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Sensor could detect concealed weapons without x-rays

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A new sensor being patented by Ohio State University could be used to detect concealed weapons or help pilots see better through rain and fog. Unlike X-ray machines or radar instruments, the sensor doesn't have to generate a signal to detect objects – it spots them based on how brightly they reflect the natural radiation that is all around us every day.

There is always a certain amount of radiation – light, heat, and even microwaves – in the environment. Every object – the human body, a gun or knife, or an asphalt runway – reflects this ambient radiation differently.

Paul Berger, professor of electrical and computer engineering and physics at Ohio State and head of the team that is developing the sensor, likened this reflection to the way glossy and satin-finish paints reflect light differently to the eye.

Once the sensor is further developed, it could be used to scan people or luggage without subjecting them to X-rays or other radiation. And if the sensor were embedded in an airplane nose, it might help pilots see a runway during bad weather.

The Ohio State sensor isn't the only ambient radiation sensor under development, but it is the only one Berger knows of that is compatible with silicon – a feature that makes it relatively inexpensive and easy to work with.

Berger describes the sensor in the current issue of the journal IEEE Electron Device Letters. His coauthors include Niu Jin, who performed this work for his doctorate at Ohio State and is now at the University of Illinois at Urbana-Champaign; Ronghua Yu and Sung-Yong Chung, both graduate students at Ohio State; Phillip E. Thompson of the Naval Research Laboratory; and Patrick Fay of the University of Notre Dame.

Berger said that the new sensor grew out of his team's recent invention of a device called a tunnel diode that transmits large amounts of electricity through silicon.

He was reading about another team's ambient radiation sensor when he realized that their device worked like one of his diodes -- only in reverse.

“It's basically just a really bad tunnel diode,” he explained. “I thought, heck, we can make a bad diode! We made lots of them back when we were figuring out how to make good ones.”

As it turns out, a really bad tunnel diode can be a really good sensor.

Diodes are one-way conductors that typically power amplifiers for devices such as stereo speakers. Berger's diode is unique because it is compatible with mainstream silicon, so computer chip makers could manufacture it cheaply and integrate it with existing technology easily.

The new sensor is essentially one of these tunnel diodes with a strong short circuit running backwards and very little tunneling current running forwards.

Thompson prepared the films of layered semiconductor material, and the Ohio State team fabricated and tested the sensors.

The way engineers measure the effectiveness of such sensors is to draw a line graph charting the amount of current passing through them. Then they measure the curvature of the line at the point where the current is zero. A steep curve indicates that a sensor is working well, so the higher this so-called “curvature coefficient” is, the better.

In the laboratory, prototypes of the Ohio State sensor averaged a curvature coefficient of 31. While one other research team has produced a sensor with a coefficient of 39, that sensor is made of antimony – an exotic metal that is hard to work with and not directly compatible with the silicon circuit that surrounds the sensor element, Berger pointed out.

“So our raw sensor performance isn't quite as good, but our ultimate performance should be superior because you could integrate our device directly with any conventional microchip readout circuitry that you wanted to build,” he said.

The team that is making the antimonide sensor has succeeded in combining it with a camera system; the pictures look a lot like X-ray images, with bodies and clothing appearing as dim outlines and metal objects such as guns standing out in sharp relief.

That camera system has performance issues that Berger thinks could be solved with his silicon-compatible design. Still, the image has inspired him to think big about where his work could go in the future. Combat pilots, for instance, could potentially use this technology to stealthily identify other aircraft as friend or foe.

“If you got a fast enough response and a high-resolution image, I wonder if you might be able tell one kind of aircraft from another without revealing your location to the enemy,” he said.

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Links: [IEEE Electron Device Letters]

Source: Ohio State University