Study offers details on using electric fields to tune thermal properties of ferroelectric materials

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Ankit Negi holds a PMN-PT crystal, like those used in the research. Standing with him is study co-author Hwang Pill Kim. Credit: North Carolina State University

New research from North Carolina State University sheds light on how electric fields can be used to alter the thermal properties of ferroelectric

materials, allowing engineers to manipulate the flow of heat through the materials. Ferroelectric materials are used in a wide variety of applications, from ultrasound devices to memory storage technologies.

"Our work here is a significant advance because we worked with large sample sizes and provide detailed information on the relationship between the type of electric field being applied to the ferroelectric material and the thermal response in the material," says Jun Liu, an associate professor of mechanical and aerospace engineering at NC State and corresponding author of the study. "In practical terms, this allows users to tune the thermal behavior of the material by applying different electric fields—using alternating current (AC) or direct current (DC)—which paves the way for developing new techniques for managing the flow of heat through various devices."

For this work, the researchers worked with a ferroelectric material called PMN-PT, which is used in technologies such as sensors, actuators and ultrasound devices. To reflect real-world conditions, the researchers worked with 2.5 mm-thick samples at room temperature.

For the study, researchers applied electric fields of varying strengths to the material using both AC and DC sources. Other variables in their testing were the frequency of the current and the length of time that the material was exposed to the electric field.

The researchers then used a suite of methods to measure how each sample's thermal properties changed in response to the different electric field conditions.

The researchers found that all four variables—the strength of the field, whether it was AC or DC, time and frequency—played a role in how the electrical field altered the material's thermal properties.

"Having a detailed understanding of how each of the four variables influences the material's thermal properties gives us a significant amount of control in engineering the material's thermal behavior," says Ankit Negi, a Ph.D. student at NC State and first author of a journal article on the study.

"We're hoping to establish a similarly detailed understanding of the relationship between electric fields and thermal characteristics for other ferroelectric materials," Liu says. "And we are open to collaborations on how this work could inform the development of new applications."

The paper, "Ferroelectric Domain Wall Engineering Enabled Thermal Modulation in PMN-PT Single Crystals," is published open access in the journal *Advanced Materials*.

More information: Ankit Negi et al, Ferroelectric Domain Wall Engineering Enabled Thermal Modulation in PMN-PT Single Crystals, *Advanced Materials* (2023). DOI: 10.1002/adma.202211286

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