Metamaterial-enabled antennas help improve satellite communications systems

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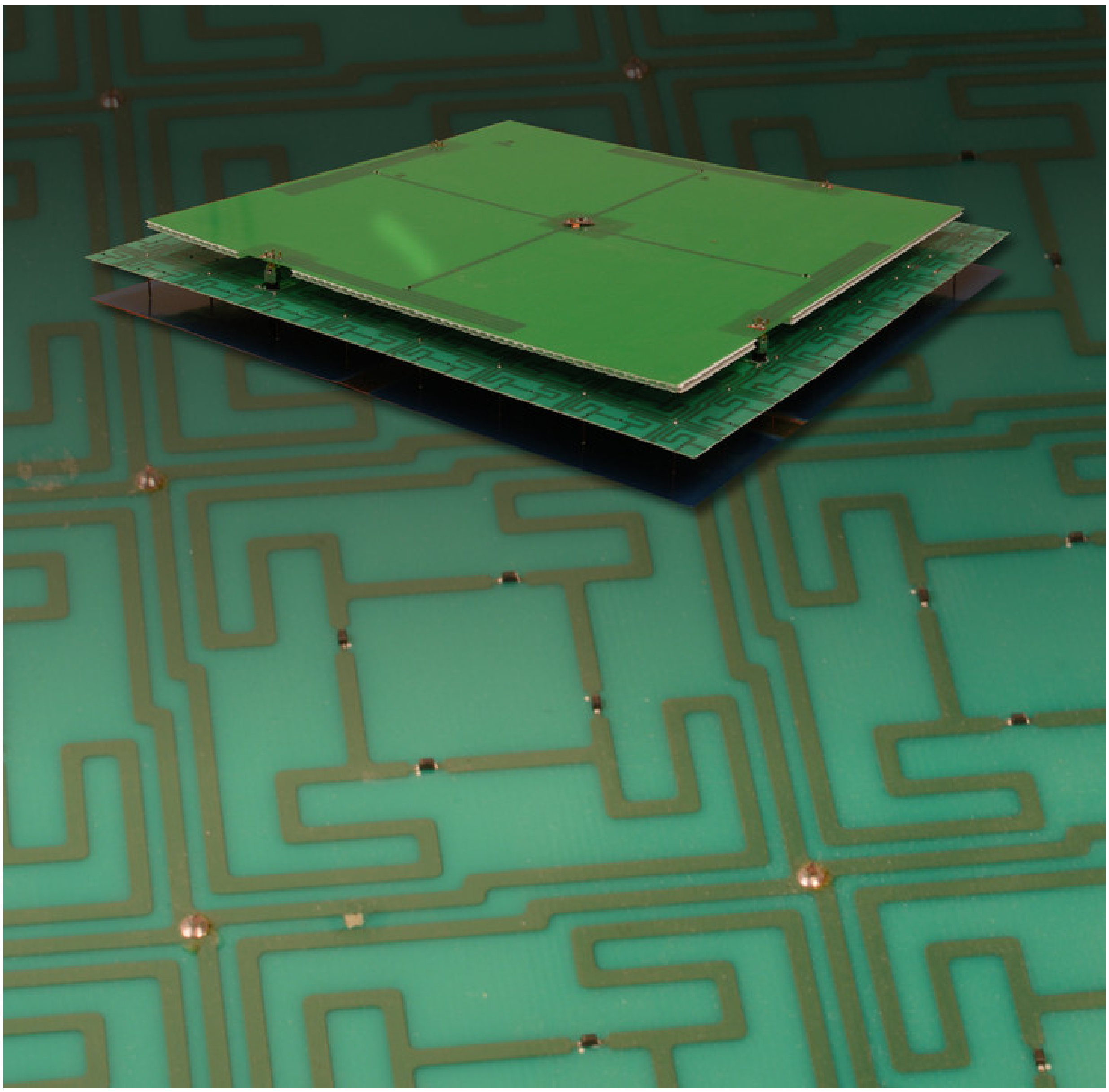

Metamaterial-enabled antenna created by Scarborough and Werner. Credit: Penn State

Smaller, lighter weight, better performing and more multifunctional miniature antennas with increased performance may be possible using smart materials, according to Penn State engineers. One particularly promising application of this technology is for satellite communications systems.

These antennas made of metamaterials—manufactured materials that possess exotic properties not usually found in nature—can be integrated with modern digital electronic radios that are software controlled, facilitating a transformative communications system with remarkable frequency and polarization agility.

The engineers, who reported their research in a recent issue of Advanced Electronic Materials, developed a small, functionalized, metamaterial antenna operated by simultaneously tuning components of the metamaterial and the antenna together as a system, said Clinton Scarborough, who worked on this research for his dissertation.

Metamaterials derive their unusual properties from manufactured structures rather than atomic or molecular interactions alone.

"Metamaterial-based antennas often suffer a stigma of impractically narrow operating bandwidths, just like small antennas," said Scarborough. "Radios need to be able to operate over a significant bandwidth, but typically only on a single channel at a time. The laws of physics dictate that a small metamaterial antenna will have a small bandwidth, but modern radios can easily tune the antenna so that it operates on whatever channel the radio is currently using, giving comparable performance to a large broadband antenna while taking up less space and even providing new capabilities."

The engineers developed a tunable metamaterial that allows them to tune a miniaturized antenna with narrow instantaneous bandwidths across an entire communications band depending on the channel in use, said Douglas H. Werner, John L. and Genevieve H. McCain Chair Professor of Electrical Engineering.

"Tuning the metamaterial and antenna in tandem provides a dynamic operating channel, with a tunable, nearly-arbitrary polarization response as an added benefit," said Werner. "By employing our functionalized metamaterial concepts, we have been able to devise a way to dynamically tune the frequency response and polarization for the antenna, while, at the same time, providing a pathway to scaling the designs to low frequencies."

Many research groups are working on different kinds of metamaterial-enabled antennas, but the one area that has been quite challenging is figuring out a way to scale these metamaterial and associated antenna structures down to operate at lower frequencies while maintaining a practical physical size and weight for the resulting integrated device—in general, the lower the frequency, the bigger the antenna, said Werner.

More information: Clinton P. Scarborough et al. Functionalized Metamaterials Enable Frequency and Polarization Agility in a Miniaturized Lightweight Antenna Package, *Advanced Electronic Materials* (2016). DOI: 10.1002/aelm.201500295

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