Physics and Application of Sliding Ferroelectricity

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Abstract

Creating atomically thin ferroelectric materials for use in non-volatile memory is a major challenge in materials science, mainly because of issues with depolarization at very small scales. To overcome this, we have developed a new way to engineer these thin ferroelectrics using van der Waals heterostructures. Our method involves inducing ferroelectricity by adjusting the stacking angle of non-ferroelectric materials like bilayer boron nitride [1] and bilayer transition metal dichalcogenides [2]. This approach allows us to create atomically thin ferroelectrics that can function as non-volatile memory at room temperature.

The performance of sliding ferroelectrics in a ferroelectric field effect transistor is remarkable, where it enables extremely fast and high endurance switching, surpassing the limitations of conventional ferroelectrics [3]. This high performance is due to a unique mechanism where polarization is switched by sliding between the van der Waals layers, named sliding ferroelectricity.

By twisting the two layers of boron nitride, we can obtain moiré ferroelectrics. This is a novel ferroelectric state having an alternating polarization pattern. We discuss how moiré ferroelectrics can be used as substrates to modify the band structure of 2D materials in momentum space [4].

References

[1] K. Yasuda et al., Science 372, 1458–1462 (2021).
[2] X. Wang, K. Yasuda et al., Nat. Nanotech. 17, 367–371 (2022).
[3] K. Yasuda et al., Science 385, 53–56 (2024).
[4] X. Wang … K. Yasuda et al., Nat. Commun. 16, 178 (2025).

Figures

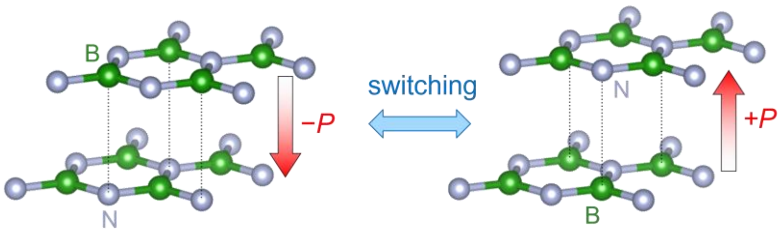

Figure 1: Schematic illustration of sliding ferroelectric bilayer boron nitride.