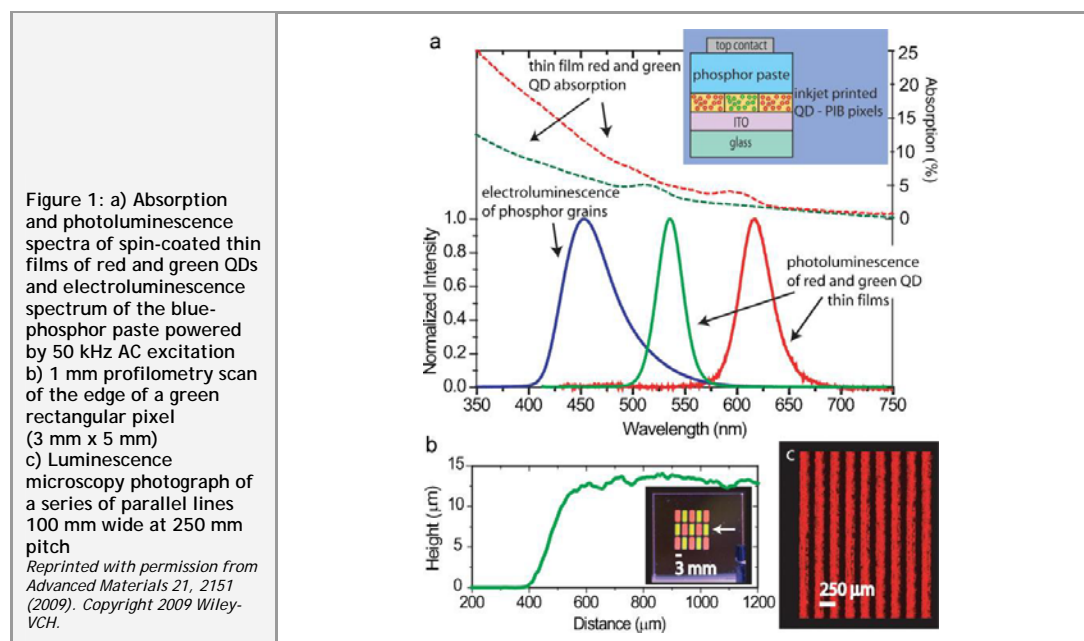
Inkjet-printed full-color
AC-driven displays



In two recent publications [1, 2], a joint research group from the Electrical Engineering and Computer Science Department and the Chemistry Department at MIT presented proofs-of-concept for a tabletop liquid-processing manufacturing strategy for LED devices with tunable colors. The produced devices rely on down-conversion of photons in favour of a direct electrical excitation of the emissive material. Referring to a mid-1990 technology review of Y.A. Ono [3], the authors see this approach superior to direct electrical excitation of the emissive material for the reason that AC-driven powder and thin-film electroluminescence was already a mature field and commercial products of visible displays in use. In the approach of optical down-conversion, a high-frequency alternating current (AC) voltage signal is used to excite an electroluminescent powder phosphor, generating blue photons that are absorbed by the adjacent active material layer and subsequently re-emitted at longer wavelengths.

In both cases, the active materials are nanoparticles (quantum dots) made from II-VI core-shell semiconductors (CdSe/ZnS [1], PbS/CdS [2]) suspended in a matrix of polyisobutylene (PIB). With that, an enhanced photoluminescence (PL) efficiency over thin films of pristine QDs is obtained, possibly due to an effective passivation of dangling bonds at the QD interface. The QD-PIB 'inks' were printed on ITO-coated glass or polyethylene terephthalate (PET) substrates. Printing was realized with a Hewlett-Packard Thermal Inkjet Picofluidic Dispensing System (TIPS) operated in conjunction with a movable stage. Patterns in this work were formed with 50–300 pl drop volumes, deposited at a 50 mm to 100 mm pitch.

The papers combine in a markable way the combination of inorganic and organic materials with a scalable liquid processing method to a working device. As the luminescence emission wavelength of (inorganic) semiconductor QDs is correlated with their size (or rather the confinement range of the exciton) it demonstrates scalability in a way that liquid processing does need a multitude of chemical ink systems to obtain multiple colors. By these means, the authors obtained a color triangle comparable to that of the International Telecommunication Union HDTV standard just by choosing QDs of appropriate size.



[1] "Inkjet-Printed Quantum Dot-Polymer Composites for Full-Color AC-Driven Displays"; V. Wood, M.J. Panzer, J. Chen, M.S. Bradley, J.E. Halpert, M.G. Bawendi, V. Bulovic: *Advanced Materials* 21, 2151 (2009).

[2] "Tunable Infrared Emission From Printed Colloidal Quantum Dot/Polymer Composite Films on Flexible Substrates"; M.J. Panzer, V. Wood, S.M. Geyer, M.G. Bawendi, V. Bulovic: *Journal of Display Technology* 6(3), 90 (2010).

[3] "Electroluminescent Displays"; Y.A. Ono: *World Scientific* (1995).