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White Electroluminescence Using Silicon Quantum Dots

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Extended Abstract

Solution-processed white QD-LEDs have been recently focused much by the scientist for their potential for low-cost manufacturing, large-area and flexible device structures, high photochemical and thermal stabilities, as well as energy-efficient operation. There are very few reports on QD-LEDs with efficient white emission (Yang et al., 2012). At present, it is very difficult to obtain high-performance white QD-LEDs only by mixing blue-, green-, and red-emitting QDs as white emissive layer due to the low efficiency for the blue QDs. Currently, some research groups demonstrated that the combination of emission of organic molecules and QDs is quite promising for fabricating high-performance white hybrid QD-LEDs.[1] Silicon quantum dots catch attention of the scientist after the discovery of efficient emission (Florian et al., 2013). Silicon being second earth abundant element and environment friendly adds much more advantage than other Cd or Pb QD based devices (Ghosh et al., 2014).

We designed and fabricated solution-processed white LEDs containing a bilayer of non-toxic colloidal Si QDs and polymer in the device as active region. White electroluminescence was obtained in the LEDs by mixing the broad red-emission of Si QD and the blue-green emission of poly-TPD. In our device the advantages are (i) Unlike Cd based QD Forster energy transfer from polymer to Si QD is not possible due to any overlap between emission of polymer and absorbance of Si-QDs. (Ii) Unlike the approach of mixing multicolor emitters into a composite active region in early white QD-LEDs, the design of bilayered active region physically separates the blue green- emitting molecules from the red-emitting QDs except at the interface. (iii) We replace the organic (mainly TBPi) layer that was used in previous reported Si-QD based LED devcies by inorganic robust stable solution processed zinc oxide (ZnO) as n type electron injecting layer which acts as a good hole blocker also.

We have recorded current-voltage (I-V) characteristics of the devices and measured the EL output. At 3V photodetector current starts to increase its current value from the dark noise current which is called ‘‘turn on voltage’’ to get light from LED. We achieved low turn on voltage to produce white light. Also CIE co-ordinate shows (0.3,0.29) which is very close to white.

Electroluminescence spectra from the device exhibit some voltage dependence. The spectral profile at 4 V-bias shows the luminance contribution from the poly-TPD molecules and Si QD is nearly equal, which is close to white light emission. At higher voltage contribution from poly-TPD increases.

References

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