Ferroelectricity Driven by Twisting of Silicate Tetrahedral Chains

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To date, ferroelectric materials have been widely applied in various electronic devices, including actuators, non-volatile memory, and sensors. Ferroelectric materials traditionally comprise oxygen octahedral units, such as those found in perovskite-type oxides. The strong covalency of the cations in the perovskite structures plays an important role for achieving robust ferroelectricity with a high-T_c and a large spontaneous polarization. With this in mind, recent ferroelectric devices typically rely on the use of lead-based compounds such as $Pb(Zr,Ti)O_3$ (PZT) to achieve such robust ferroelectricity. Mindful of the toxicity of Pb, there is an increasing demand for sustainable and environmentally friendly electronic devices, free from toxic elements. As such, a new guiding principle for designing ferroelectric materials is necessary.

In the present study, we demonstrate the occurrence of ferroelectricity in a silicate-based compound, Bi_2SiO_5, by direct observation of polarization switching. The novel mechanism of ferroelectricity in Bi_2SiO_5 has been elucidated from comprehensive studies employing Raman scattering, transmission electron microscopy, X-ray powder diffraction, and first principles calculations. The obtained experimental results and calculations clarified that the observed ferroelectricity in Bi_2SiO_5 stems from twisting of the one-dimensional SiO_4 tetrahedral chain.[1] This recent discovery opens up a new frontier for designing functional oxides based on "tetrahedra-engineering", as opposed to conventional "octahedra-engineering". Furthermore, it also provides a guiding principle for the development of sustainable and environmentally friendly electronic and electro-mechanical devices, as compounds comprising tetrahedral chains are widely found in rock-forming oxides, which are abundant in the earth's crust.

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Reference:

[1] H. Taniguchi *et al.*, Angew. Chem. Int. Ed. **52** (2013) 1-6.