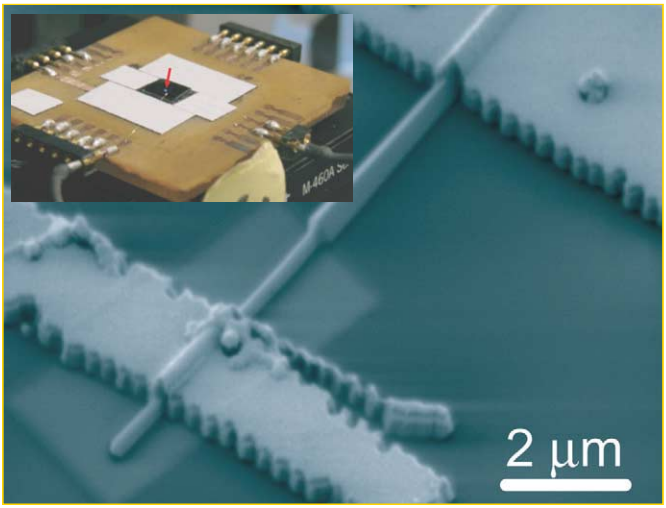
# Nanowires shed a blue light on photonics

OPTICAL MATERIALS




*Scanning electron micrograph of an electrically wired CSS device. (Inset) Digital camera image of a device chip illustrating the high-brightness blue emission from a CSS LED visible to the naked eye. (Reprinted with permission. © 2004 American Chemical Society.)*

**Charles M. Lieber's group at Harvard University have developed a new class of electrically driven light-emitting structures based on nanowires [Qian *et al.*, *Nano Lett.* (2004), doi: 10.1021/nl0487774].**

**Previous work has shown that crossed and axial structures of semiconductor nanowires can be used to build photonic devices such as photodetectors, light-emitting diodes (LEDs), and lasers. But the small area of the *p-n* junction created at the intersection limits the current and light emission. "We have overcome this limitation with a core-shell type of structure," explains Lieber. They use metal-organic chemical vapor deposition (MOCVD) to synthesize doped core/shell/shell (CSS) nanowire heterostructures based on GaN. "[The] structure enables efficient injection and recombination of carriers (to produce photons) along a large portion of the nanowire, or correspondingly as a means for electrically detecting photons."**

**One of the advantages of the *n*-GaN/InGaN/*p*-GaN CSS nanowire structure is that the substrate-free synthesis prevents the formation of dislocations, which reduces unwanted nonradiative recombination. The well-defined CSS structure produces controllable optical properties with strong emission from the InGaN shell at 448 nm. The structure can also be made to emit blue light by attaching contacts to the *n*-type core and the *p*-type outer shell and forward biasing. Remarkably, say the researchers, the blue light emitted from the forward-biased single CSS nanowire devices is visible to the naked eye.**

**"Our demonstration of this concept opens up great opportunities for both nanophotonic and nanoelectronic devices since the *p-n* junction is central to so many device concepts in semiconductors," says Lieber. The researchers suggest that the *n*-GaN/InGaN/*p*-GaN CSS nanowire heterostructures could be used as optical waveguides or optical cavities in single nanowire injection lasers. As LEDs, the CSS nanowire devices could be used as sources in lab-on-a-chip and optical data storage systems. The emission wavelength can be adjusted from the ultraviolet through to the visible by varying one of the shells. Lieber's group are now working toward the concept of multicolored LED sources. Ultimately, the efficient injection enabled by the CSS structure geometry could be used to create electrically driven nanoscale lasers.**

***Cordelia Sealy***

# Tuning the color of light with dendrimers

OPTICAL MATERIALS

Researchers from the University of St. Andrews and the University of Oxford in the UK have developed a simple way of tuning the color of organic light-emitting diodes (OLEDs) using dendrimers [Markham *et al.*, *Appl. Phys. Lett.* (2004) **85** (9), 1463].

Dendrimers are a new class of light-emitting material that combine the ordered synthesis of small molecules with the solution processing capabilities of polymers. Recently, these materials have been successfully incorporated into efficient OLEDs, replacing the widely used conjugated polymers. These first dendrimer OLEDs were green emitters, but now it seems that it may be possible to tailor the color of the light emission very simply.

Paul L. Burn and coworkers take a physical approach to the problem. Rather than modifying the chemical structure of the light-emitting dendrimers to change their color, as is done with polymers and small molecules, the researchers blend two different dendrimers to obtain the required color.

Polymer blends tend to phase separate and small molecule blends can be difficult to process from solution, but dendrimers suffer from neither of these limitations. By using dendrimers with different cores but the same surface groups, it is possible to tune their electronic and processing properties independently, thus avoiding the problems of phase separation.

"By blending two dendrimers, which emit light of different colors, we can obtain the color of one, or the other, or any color in between," explains Burn.

The researchers blended two different dendrimers to vary the color of the emitted light from the ultraviolet/violet to blue green. Furthermore, the color can be changed without affecting the emission efficiency or operating voltage. Nor does the color change with brightness.

"The results are useful for giving a simple way of making an OLED with a particular color and are also useful for optimizing the color of light emission for a particular application," says Burn. "The next stage," he told *Materials Today*, "would be to demonstrate color tuning over a wider range, for example all the way from green to red."

***Cordelia Sealy***