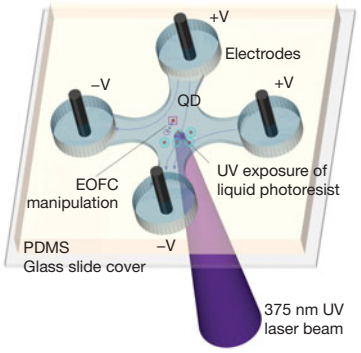
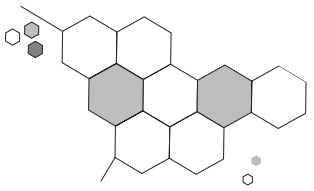


A microfluidic device for precisely positioning quantum dots on a surface using electroosmotic flow control (EOFC). A UV laser is used to polymerize the fluid and trap individual quantum dots in place. Reproduced with permission from *Nano Lett*. **10** (11) (2010) DOI: 10.1021/nl1029557; p. 4673. © 2010 American Chemical Society.

precise, sub-pixel, imaging algorithm, a specific QD can be manipulated into position with more and more slight adjustments to the flow, while other QDs drift in a divergent fashion. When the QD has reached the desired location, the spot is automatically irradiated with a UV laser, which causes cross-linking of the photoresist around the QD and effectively encapsulates it. The nature of the photoresist fluid, comprised of a photoinitiator, a water-soluble acrylic monomer, and a viscosity modifier, is crucial to the process. Using high concentrations of the monomer causes segregation of the QDs near the glass surface, providing an element of control over the third dimension and enhancing the actuation effect.

Immobilizing the QDs allows successive objects to be moved without disturbing them, and introduces the possibility of surface patterning. The team demonstrates this, as well as the ability to spectrally select for QDs, by organizing a 3 × 3 array of alternating color QDs, 5 μm apart. The technique could easily be extended to positioning any imageable nanoparticle on water-compatible surfaces, and should prove to be a powerful tool to the nanotechnologist.

Tobias Lockwood



Energy Focus

PV composites with enriched semiconducting SWNTs display prolonged charge separation

Current organic photovoltaic (OPV) solar cells utilize bulk heterojunctions (BHJs) comprised of conjugated polymers acting as electron donors, and derivatized fullerenes acting as electron acceptors. With electron mobility dependent on fullerene clustering and hopping transport, solar power conversion efficiencies (PCEs) now approach 8%. The properties of single-walled carbon nanotubes (SWNTs) have led to speculation that superior PCEs would result if they were to replace the fullerene phase in OPV solar cells. However, the maximum PCE achieved by SWNT-composite solar cells is only about 0.5%. This low performance has been hypothesized to be due, in part, to the relatively large fraction of metallic (m-) nanotubes in as-produced samples—about one-third, with the remainder semi-conducting (s-) nanotubes—because m-SWNTs lack a true bandgap and can therefore act as recombination centers for charge-carriers or excitons, lowering charge-separation efficiency. One obstacle to a systematic investigation of this hypothesis has been the controllable incorporation of only m-SWNTs or s-SWNTs into photovoltaic blends with semiconducting polymers. Recently, however, J. Blackburn, J. Holt, and a team of researchers at the National Renewable Energy Laboratory produced blends enriched in either m-SWNTs or s-SWNTs dispersed in a semi-conducting polymer matrix, and presented conclusive experimental evidence that charge separation is significantly enhanced as the concentration of m-SWNTs is reduced.

As reported in the November 10, 2010 issue of *Nano Letters* (DOI: 10.1021/nl102753z; p. 4627), the research team separated m-SWNTs from s-SWNTs with density-gradient ultracentrifugation. Photoabsorption spectroscopy was used to determine the ratios of s- and m-SWNTs in the separated bands. Then, enriched aliquots were combined into large volumes of dispersions with varying ratios of s- and m-SWNTs. Surfactants were removed before the SWNTs were blended with poly(3-hexylthiophene) (P3HT, a prototypical conjugated polymer) to form solutions and films. The researchers used photoluminescence excitation (PLE) spectroscopy to show that P3HT effectively isolates SWNTs primarily as individual SWNTs in dispersions of 90% s-SWNTs and P3HT.

The researchers then used time-resolved microwave conductivity (TRMC), which is sensitive only to mobile carriers and not to charge-neutral excitons, to study the yield, mobility, and decay dynamics of free carriers generated by illumination of composite films with varying fractions of s-SWNTs. They found that the long-lived population of charge carriers increases substantially for samples highly enriched in s-SWNTs in comparison to samples enriched in m-SWNTs.

The researchers concluded that m-SWNTs blended with P3HT are detrimental to PCEs and that eliminating them can significantly improve photocurrents. To summarize, the researchers said that "effectively, what has often been considered as a two-component hybrid system (conjugated polymers and SWNTs) should be treated at a minimum as a three-component system: conjugated polymer, s-SWNTs, and m-SWNTs. Moreover, since every species of SWNT with distinct chiral (*n,m*) indices expresses unique electronic properties, future work will likely afford valuable insight into specific electronic traits of even more well-defined blends of polymers with chiral-specific s-SWNTs."

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