New kind of ultraviolet LED could lead to portable, low-cost devices

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Commercial uses for ultraviolet (UV) light are growing, and now a new kind of LED under development at The Ohio State University could lead to more portable and low-cost uses of the technology.

The patent-pending LED creates a more precise wavelength of UV light than today's commercially available UV LEDs, and runs at much lower voltages and is more compact than other experimental methods for creating precise wavelength UV light.

The LED could lend itself to applications for chemical detection, disinfection, and UV curing. With significant further development, it might someday be able to provide a source for UV lasers for eye surgery and computer chip manufacture.

In the journal *Applied Physics Letters*, Ohio State engineers describe how they created LEDs out of semiconductor nanowires which were doped with the rare earth element gadolinium.

The unique design enabled the engineers to excite the rare earth metal by passing electricity through the nanowires, said study co-author Roberto Myers, associate professor of materials science and engineering at Ohio State. But his team didn't set out to make a UV LED.

"As far as we know, nobody had ever driven electrons through gadolinium inside an LED before," Myers said. "We just wanted to see what would happen."

When doctoral students Thomas Kent and Santino Carnevale started creating gadolinium-containing LEDs in the lab, they utilized another patent-pending technology they had helped develop—one for creating nanowire LEDs. On a silicon wafer, they tailor the wires' composition to tune the polarization of the wires and the wavelength, or color, of the light emitted by the LED.

Gadolinium was chosen not to make a good UV LED, but to carry out a simple experiment probing the basic properties of a new material they were studying, called gadolinium nitride. During the course of that original experiment, Kent noticed that sharp emission lines characteristic of the element gadolinium could be controlled with electric current.

Different elements fluoresce at different wavelengths when they are excited, and gadolinium fluoresces most strongly at a very precise wavelength in the UV, outside of the range of human vision. The engineers found that the gadolinium-doped wires glowed brightly at several specific UV frequencies.

Exciting different materials to generate light is nothing new, but materials that glow in UV are harder to excite. The only other reported device which can electrically control gadolinium light emission requires more than 250 volts to operate. The Ohio State team showed that in a nanowire LED structure, the same effect can occur, but at far lower operating voltages: around 10 volts. High voltage devices are difficult to miniaturize, making the nanowire LEDs attractive for portable applications.

"The other device needs high voltage because it pushes electrons through a vacuum and accelerates them, just like a cathode ray tube in an old-style TV. The high-energy electrons then slam into gadolinium atoms, which absorb the energy and re-emit it as light in the UV," Myers explained.

"We believe our device works at significantly less voltage precisely because of the LED structure, where the gadolinium is placed in the center of the LED, exactly where electrons are losing their energy. The gadolinium atoms get excited and emit the same UV light, but the device only requires around 10 volts."

Because the LED emits light at specific wavelengths, it could be useful for research spectroscopy applications that require a reference wavelength, and because it requires only 10 volts, it might be useful in portable devices.

The same technology could conceivably be used to make UV laser diodes. Currently high-powered gas lasers are used to produce a laser at UV wavelengths with applications from advanced electronics manufacturing to eye surgery. The so-called excimer lasers contain toxic gases and run on high voltages, so solid-state lasers are being explored as a lower power—and non-toxic—alternative.

As to cost, Kent pointed out that the team grows its LEDs on a standard silicon wafer, which is inexpensive and easily scaled up to use in industry.

"Using a cheap substrate is good; it balances the cost of manufacturing the nanowires," he said.

The team is now working to maximize the efficiency of the UV LED, and the university's Technology Commercialization and Knowledge Transfer Office will license the design—as well as the method for making specially doped nanowires—to industry.

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