Novel man-made material could facilitate wireless power

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Electrical engineers at Duke University have determined that unique man-made materials should theoretically make it possible to improve the power transfer to small devices, such as laptops or cell phones, or ultimately to larger ones, such as cars or elevators, without wires.

This advance is made possible by the recent ability to fabricate exotic composite materials known as metamaterials, which are not so much a single substance, but an entire man-made structure that can be engineered to exhibit properties not readily found in nature. In fact, the metamaterial used in earlier Duke studies, and which would likely be used in future wireless power transmission systems, resembles a miniature set of tan Venetian blinds.

Theoretically, this metamaterial can improve the efficiency of "recharging" devices without wires. As power passes from the transmitting device to the receiving device, most if not all of it scatters and dissipates unless the two devices are extremely close together. However, the metamaterial postulated by the Duke researchers, which would be situated between the energy source and the "recipient" device, greatly refocuses the energy transmitted and permits the energy to traverse the open space between with minimal loss of power.

"We currently have the ability to transmit small amounts of power over short distances, such as in radio frequency identification (RFID) devices," said Yaroslav Urzhumov, assistant research professor in electrical and computer engineering at Duke's Pratt School of

Engineering. "However, larger amounts of energy, such as that seen in lasers or microwaves, would burn up anything in its path.

"Based on our calculations, it should be possible to use these novel metamaterials to increase the amount of power transmitted without the negative effects," Urzhumov said.

The results of the Duke research were published online in the journal *Physical Review B*. Urzhumov works in the laboratory of David R. Smith, William Bevan Professor of electrical and computer engineering at Pratt School of Engineering. Smith's team was the first demonstrate that similar metamaterials could act as a cloaking device in 2006.

Just as the metamaterial in the cloaking device appeared to make a volume of space "disappear," in the latest work, the metamaterial would make it seem as if there was no space between the transmitter and the recipient, Urzhumov said. Therefore, he said, the loss of power should be minimal.

Urzhumov's research is an offshoot of "superlens" research conducted in Smith's laboratory. Traditional lenses get their focusing power by controlling rays as they pass through the two outside surfaces of the lens. On the other hand, the superlens, which is in fact a metamaterial, directs waves within the bulk of the lens between the outside surfaces, giving researchers a much greater control over whatever passes through it.

The metamaterial used in wireless power transmission would likely be made of hundreds to thousands – depending on the application – of individual thin conducting loops arranged into an array. Each piece is made from the same copper-on-fiberglass substrate used in printed circuit boards, with excess copper etched away. These pieces can then be arranged in an almost infinite variety of configurations.

"The system would need to be tailored to the specific recipient device, in essence the source and target would need to be 'tuned' to each other," Urzhumov said. "This new understanding of how matematerials can be fabricated and arranged should help make the design of wireless power transmission systems more focused."

The analysis performed at Duke was inspired by recent studies at Mitsubishi Electric Research Labs (MERL), an industrial partner of the Duke Center for Metamaterials and Integrated Plasmonics. MERL is currently investigating metamaterials for wireless power transfer. The Duke researchers said that with these new insights into the effects of metamaterials, developing actual devices can be more targeted and efficient.

Provided by Duke University