catalog of 388 individual grain boundaries in pure nickel. At a given temperature they found that each grain boundary was either a smooth atomic-structured boundary with very low mobility, or rough atomic-structured boundaries with high mobility. After reaching a transition temperature, which differs from boundary to boundary, the grain boundary structure changes from smooth to rough and the mobility decreases. Holm and Foiles applied these data to a mesoscale simulation for a polycrystalline microstructure using the Monte Carlo Potts model for grain growth. When smooth/slow boundaries are present, the researchers found that grain growth plateaus at a finite grain size value which decreased as the fraction of smooth/slow boundaries increases. In addition, they found that stagnant grain size increases with temperature. These results suggested that the boundary roughening transition could influence grain growth stagnation.

Holm and Foiles performed another MD simulation, a grain growth in a realistic three-dimensional nanocrystalline nickle grain structure. At the temperatures analyzed, simulation results showed that after a short initial transient state, normal grain growth occurs. However, after some time, grain growth slows and grain size appears to stagnate. Moreover, the stagnant grain sizes observed were consistent with results from mesoscale simulations. Simulation results from different methods demonstrated that the presence of atomically smooth grain boundaries can stop in the absence of solute or pinning particles grain growth. Holm and Foiles said that atomically smooth grain boundary structures provide an alternative mechanism for grain-growth stagnation at high temperatures for pure materials.

SIARI S. SOSA

All-Quantum-Dot Multilayer LEDs Prepared Using Layer-by-Layer Solution Processing Show High Brightness

The quest for cheap and energy-efficient lighting and light-emitting displays has resulted in robust efforts to develop technologies for light-emitting diodes (LEDs). The use of quantum dots (QDs) in LEDs offers the advantages of high color purity and easy tunability of emission. High brightness has been achieved with very thin QD layers (one-to-two monolayers), but challenges in research on QD LEDs remain. Increasing the devices' lifetime, brightness, and homogeneous deposition over large areas, as well as avoiding the use of toxic materials, would make them serious alternatives to organic devices. W.K. Bae, K.H. Char, C.H. Lee, S.H. Lee, and co-workers from the Seoul National University have recently demonstrated the large-area deposition of multicolored all-QD (QDs with core and chemical composition gradient shell structure—mostly CdSe/ZnS) LEDs prepared by the spin-assisted layer-by-layer assembly method.

As reported in the July 14th issue of *Nano Letters* (DOI: 10.1021/nl100168s; p. 2368), the research team fabricated all-quantum-dot LEDs with well-controlled vertical and horizontal structures. Quantum dots were treated with cysteamine (CAm) or mercaptopropionic acid (MPA) and dispersed in water to obtain positive and negative charges on the surface of the nanocrystals. Alternate spin-coating depositions of positively and negatively charged nanocrystals allowed the build-up of multilayered thin films consisting of submonolayers of nanocrystals (i.e., QD-CAm/QD-MPA$_n$). Such deposition techniques permit the facile scale-up to larger device area of homogeneous and uniform films.

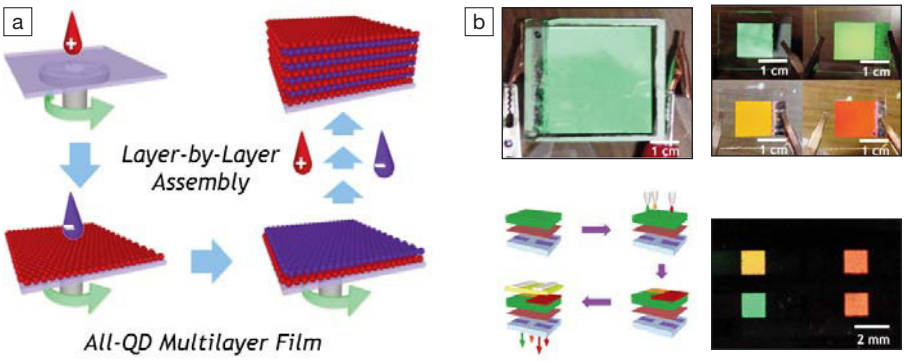

Figure 1. Preparation of all-quantum-dot (QD) multilayer films by (a) spin-assisted layer-by-layer deposition of oppositely charged monolayers; and (b) multicolored-QD light-emitting diodes in large area arrays with schematics of deposition procedure obtained by variation of the nature of the nanocrystals in the exciton recombination zone.

The researchers could, with this processing method, control the vertical multilayered morphology of their films. In order to figure out where an exciton recombination occurred, they integrated a single or double layer of green-emitting nanocrystals located at different vertical positions in thin films comprised primarily of layers of red-emitting nanocrystals. They studied the electroluminescence of these various multilayered thin films and found that it mostly arises from the top layer, adjacent to the electron transporting layer—made of 40 nm of 2,2′,2′′-(1,3,5-benzinetryil)tris(1-phenyl-1-*H*-benzimidazole) that is, TBPi. The vacancies in the first submonolayer induced a small electroluminescent contribution (~10%) from the second-to-the-top layer. This is consistent with the previous optimized architecture consisting of one or two monolayers of quantum dots.

The researchers coupled the spin-assisted layer-by-layer assembly to patterning techniques compatible with solution processing, thus also controlling the horizontal morphology of devices. By using nanocrystals of different sizes, they realized three-colored LEDs fabricated from all-quantum dot multilayers with the potential for full-color, larger area deposition and device characteristics improvements.

ELSA COUDERC