Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Inkjet printed fluorescent nanorods layers exhibit superior optical performance over quantum dots

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1. DLS analysis of CdSe/CdS nanorods inks

At a first stage, green and red emitting CdSe/CdS nanorods (NRs) ink solutions were prepared. In order to test the quality of the NRs dispersion within the ink formulations, dynamic light scattering (DLS) measurements were applied. Figure S1 shows the DLS results of three runs (black, red, and blue) of green emitting NRs ink formulation. The average size of the particles is 21nm, which is similar to the average size of the particles dispersed in toluene as measured in DLS (25nm). This is also close to the dimensions of the NRs from TEM analysis (31/4.2nm). Each run contains 16 individual measurements in order to improve the accuracy of the results.

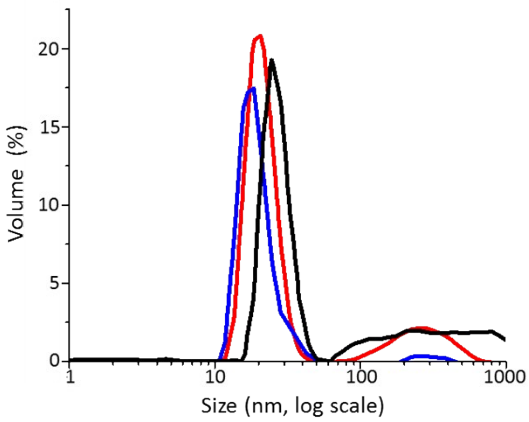

Figure S1: Three runs (black, red, and blue) of DLS measurements of green emitting NRs ink. Each run includes 16 individual measurements for more accurate results. The average size of the particle is 21nm, which correlates to the measurements of the same NRs in toluene solution.

2. Optical properties of printed nanorods

The seeded NRs inks were successfully printed on a variety of substrates. Figure S2 shows green and red emitting NRs ink formulations printed on Perspex with (a) and without (b) blue LED exposure. As clearly shown in the image, the fluorescent signage is highly emissive under LED light, while under ambient light no fluorescence is seen and the Perspex appears nearly transparent.

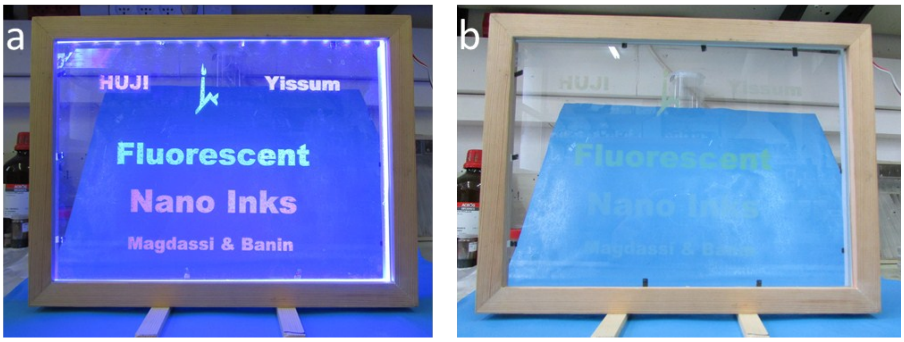

Figure S2: Green and red emitting CdSe/CdS seeded NRs inks printed on Perspex with (a) and without (b) exposure to blue LED.

Analysis of the optical behavior of green and red emitting NRs inks printed on glass at different number of layers was performed. The optical densities (O.D) of the different layers were extracted using the Hamamatsu absolute QY instrument. Figure S3 shows the number of layers versus calculated O.D at the excitation wavelength of 450nm for green emitting NRs (green) and red emitting NRs (red). As seen in the graph, there is a linear correlation between the number of layers and the optical densities extracted from the measurement.

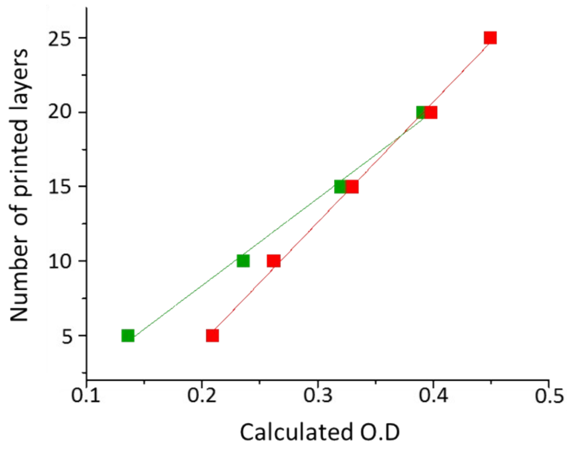

Figure S3: Number of printed layers versus O.D of green emitting NRs ink (green) and red emitting NRs ink (red). A linear correlation between the number of layers printed on the substrate and the extracted optical density is seen.

Figure S4 shows the emission intensity (a), quantum yield (b), and emission shift (c) of red emitting CdSe/CdS NRs (25/5.2nm) inks versus optical densities at the excitation wavelength of 450nm. The emission intensity increases with the optical density, while the quantum yield and the emission shift do not show a significant modification with the addition of printed layers.

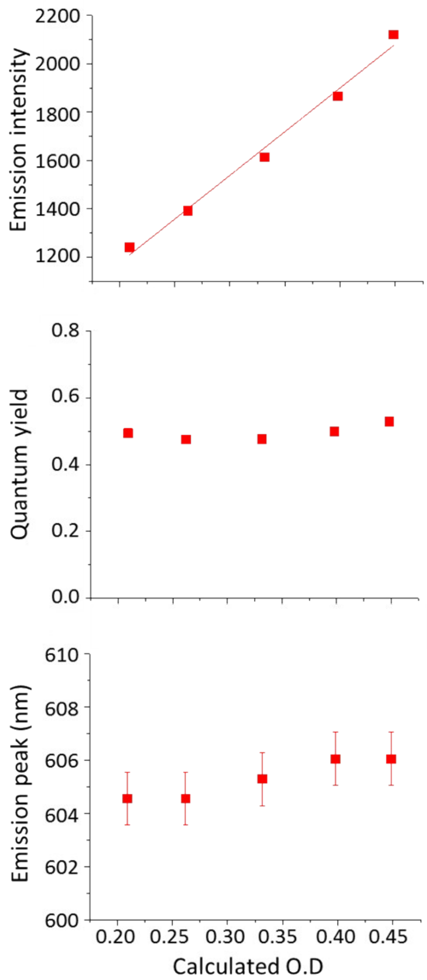

Figure S4: a) Emission intensity of red emitting NRs (25/5.2nm) at different optical densities. The fluorescence intensity increases with the addition of printed material. b) Quantum yield values at different optical densities of the same red emitting NRs. The quantum yield remains stable upon the addition of printed material. c) Emission wavelength peak values of the same printed red NRs, which is stable even at thicker NR layers.

3. Optical measurements for NRs and Qdots in solutions

We examined the optical properties of both NRs and quantum dots (QDs) solutions at different optical densities at the excitation wavelength of 450nm. Figure S5a shows the QY values of green emitting NRs and QDs in toluene solutions. As seen in the graph, as the optical density of the solution increases, the QY of the QDs solution decreases dramatically, while the NRs solutions show only a slight decrease of the QY. Figure S5b shows the emission shift of the same solutions of QDs and NRs. The solutions containing QDs show a significant red shift upon the increase in the solution's concentration, while the solutions containing NRs show small emission shift at higher concentrations. These effects are caused by the self-absorption phenomenon, which is more pronounced for the QDs, due to the significant overlap of the absorption and the emission spectra in the QDs in comparison with the seeded NRs.

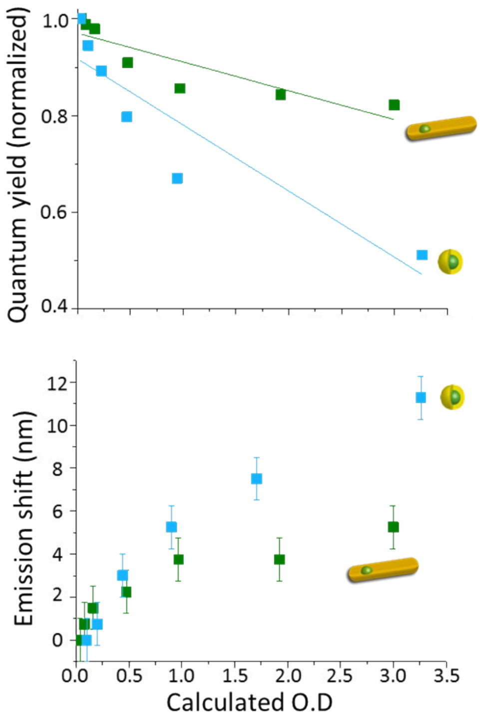

Figure S5: a) Normalized QY values of green emitting NRs solutions (green) and green emitting QDs solutions (blue) at different optical densities. As the solution's concentration increases, the quantum yield of the QDs solutions decreases more significantly than for the solutions containing NRs. b) Emission shift of the same solutions containing NRs (green) and QDs (blue). The emission shift is significantly larger for the solutions containing QDs than for the solutions containing NRs. These optical behaviors are caused by the self-absorption effect that is highly pronounced for the QDs in comparison with the NRs.