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Physicists Discover Ultrasensitive Microwave Detector

Physicists from Rice University and Princeton University have discovered how to use one of the information technology industry's mainstay materials -- gallium arsenide semiconductors -- as an ultrasensitive microwave detector that could be suitable for next-generation computers. The discovery comes at a time when computer chip engineers are racing both to add nanophotonic devices directly to microchips and to boost processor speeds beyond 10 gigahertz (GHz).

"Tunable photon-detection technology in the microwave range is not well-developed," said Rice physicist Rui-Rui Du, one of the study's authors. "Single-photon detectors based on superconductors in the 10-GHz to 100-GHz range are available, but their resonance frequency has been difficult to tune. Our findings suggest that tunable single-photon detection may be within reach with ultrapure gallium arsenide."

The study, which is available online and due to appear in print this week in *Physical Review Letters*, is the latest result from a long-term collaboration between Du and Princeton University physicist Loren Pfeiffer, whose group produces the world's purest samples of gallium arsenide. For the new study, Rice graduate student Yanhua Dai cooled one of Pfeiffer's ultrapure samples to below 4 degrees Kelvin -- the temperature of liquid helium. She then bombarded the sample with microwaves while applying a weak magnetic field -- approximately the same strength as that of a refrigerator magnet. Du and Dai were surprised to find that microwaves of a specific wavelength resonated strongly with the cooled sample. They also found they could use the magnet to tune this resonance to specific microwave frequencies.

Du said previous experiments have typically measured weak resonance effects from microwaves. "A signal level

of 1 percent is a common measurement. In our case, the change was a thousand times that much."

While the team does not yet understand the mechanism that leads to such a sensitive reaction, they are eagerly pursuing follow-up research to try to prove they can use the effect for single-photon measurements.

A photon is the smallest possible unit of light or electromagnetic radiation. By incorporating devices that create, transmit and measure digital information via photons, rather than with electrons, makers of computer chips hope to produce computers that are both faster and more powerful.

"The clock speed of a new computer right now is about 2 GHz," Du said. "For the next generation, the industry is shooting for around 100 GHz, which is a microwave device. The phenomenon we've observed is in this region, so we hope it may be useful for them."

Additional co-authors include Princeton scientist Ken West. The research was supported by the National Science Foundation.

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