

neighboring Tb^{3+} resulting in a reduction in luminescence.

In addition, the emitting color varied from bluish-green to greenish-yellow

with increasing Tb^{3+} content. Excited at 330 nm, the Commission Internationale de l'Éclairage (CIE) chromaticity coordinates shifted from (0.25, 0.33) to

(0.40, 0.52) as the value of y increased from 0.1 to 0.6 in the $Mg(Y_{3.8-y}Ce_{0.2}Tb_y)Si_3O_{13}$ materials.

Melissa A. Harrison

Energy Focus

Quantum efficiency improved in bulk heterojunction PVs

Although bulk heterojunction photovoltaics (BHJs) are attractive as low-cost solar cells due to their ease of processability, devices incorporating low-bandgap quantum dots (QDs) fall short of the performance achieved by analogous blends of polymers and CdSe QDs. Previously, D.S. Ginger, S.A. Jenekhe, and co-researchers at the University of Washington, Seattle, hypothesized that the poor performance by BHJs composed of PbS QDs blended with common conjugated polymers is due to insufficient photoinduced charge transfer at the organic–inorganic interface. Recently, Ginger and co-researchers showed that BHJs made from PbS QDs and new donor–acceptor polymers exhibit efficiencies two orders of magnitude greater than those observed for blends of PbS with conventional host polymers.

As reported in the July 14th issue of *Nano Letters* (DOI: 10.1021/nl1013663; p. 2635), Ginger and co-researchers selected three polymers (PDTPQx, PDTPPPz, and PDTPBT; see figure) to blend with PbS QDs because their ionization potentials show that their highest occupied molecular orbitals lie within the PbS bandgap. Photoinduced absorption (PIA) spectroscopy shows that in the

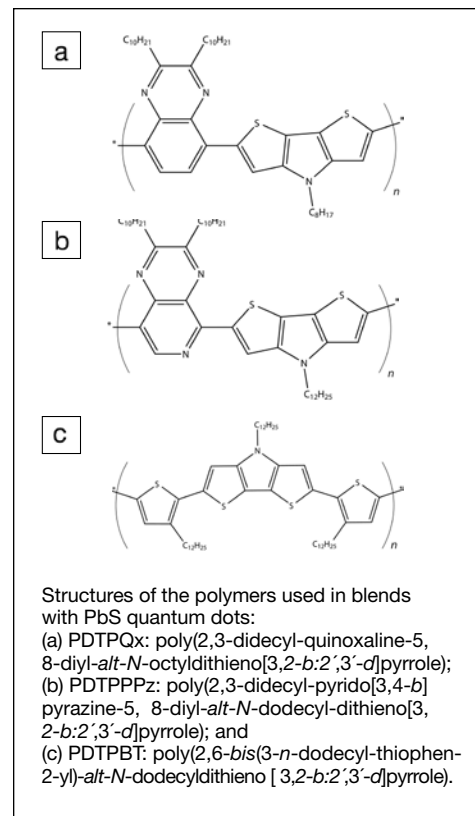
range of 0.8 eV to 2.2 eV BHJ blends of PDTPQx and PbS QDs exhibit new sub-bandgap absorptions by the PDTPQx and a bleach of the polymer's bandgap transition following photoexcitation, while the PDTPBT blend shows very weak PIA signal, and the PDTPPPz blend shows no detectable PIA signals. Because neat PDTPQx shows no PIA signal, the researchers attribute the blend's PIA spectrum to long-lived polarons on the PDTPQx polymer chains created by photoinduced electron transfer from the polymer to the PbS QDs, leading them to predict PDTPQx/PbS to perform significantly better in BHJ photodiodes than PbS QDs blended with either of the other two polymers considered. The researchers verified this prediction by showing that the quantum efficiencies exhibited by the PDTPQx/PbS blends are two orders of magnitude higher than those exhibited by blends with the other two polymers.

Under simulated AM 1.5 illumination, the researchers estimated a power conversion efficiency (PCE) of about 0.55%, which is modest in comparison to polymer-fullerene BHJ cells but is significantly higher than BHJ devices made from previous polymer blends with low-bandgap QDs. The researchers plan to improve performance by increasing the PDTPQx molecular weight to facilitate thicker films, and by controlling the shape of the QDs.

The researchers said, “We anticipate

that the viability of new organic host materials when blended with PbS should reinvigorate the study of solution-processable bulk-heterojunction excitonic solar cells made with a range of low-bandgap nanoparticles and should facilitate their use in both hybrid photovoltaics and photodetectors with bandgaps tailored via quantum confinement.”

Steven Trohalaki

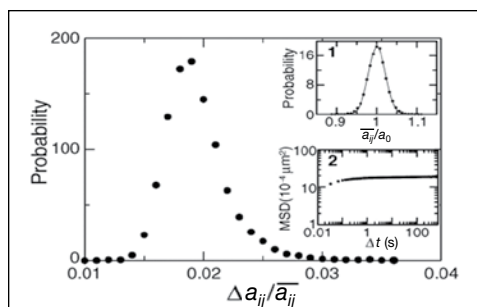


Normal modes and density of states achieved in disordered colloidal solids

Colloidal suspensions have been used as model systems in experimental research on the fundamentals of statistical mechanics. In colloidal systems,

a crystal or amorphous structural glass can be produced using traditional hard-sphere particles such as silica sphere. However, the perfect crystals produced with these conventional particles show spatial homogeneous fluctuations. These fluctuations are measured using optical microscopy to observe individual particle motion within the interior of the system.

Recently, D. Kaya, N.L. Green, C.E. Maloney, and M.F. Islam of Carnegie Mellon University developed an approach to measure the correlation in particle displacement using strongly disordered colloidal crystals composed of deformable microgel colloidal particles to determine the normal modes and the density of states (DOS). Normal modes and the DOS of a



Measurement of normal modes and density of states in a disordered colloidal crystal, where $\Delta a_{ij}/a_{ij}$ stands for probability distribution of temporal fluctuations in nearest-neighbor spacing, $\Delta a_{ij}/a_0$ indicates the probability distribution of nearest-neighbor spacing in the equilibrium configuration, and Δt (s) is change in time in seconds. Reproduced with permission from *Science* **329** (2010) DOI: 10.1126/science.1187988; p.656. © 2010 AAAS.

disordered atomic system have not been experimentally measured because tracking the dynamics of individual atoms directly is experimentally not feasible. Normal modes and the DOS of any material provide a basis for understanding thermal, mechanical, and transport properties.

As reported in the August 6th issue of *Science* (DOI: 0.1126/science.1187988; p. 656), the researchers experimentally measured the normal modes and the energies of the normal modes. From these experiments, they deduced the average particle separations to demonstrate the high degree of geometrical order in their system. The figure shows an average mean squared displacement (MSD) with

a clear plateau which is an indication of solid-like behavior and the absence of diffusion. The team in determining the normal modes observed the spectrum energy eigenvalues converged by 20,000 independent observations of the displacement field. The researchers observed a Debye-like behavior at low energies, with a Boson peak at higher energy.

According to the researchers, this general procedure will be a vital tool to identify the impacts at particle level of different types of disorder on the structure of the normal modes and elasticity that are present in various atomic, molecular, and colloidal crystals and glasses.

Jean L.W. Njoroge

Bio Focus

Graphene serves as trans-electrode membrane for DNA molecules

Researchers S. Garaj, D. Branton, and J.A. Golovchenko of Harvard University, and their colleagues from Harvard and the Massachusetts Institute of Technology have demonstrated that graphene can act as an artificial membrane separating two liquid reservoirs. As reported in the cover story of the September 9th issue of *Nature* (DOI: 10.1038/nature09379; p. 190), by drilling a nanopore in the graphene membrane, the researchers were able to measure exchange of ions through the pore and demonstrated that a long DNA molecule can be pulled through the graphene nanopore just as a thread is pulled through the eye of a needle.

“By measuring the flow of ions passing through a nanopore drilled in graphene we have demonstrated that the thickness of graphene immersed in liquid is less than 1 nm thick, or many times thinner than the very thin membrane which separates a single animal or human cell from its surrounding environment,” said lead author Slaven Garaj, a research associate in the Department of Physics at Harvard. “This makes graphene the thinnest membrane able to separate two liquid compartments

from each other. The thickness of the membrane was determined by its interaction with water molecules and ions.”

Graphene, the strongest material known, has other advantages. Most importantly, it is electrically conductive.

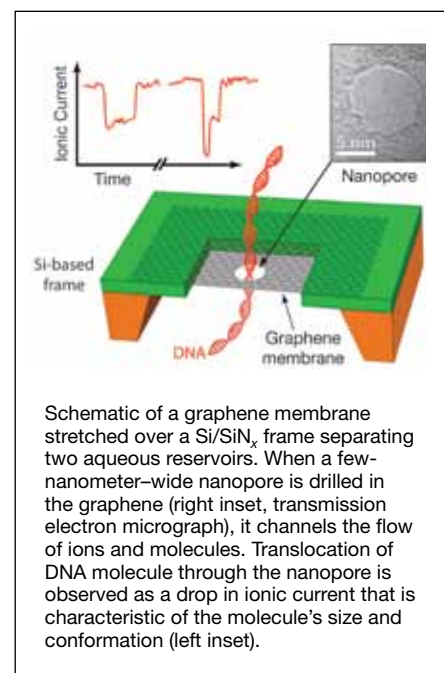
“Although the membrane prevents ions and water from flowing through it, the graphene membrane can attract different ions and other chemicals to its two atomically close surfaces. This affects graphene’s electrical conductivity and could be used for chemical sensing,” said co-author Jene Golovchenko, Rumford Professor of Physics and Gordon McKay Professor of Applied Physics at Harvard, whose pioneering work started the field of artificial nanopores in solid-state membranes.

The researchers stretched the graphene over a silicon-based frame, and inserted it between two separate liquid reservoirs. An electrical voltage applied between the reservoirs pushed the ions toward the graphene membrane. When the researchers drilled a nanopore through the membrane, this voltage channeled the flow of ions through the pore and registered as an electrical current signal.

When the research team added long DNA chains in the liquid, they were electrically pulled one by one through the graphene nanopore. As the DNA molecule threads the nanopore, it blocks the

flow of ions, resulting in a characteristic electrical signal that reflects the size and conformation of the DNA molecule.

Previously, co-author Daniel Branton, Higgins Professor of Biology, Emeritus at Harvard, together with his colleague David Deamer at the University of California, suggested that nanopores might be used to quickly read the genetic code, much as one reads the data from a ticker-tape machine. As a DNA chain passes through the nanopore, the nucleobases,



Schematic of a graphene membrane stretched over a Si/SiN_x frame separating two aqueous reservoirs. When a few-nanometer-wide nanopore is drilled in the graphene (right inset, transmission electron micrograph), it channels the flow of ions and molecules. Translocation of DNA molecule through the nanopore is observed as a drop in ionic current that is characteristic of the molecule’s size and conformation (left inset).