Poliarizacijos perjungimo mechanizmai van der Waals sluoksniniuose kristaluose

Polarization Switching Phenomena of van der Waals layered single crystal

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In addition to graphene and graphite, some of the best known layered materials are the layered thiophosphates with common chemical composition of $CuInP_2Q_6$ (Q=S, Se). This class of materials has been studied extensively for a long time. A comprehensive study of polarization swithing in a ferroelectric copper indium thiophosphate $CuInP_2S_6$ (CIPS) has been reported both in nanoscale as well as bulk crystals [1], [2]. It was confirmed stable ferroelectric polarization in an intrinsically layered CIP (below ~50 nm thickness). Anomalous polarization switching was found in a ferroelectric CIPS in bulk crystalline. Such anomalous behaviour were found to correlate with its ionic conductivity. The sulfur and selenium compounds have similar structure. Despite this structural similarity, the physical properties are quite different as evidenced by dielectric, ultrasonic, caloric etc. characterization [3]. It was proposed that this anomaly is evidenced for the coexistence of ferrielectric and antiferroelectric ordering [4]. In this report, swithing dynamics of $CuInP_2Se_6$ single crystals are presented over wide ranges of temperature and electric field.

The single crystals $CuInP_2Se_6$ were grown from gas phase by chemical transport reactions. All samples were measured in the form of parallel plate capacitors with silver electrodes. Ferroelectric hysteresis loops were carried out using a commercial ferroelectric test system (TF Analyzer 2000E, AixACCT Germany). Dielectric data were collected using LCR meter HP4284 from 20 Hz to 1 MHz.

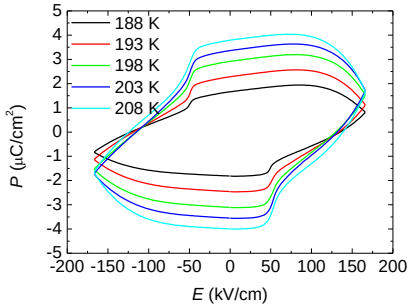

Figure 1. Temperature dependent polarization switching characteristics of $CuInP_2Se_6$

Ferroelectric swithing is usually dificult to experimentally demonstrate in these materials, mostly due to an intrinsic high conductivity and low-temperature ferroelectric behaviour. Through comprehensive polarization switching (Figure 1) and dielectric spectroscopy studies in both temperature and frequency domains, we reveal that the ionic conductivity influences polarization swithing behavior by thermally activated hopping of copper ions in the lattice of $CuInP_2S_6$.

Keywords: van der Waals crystals, polarization, electrocaloric effect

References

[1] A. Belianinov *et al.*, "$CuInP_2S_6$ Room Temperature Layered Ferroelectric," *Nano Lett.*, vol. 15, no. 6, pp. 3808–3814, 2015.
[2] S. Zhou *et al.*, "Anomalous polarization switching and permanent retention in a ferroelectric ionic conductor," *Mater. Horizons*, vol. 7, no. 1, pp. 263–274, 2020.
[3] S. Zhou, L. You, H. Zhou, Y. Pu, Z. Gui, and J. Wang, "Van der Waals layered ferroelectric $CuInP_2S_6$: Physical properties and device applications," *Front. Phys.*, vol. 16, no. 1, pp. 13301-1–30, 2021.
[4] A. Dziaugys *et al.*, "Piezoelectric domain walls in van der Waals antiferroelectric $CuInP_2Se_6$," *Nat. Commun.*, vol. 11, no. 1, pp. 1–7, 2020.