Gold structures improve spin wave transfer to address electronics overheating problem

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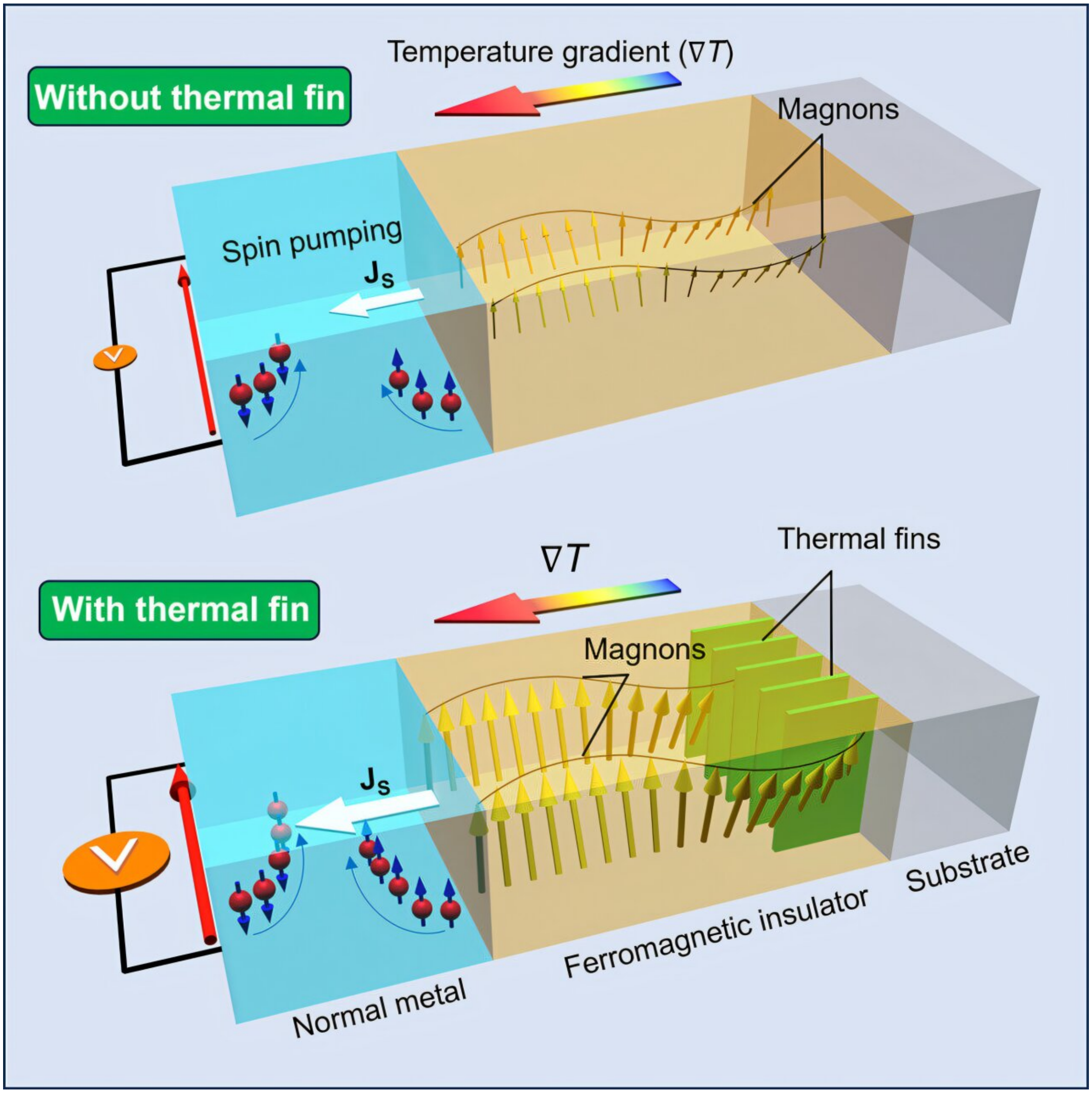

Schematic illustration of spin wave transmission characteristics with and without nanostructures. Credit: POSTECH

A research team has made a breakthrough in significantly enhancing the commercial viability of spin wave harnessing technology. This innovation is being heralded as a next-generation technological solution to the persistent issue of heat generation in electronic devices. The research findings were published on September 26 in the online edition of *Matter*.

If you've been using your smartphone or computer for some time, you may have been surprised to suddenly realize that your device is getting hot. It's due to the movement of electrons within the device as they process and store data, causing some energy to convert into heat. With the rapid advancement of artificial intelligence and cloud computing, electronics are becoming smaller and more complex, intensifying the overheating problem.

As a way to solve the problem of heat generation in electronic devices, information transmission technology using "spin waves" is gaining attention. Spin waves are waves that can transmit information without the flow of electrons by utilizing the spin characteristics of electrons in magnetic insulators.

Recent research has shown that increasing the temperature imbalance of spin waves in a material—i.e., the tendency of spin waves on one side of the material to become hotter and the other side to become colder—increases the information-carrying efficiency of spin waves. However, there is no technology that can independently control the temperature of spin waves.

A collaborative research team from POSTECH, Chungnam National University, and KAIST has developed a novel approach inspired by the radiator fins used to cool automobile engines. The team incorporated nanometer-scale gold structures at one end of a thin film made of magnetic insulator, designing it to effectively regulate temperature based on the concentration of the gold.

These gold structures effectively reduced the temperature of the spin waves at the targeted location, creating a temperature imbalance within the material. Their experiments demonstrated that this thin film improved spin wave transfer efficiency by over 250% compared to conventional methods. This study is the first to report the successful independent control of spin wave temperature and to demonstrate a method for enhancing spin wave transfer efficiency by utilizing this control.

Professor Hyungyu Jin of POSTECH who led the research expressed the significance of the research by saying, "This research represents a significant milestone in developing next-generation information transfer technologies to address heat generation in electronics."

Dr. Sang Jun Park, the study's lead author remarked, "By overcoming previous limitations, this technology has promising potential for a wide range of future applications using spin waves."

The team was led by Professor Hyungyu Jin and Dr. Sang Jun Park (currently, a postdoctoral researcher at the National Institute for Materials Science, Japan) from the Department of Mechanical Engineering at POSTECH, in collaboration with a research team of Professor Jong-Ryul Jeong from Department of Materials Science and Engineering at Chungnam National University and Professor Se Kwon Kim's research team from the Department of Physics at Korea Advanced Institute of Science and Technology (KAIST).

More information: Sang J. Park et al, Enhancing spin pumping by nonlocal manipulation of magnon temperature, *Matter* (2024). DOI: 10.1016/j.matt.2024.08.023

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