Someday, a way to 'see' nuclear, chemical threats

April 1 2010, By Tom Avril

Ordinarily, the small square of plastic and glass has a reddish color. But when Drexel University graduate student Sameet Shriyan flicks a switch, applying a bit of electricity, suddenly the red fades and the material becomes clear enough to see through. The square is essentially a mirror that reflects red light, but can be turned on and off.

This curious bit of laboratory prowess, when multiplied many times over with a rainbow of colors, could serve someday as the basis for a device to safeguard national security. At least that's the goal of Shriyan's supervisor, Drexel associate professor Adam Fontecchio, whose project is funded by the U.S. Department of Energy.

The idea is to make a sophisticated, airborne camera that could instantly detect gases emitted during the manufacture of certain weapons of mass destruction. One likely target is nuclear facilities, but in theory such a device could spot other nefarious chemical or biological activity, such as a release of nerve gas.

The concept is known as hyperspectral imaging: finding something by looking for its spectral signature -- essentially, its precise color or mix of component colors.

The U.S. military has used the technique to detect camouflaged tanks beneath trees, picking out ever-so-subtle differences in shades of green that would be indistinguishable to the human eye. It also is used in the civilian realm to identify such diverse quarry as skin cancers, diseased poultry and invasive plant species.

But the devices used in such applications are typically bulky and not readily adjustable. Collaborating with a high-tech firm in Massachusetts called Optra Inc., Fontecchio aims to make a device that is both lightweight and instantly "tunable" for different light signatures -- one that would be small enough to mount on an unmanned surveillance plane.

It would have a stack of dozens of different filters like the red one that Shriyan demonstrated, each one a slightly different color. By turning various precise colors on or off -- blocking them or allowing them to be captured by the camera -- the device could detect a target that reflects that specific mix of colors, says Fontecchio, who teaches in Drexel's electrical and computer engineering department.

With a gas, the color is typically too faint to be seen. But the device would detect it. The spectral signature of hydrogen, for example, includes several component "peaks," including one at a wavelength of 656 nanometers -- a specific shade of reddish-orange light. So if you were looking for hydrogen, you would turn on the correct filter to capture that color, along with others.

David Thompson, a physicist at Los Alamos National Laboratory who is monitoring the project, declined to say much about how such a device would be used. But he is impressed by the Drexel-Optra effort thus far -- while cautioning that it is still in the early stages.

"It's an ingenious technique," Thompson said.

One way such a device might be useful is in spotting a facility that is separating plutonium from spent uranium-based fuel, says David Albright, a physicist and president of the nonprofit Institute for Science and International Security in Washington, D.C.

That separation process requires the use of certain acids and other chemicals that could be detectable when they are vented to the air, says Albright, author of the book "Peddling Peril: How the Secret Nuclear Trade Arms America's Enemies."

Fontecchio, 35, who came to Drexel in 2002, began his career in physics before switching to more applied science.

But from an early age, he knew the sciences were in his future in some form. He has fond memories of tinkering with appliances with his grandfather, a carpenter who had all sorts of odds and ends strewn about his basement in Massachusetts.

"When something would break in the house, even when I was 8 or 9 or 10, I was the one who would help fix it," Fontecchio says.

The equipment in Fontecchio's lab at Drexel is a far cry from carpentry.

The mirrorlike filters are made using lasers. And the white-walled lab space is abuzz with other projects involving the interaction of light and matter.

One grad student, Jared Coyle, is working with something called "solar paint" -- which would generate electricity like a solar panel but could be painted onto a surface, such as a car.

Another one, David Delaine, is working with sophisticated versions of radiometers -- those classic science toys with the black-and-white squares that spin when exposed to light.

The version in the lab is sensitive to heat as well as light, so they work even in the dark. The goal is to cram hundreds of tiny ones onto a chip. If installed on say, a laptop computer, they would spin in response to excess heat from the battery, and thus could be used to make electricity that could be funneled back into the battery.

The hyperspectral project for the Department of Energy began when Optra officials came across Fontecchio's work in a literature search and urged him to join them in applying for the money. The project is now in its second phase, with a two-year, $750,000 federal grant split between the company and Drexel.

To make one of the filters -- the colored "mirrors" that can be turned on and off -- the engineers start with a viscous mixture of light-sensitive polymer and liquid crystals, similar to the stuff in a calculator display window or a flat TV screen. This mixture is sandwiched between a pair of glass squares.

The engineers then use laser beams to organize the mixture into a striped layer-cake pattern, technically a hologram with alternating stripes of liquid crystal and polymer.

"It's kind of like stacking pages in a book," Fontecchio says.

By controlling the thickness of the stripes, the engineers can change the way light of different wavelengths will bounce off the material -- allowing them to reflect any color they want. Ultimately they plan to make filters for 100 different colors.

The reason the engineers are then able to turn a given color on and off has to do with the layers of liquid crystals.

When electricity is applied, the crystals orient themselves in such a way that all colors of light pass through the filter. The physics involved defies a brief explanation, but the end result is indisputable. Flick a switch, and the mirrorlike material becomes transparent.

There are applications beyond national security.

Shriyan and Fontecchio would like to use the colored filters to make ultra-thin, low-energy laptop screens. Currently, such screens are illuminated from behind with a power-hogging white light.

But imagine a computer screen in which the traditional pixels were replaced with thousands of the colored, mirrorlike filters -- each one the size of a pixel. In order to project a certain image, the machine would turn various mirrors on and off to reflect the right mix of colors. All you'd need would be ambient light to see it.

The laptop screen is years away from fruition, while a prototype of the plane-mounted camera could be ready within a year and a half.

Whatever the time frame, it doesn't take much reflection to see that these Drexel engineers have a way with light.

Citation: Someday, a way to 'see' nuclear, chemical threats (2010, April 1) retrieved 26 April 2024 from https://phys.org/news/2010-04-nuclear-chemical-threats.html