Direct observation of geometric and sliding ferroelectricity in an amphidynamic crystal

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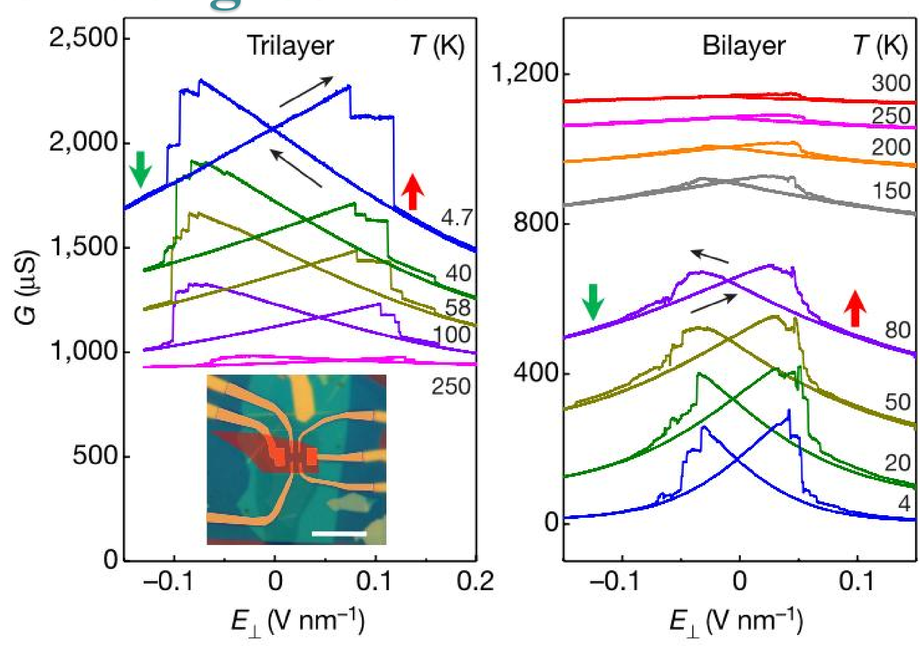
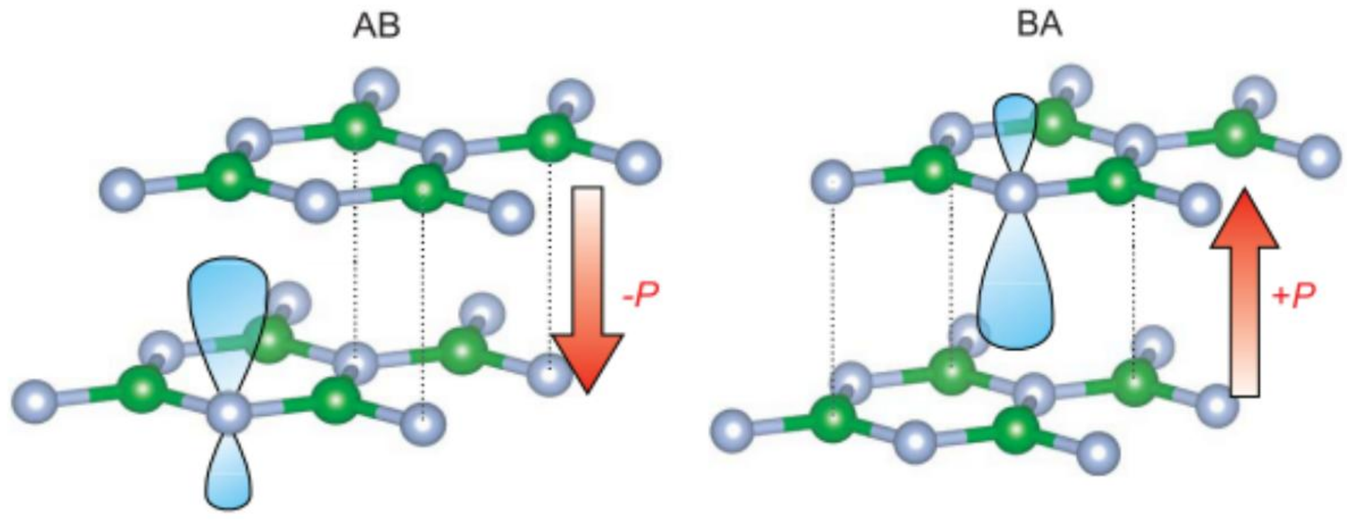
Sliding ferroelectricity is a recently observed polarity existing in two-dimensional materials. However, due to the weak polarization and poor electrical insulation in these materials, existing experimental evidences are indirect and mostly based on nanoscale transport properties or piezoresponse force microscopy. We report the direct observation of sliding ferroelectricity, using a high-quality amphidynamic single crystal (15-crown-5)Cd_3Cl_6, which possesses a large bandgap and so allows direct measurement of polarization–electric field hysteresis. This coordination polymer is a van der Waals material, which is composed of inorganic stators and organic rotators as determined by X-ray diffraction and NMR characterization. From density functional theory calculations, we find that after freezing the rotators, an electric dipole is generated in each layer driven by the geometric mechanism, while a comparable ferroelectric polarization originates from the interlayer sliding. The net polarization of these two components can be directly measured and manipulated. Our finding provides insight into low-dimensional ferroelectrics, especially control of the synchronous dynamics of rotating molecules and sliding layers in solids.

◎Background



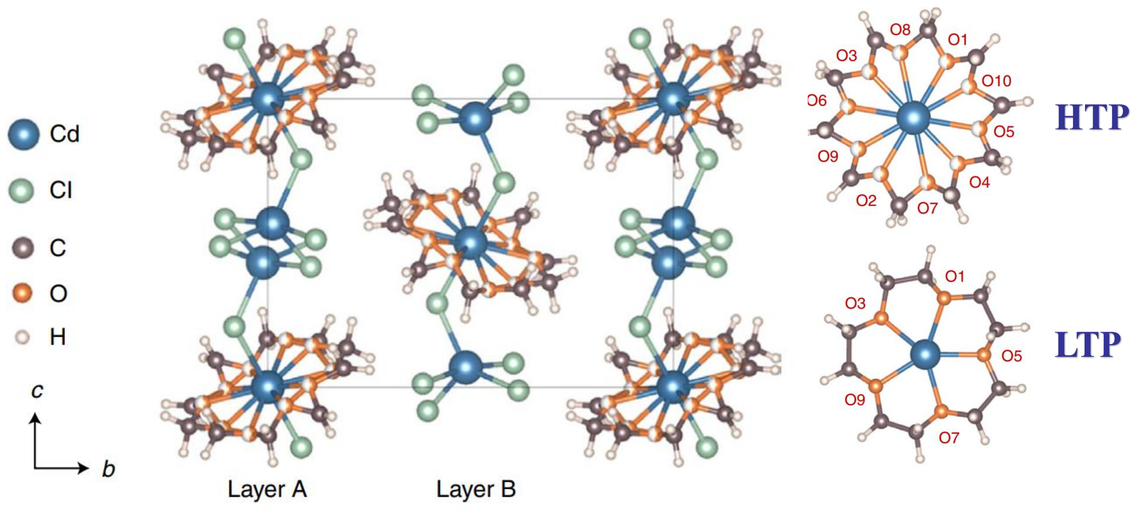
Nature 560, 336 (2018)
Science 372, 1458 (2021)



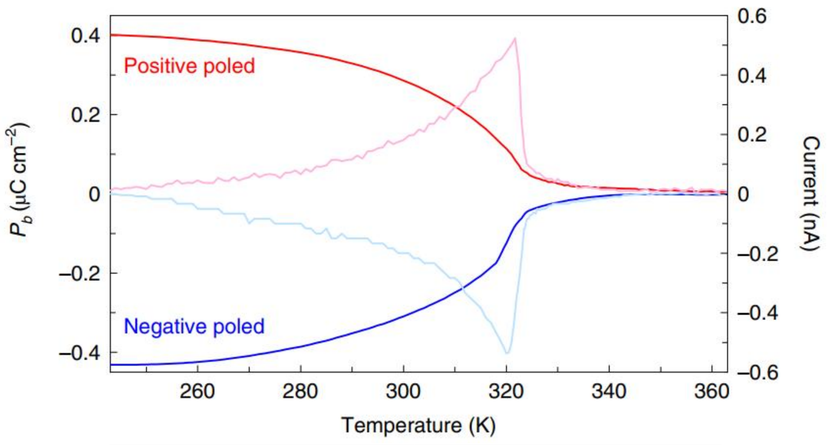
Methods of measurement: transport, SHG, PFM/KPFM
indirect
The urgent issue for sliding ferroelectric: P-E loop
direct

◎Direct measurement of ferroelectric

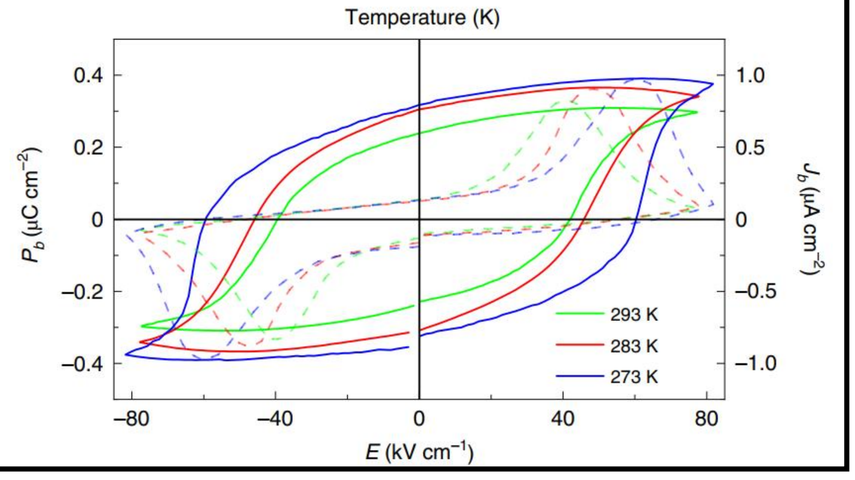
➢ **amphidynamic crystal**



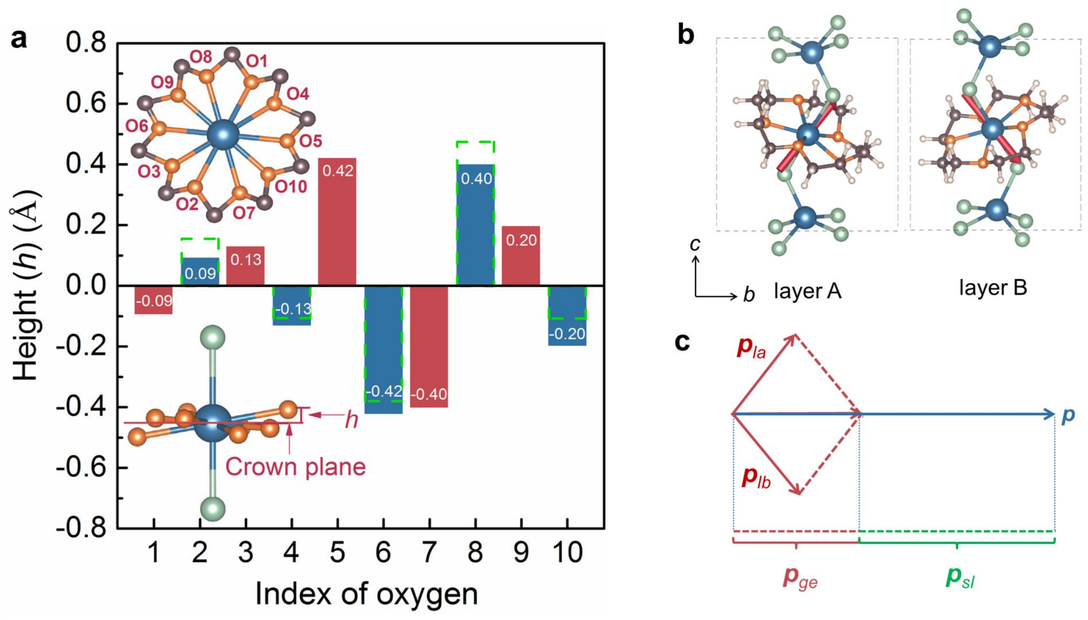
➢ **Pyroeletric**



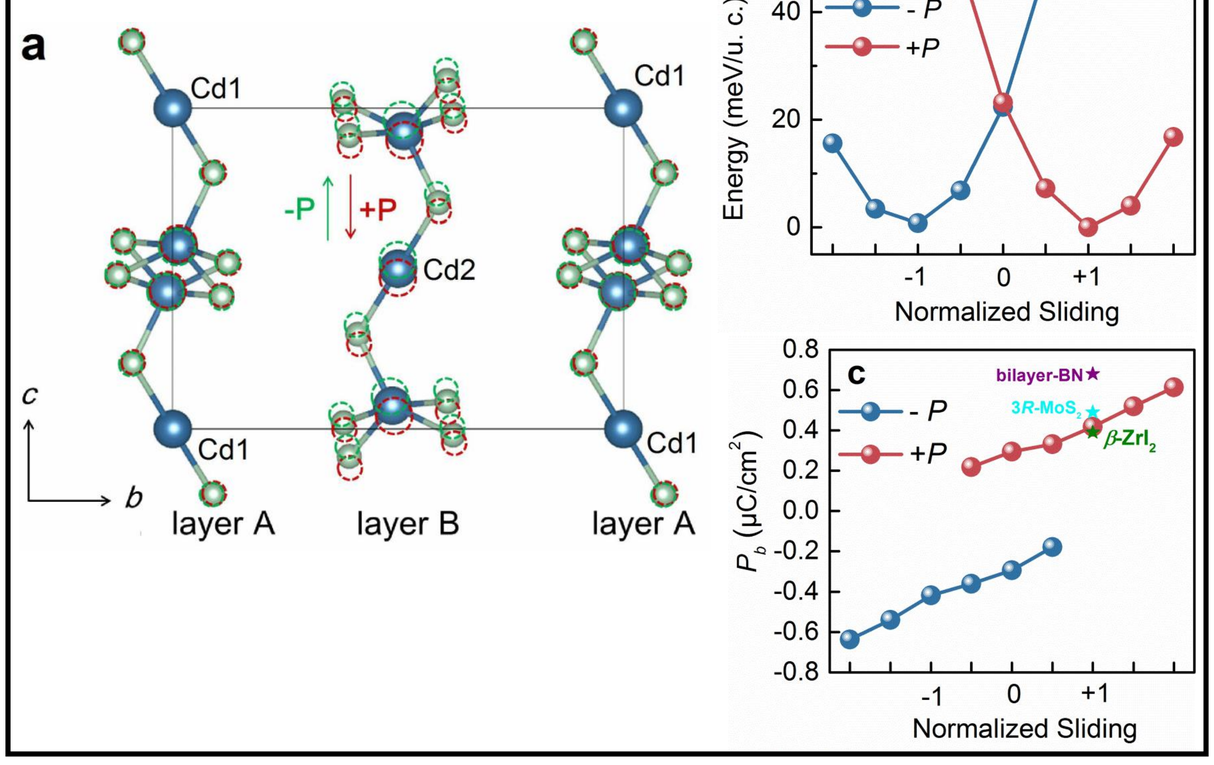
➢ **P-E loop**



◎Geometric ferroelectricity



◎Sliding ferroelectricity



Nat. Mater. 21, 1158-1164 (2022)

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