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What Quantum Dots Can Do for You

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Recent clever techniques for fabricating nanosize materials, one-atomic-layer-at-a-time, have simultaneously opened a door to a fantastic adventure at the frontier of physics, chemistry, biology, and engineering. Nanosize materials simply do not behave as the bulk. Indeed, the rules that govern the growth and behavior of these tiny structures are unexplored. In this talk we will discuss our recent efforts to be the architect of their shape, size, density, and position of nanostructures and along the way, the interactions between them that lead to their optical and electrical behavior. While self-assembly is providing exciting quantum dot (QD) structures to explore, like the QD molecules shown here, it is equally exciting to try to use the rules we uncover to encourage QD formation to take a desired path. Can we understand the formation of faceted nanostructures? Can we encourage or seed dot structures to form specific arrays? Is it possible to engineer greater homogeneity of dot shape and size? Can we design both the optical and electrical behavior of either individual or arrays of nanostructures to mimic those we find in nature? In this talk we will review our progress to answer these questions and discuss the possibilities and challenges ahead. For example, we will discuss the formation of individual faceted nanostructures as well as the fabrication of a vertically and laterally ordered QD stacks forming three-dimensional QD arrays. As another example, we will discuss the importance of surfaces with high Miller indices, as a template to the formation of nanostructures as well as their potential role in determining the shape and increased size uniformity of the confined structures. Importantly, these observations lead to an even more basic question of when and why high index surfaces are stable. Indeed, we have found that in order to understand the origin of high index surfaces that bound nanostructures we have to study them directly.