Breaking the efficiency bottleneck of micro-LEDs through nanoscale and excitonic engineering

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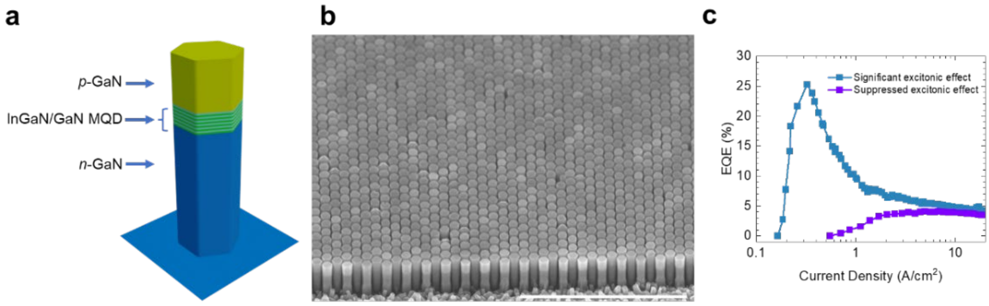

Figure 1. Ultrahigh efficiency green emitting μLEDs. (a) Schematic of the nanowire LED design, with a green InGaN/GaN multiple-quantum-dot (MQD) structure serving as the active region. (b) Scanning electron microscope of such a nanowire array. Scale bar: 3 μm. (c) Variation in external quantum efficiency due to differences in nanowire diameters, with the navy blue curve coming from a thin nanowire diameter array and the purple curve coming from a larger diameter array. The thinner diameter array allows for more active region formation on the semi-polar plane rather than the polar c-plane, thus allowing for radiative excitonic recombination channels that are more efficient than traditional free carrier radiative recombination for InGaN.

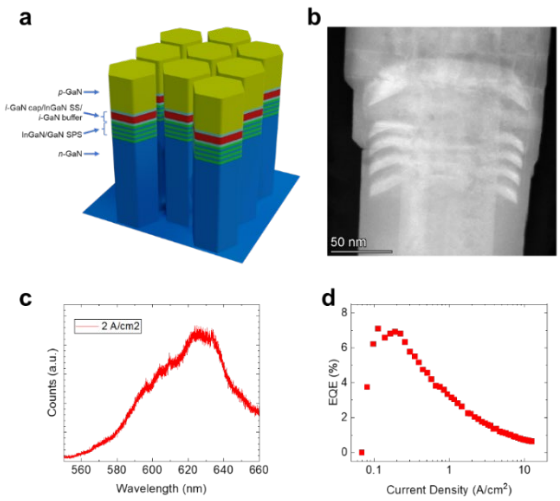

Figure 2. High efficiency red emitting μLEDs. (a) Schematic of the nanowire design, which employs a short-period superlattice (SPS) that allows for high levels of In incorporation in the single segment (SS) active region. (b) High angle annular dark field scanning transmission electron micrograph of such one such nanowire, where the four layers of SPS InGaN and the single segment active region InGaN are clearly visible at a higher contrast, as InGaN has a higher atomic number than GaN. (c) Electroluminescence of a red emitting μLED at 2 A/cm^2. (d) The external quantum efficiency (EQE) of such red emitting μLED devices can reach >7%.