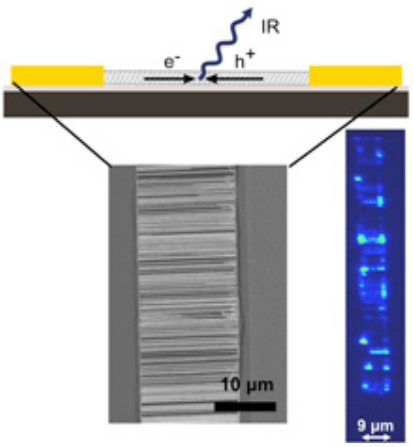
Electroluminescence from Electrolyte-gated Carbon Nanotube Field-effect Transistors

Carbon nanotubes are robust nanostructures with unique optical and electronic properties that could lead to innovations in nanoscale circuits and telecommunication applications.

The Challenge

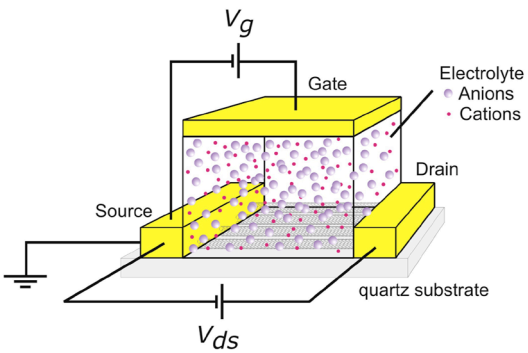
Carbon nanotubes enable the efficient transport of both electrons and holes, which recombine in the nanotubes to produce near-infrared light emission within the telecommunication window. Controlled emission can be realized with nanotubes in a field-effect transistor (FET) structure that allows for injection of both charge carriers. The challenge is to control the charge transport and light emission by applying low voltages, while achieving high brightness at the same time.



Aligned, single-walled carbon nanotubes placed in an FET device enables the control of the recombination point of electrons and holes in the nanotubes and the resulting control of light emission from the structure. The electroluminescence image from individual SWNTs integrated over gate voltage is shown above.

The Solution

With the state-of-the-art optical microscopy and spectroscopy capabilities of Argonne's Center for Nanoscale Materials, a team of researchers developed FET devices with highly aligned, dense arrays of carbon nanotubes grown by chemical vapor deposition on quartz as the active/emissive layers. By employing electrolyte gating instead of a traditional oxide dielectric, the team was able to control charge transport at extremely low voltages.



Electrolyte gating of the FET device enables control over the light emission point at very low applied voltages.

The Results

The scientists observed near-infrared light emission from many carbon nanotubes at the same time, and were able to control the position of the emission zone along individual nanotubes by changing the applied voltages. The scientists were able to control the position of the emission zone along individual nanotubes by changing the applied voltages. These nanoscale light sources could one day find applications in telecommunication devices, but improvements in efficiency are still needed.

"Light emitting devices based on large-scale arrays of carbon nanotubes may represent an important first step toward realistic applications in optoelectronics," **said John Rogers, a professor at University of Illinois at Urbana-Champaign, who worked with Argonne researchers on the project.**

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