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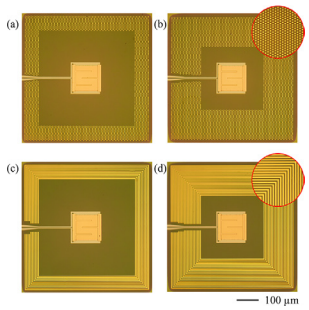
Layering metals in unique patterns reduces the conductance of freestanding silicon nitride membranes, opening new opportunities for improving low temperature sensors.



Phonon transport plays an important role in the thermal conductance of membranes. In order to study the cosmic microwave background to understand the structure and origins of the universe, scientists use superconducting transition-edge sensors (TES) and need to be able to manipulate their conductance. Though the possibility of creating freestanding membranes to control the thermal conductivity of these superconducting sensors has been theorized before, a team of scientists has developed the first device demonstrating its feasibility.

Freestanding membranes provide thermal isolation to TES detectors, which absorb photons and measure temperature to calculate the energy of the photons. Zhang et al. developed a technique to reduce the thermal conductance of freestanding membranes without increasing their size or decreasing their mechanical strength.

“The thermal isolation of a TES is a crucial design parameter because it determines operating properties,” said Xiaohang Zhang, an author on the study. “Achieving lower thermal conductance improves device sensitivity, and this technique provides greater control over thermal conductance.”

The team added layers of gold or superconducting molybdenum in different thicknesses and pattern configurations on silicon or silicon nitride membranes. Metals in these unique patterns interfered with phonon transport, reducing conductance by up to 50 percent.

To evaluate the efficiency of the approach, the team examined the membranes for unwanted thermal noise and found it did not add noise to the system. Zhang believes this method opens new opportunities for applications in the growing technology area of low temperature sensors.

“This technique can be applied to other types of membranes to reduce or control the thermal conductance,” Zhang said. “It would be interesting to study other materials that may shed light on the underlying mechanism for the conductance suppression.”

Source: “Controlling the thermal conductance of silicon nitride membranes at 100 mK temperatures with patterned metal features,” by X. Zhang, S. M. Duff, G. C. Hilton, P. J. Lowell, K. M. Morgan, D. R. Schmidt, and J. N. Ullom, *Applied Physics Letters* (2019). The article can be accessed at https://doi.org/10.1063/1.5097173.