Silicon could open the way for new terahertz technology

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Surface plasmon resonance is used for a variety of purposes including detecting protein or DNA and enhancing the sensitivity of spectroscopy. However, surface plasmon resonance requires a metal. Gold and silver are among the metals that best support surface plasmons. Unfortunately, Weili Zhang, a professor at Oklahoma State University, tells *PhysOrg.com*, “Silver isn’t always long lasting and gold can be too expensive.” The solution? Zhang and his colleagues suggest that silicon can be used for surface plasmon resonances. But first it needs to become something metallic.

Along with colleagues Abul Azad and Jiaguang Han from Oklahoma State and Jngzhou Xu, Jian Chen and X.-C. Zhang from Rensselaer Polytechnic Institute in Troy, New York, Zhang has shown how the use of laser pulses can create a surface plasmon resonance from a photonic crystal effect. “This is the first time anyone has reported seeing this transition. This is a very interesting change,” he says.

Zhang and his coauthors report their findings in “Direct Observation of a Transition of a Surface Plasmon Resonance from a Photonic Crystal Effect,” published in *Physical Review Letters*.

Surface plasmons can only exist in a metal/dielectric interface. They are electromagnetic waves that run along the surface of this interface. “What we wanted to do,” explains Zhang, “is start with a non-conductive material to see if we could excite surface plasmons in the terahertz region.” For their attempt, Zhang and his colleagues use silicon because of its properties as a semiconductor. “We used ultra-fast laser pulses that resulted in photodoping.”

Zhang explains that initially the signature of the microstructured silicon is that of a photonic crystal resonance. But as the laser pulses are introduced, the resonance changes. “We see the photonic crystal signature disappear because the permittivity changes, the silicon becomes metallic, and the condition for surface plasmons is satisfied, thus the resonance changes.”

This work is likely to result in a variety of applications across different fields, Zhang explains. Terahertz systems, which are used for spectroscopy and imaging, can be modified more efficiently with this new way of generating surface plasmon resonance, which Zhang describes as “tunable.”

“Terahertz systems always need some kind of filters to control operating frequencies and wavelengths,” Zhang points out. “But with regular metals, once the structure is fixed, the operating frequencies are fixed. With this silicon process, these things can be changed. Both the frequencies and intensity can be controlled. This new way is more flexible and efficient.”

Biomedicine is a field especially where terahertz systems can find good use. Terahertz radiation can be used to “look” deep inside organic materials, and they do it without causing the damage that X-rays do. Additionally terahertz radiation is being considered for use in screening airport passengers.

Zhang also points out that surface plasmon resonance to direct terahertz systems can also be used to enhance space communication: “This would be ideal for making tunable switches.” Indeed, astronomers are interested in using terahertz technology to study the particles that fall into the category of “far-infrared.”

“Because silicon is cheap, rigid, and tunable,” concludes Zhang, “this is an important and exciting finding. The applications for technology are just beginning.”

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