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Quantum dots with engineered interfaces for light-emitting diodes

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Lighting consumes almost one-fifth of all electricity generated today. A dramatic improvement in lighting efficiency is possible by replacing traditional incandescent bulbs by light-emitting diodes (LEDs) in which current is directly converted into photons via the process of electroluminescence. The focus of this presentation is on the emerging technology of LEDs that use solution-processed semiconductor quantum dots (QDs) as light emitters. QDs are nanosized semiconductor particles whose emission color can be tuned by simply changing their dimensions. They feature near-unity emission quantum yields and narrow emission bands, which results in excellent color purity. These properties make QDs attractive for applications in lighting and display technologies. This presentation overviews spectroscopic studies of QDs that address the problem of nonradiative carrier losses in QD-LEDs, and approaches for its mitigation via the appropriate design of QD emitters. We consider processes such as carrier recombination via surface defects including hot-electron trapping, discussed in the context of QD emission intermittency ("blinking"). We also analyze nonradiative Auger recombination in the presence of extra charges, and specifically, the asymmetry between recombination pathways in positively and negatively charged QDs. Finally, we provide evidence for the direct relation of Auger recombination to the problem of LED efficiency roll-off (known also as a "droop effect") at high driving currents, suggesting that the realization of high-performance LEDs might require a new generation of "Auger-decay-engineered" QDs that in addition to being efficient single-exciton emitters would also show high emission efficiency in the multicarrier regime.