Using plasmonics to transmit more data

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Merely a decade ago, people were amazed that their cellular phones could send a simple text message. Now smartphones send and receive high-resolution photographs, videos, emails with large attachments, and much more. The desire for endless data has become insatiable.

"The ability to deliver information from one location to another has played a very important role in advancing human civilization," said Robert P.H. Chang, professor of materials science and engineering at Northwestern Engineering. "Today, we live in a digital world where the demand for the ability to transmit large amounts of data is growing exponentially."

To meet this high demand, Chang and his team developed a means to modulate light signals in the near-infrared wavelength region. Their work demonstrates a new scheme to control infrared plasmons, opening a new door for transmitting massive amounts of information.

The research appeared online on Monday, Feb. 22, 2016 in the *Nature Photonics*. Peijun Guo, a senior PhD student in Chang's laboratory, is the paper's first author.

A plasmon is a quantum particle that arises from collective oscillations of free electrons. By controlling the plasmons, researchers can enable optical switches, potentially permitting signals in optical fibers to be switched from one circuit to another—with ultimate high speeds in the terahertz.

Researchers have demonstrated active plasmonics in the ultraviolet to visible wavelength range using noble metals, such as gold. But controlling plasmons in the near- to mid-infrared spectral range—where noble materials suffer from excessive optical losses—is largely unexplored. Research in this area has recently attracted significant attention for its importance in telecommunications, thermal engineering, infrared sensing, light emission and imaging.

Chang's team successfully controlled plasmons in this technologically important range by using indium-tin-oxide (ITO) nanorod arrays. The low electron density of ITO enables a substantial redistribution of electron energies, which results in light signal modulation with very large absolute amplitude. By tailoring the geometry of the ITO nanorod arrays, researchers could further tune the spectral range of the signal modulation at will, which opens the door for improved telecommunications and molecular sensing.

"Our results pave the way for robust manipulation of the infrared spectrum," Chang said.

More information: Ultrafast switching of tunable infrared plasmons in indium tin oxide nanorod arrays with large absolute amplitude, *Nature Photonics*, DOI: 10.1038/nphoton.2016.14

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