Direct measurement of the local electrocaloric effect in 2D a-In2Se3 by Scanning Electrocaloric Thermometry

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The electrocaloric effect (ECE) refers to the temperature change in a material when an electric field is applied or removed. Significant breakthroughs revealed its potential for solid-state cooling technologies in past decades. [1]
Electrocaloric effects are typically studied using indirect methods using polarization data, and which suffer from inaccuracies related to assumptions about heat capacity. Direct methods, although more precise, require device fabrication and face challenges in studying meso- or nanoscale systems, like 2D materials, and materials with non-uniform polarization textures where high spatial resolution is required.
A novel technique, Scanning Electrocaloric Thermometry, is introduced for characterizing the local electrocaloric effect in nanomaterials. [2] This approach achieves high spatial resolution by locally applying electric fields and by simultaneously measuring the resulting temperature change, as shown in Figure 1. By employing AC excitation, the measurement sensitivity is further enhanced and the electrocaloric effect is disentangled from other heating mechanisms such as Joule heating and dielectric losses. These losses appear at the first and third harmonic of the signal while the ECE dominates in the second harmonic, as shown at Figure 2. The effectiveness of the method is demonstrated by examining the local electrocaloric effect in two-dimensional In2Se3 μ-sized flakes.[3]

References
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[2] J. Spièce, V.Fonck, C. Evangeli, P. Dobson, J. Weaver, P. Gehring, Preprint at https://doi.org/10.48550/arXiv.2412.15884 (2024)
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Figures

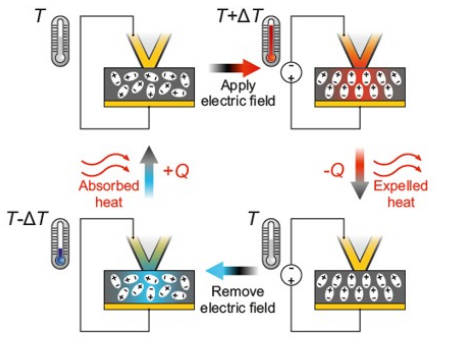

Figure 1 Measurement scheme for the Scanning Electrocaloric Thermometry (SeCT) mode

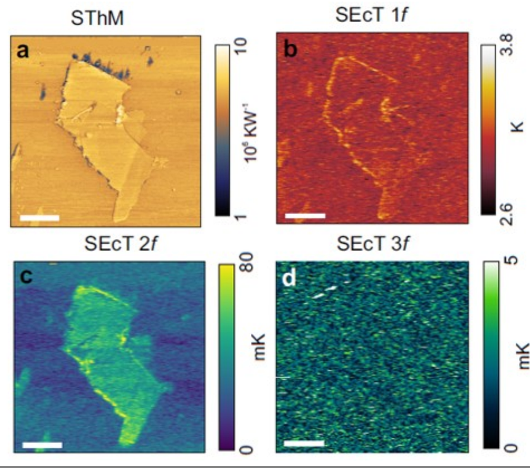

Figure 2 **a** Scanning Thermal Microscopy image of an α-In_2Se_3 flake **b** Simultaneous SeCT imaging of the local heating effects at the first harmonic of the gate excitation signal, contain **c** Idem with 2nd harmonic, highlighting the electrocaloric effect **d** Idem with 3rd harmonic