In situ transmission electron microscopy on two-dimensional ferroic chalcogenides

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Current electronic devices have encountered grand challenges ─ How to further scale down the device size, upgrade the integration of input/output, memory and computing units, and reduce the energy consumption. In particular, the massive communication between the computational unit and memory is hard to afford within current architecture of electronic devices and computers. New paradigm of in-memory-processing architecture has been put forward recently. Beyond current von Neumann systems, two-dimensional (2D) ferroelectrics (FE) with miniaturized dimension, high speed and high sensitivity, and robust ferroic order with memory functionalities, are superior candidates for next-generation in-memory computing devices. Moreover, the facile phase transition in 2D materials potentially offers another degree of freedom to manipulate the non-volatile memory states. Therefore, the 2D polymorphism and 2D ferroelectrics and ferroelastics indeed provide promising solutions to the aforementioned challenges.

In this presentation, we will clarify the ferroic ordering and their physical origin, and introduce how to control/manipulate the phase transition and the ferroelectricity as well as ferroelasticity in 2D and build novel devices. We applied a variety of in situ transmission electron microscopy techniques (Fig.1A-C), specifically employing in situ mechanical manipulation, in situ mechanical testing, in situ electrical testing, in situ heating, and in situ electron beam control, to conduct comprehensive investigations of ferroic phase transitions and ferroic ordering in two-dimensional (2D) chalcogenides (Fig. 1D). The diverse phases observed in these ferroic 2D materials showcase unique mechanical, electrical, and other captivating physical properties. Through our study, we successfully established a direct correlation between atomic-scale structures and device-level performance (Fig. 1E), thereby enhancing our understanding and enabling practical applications of 2D functional materials.

References

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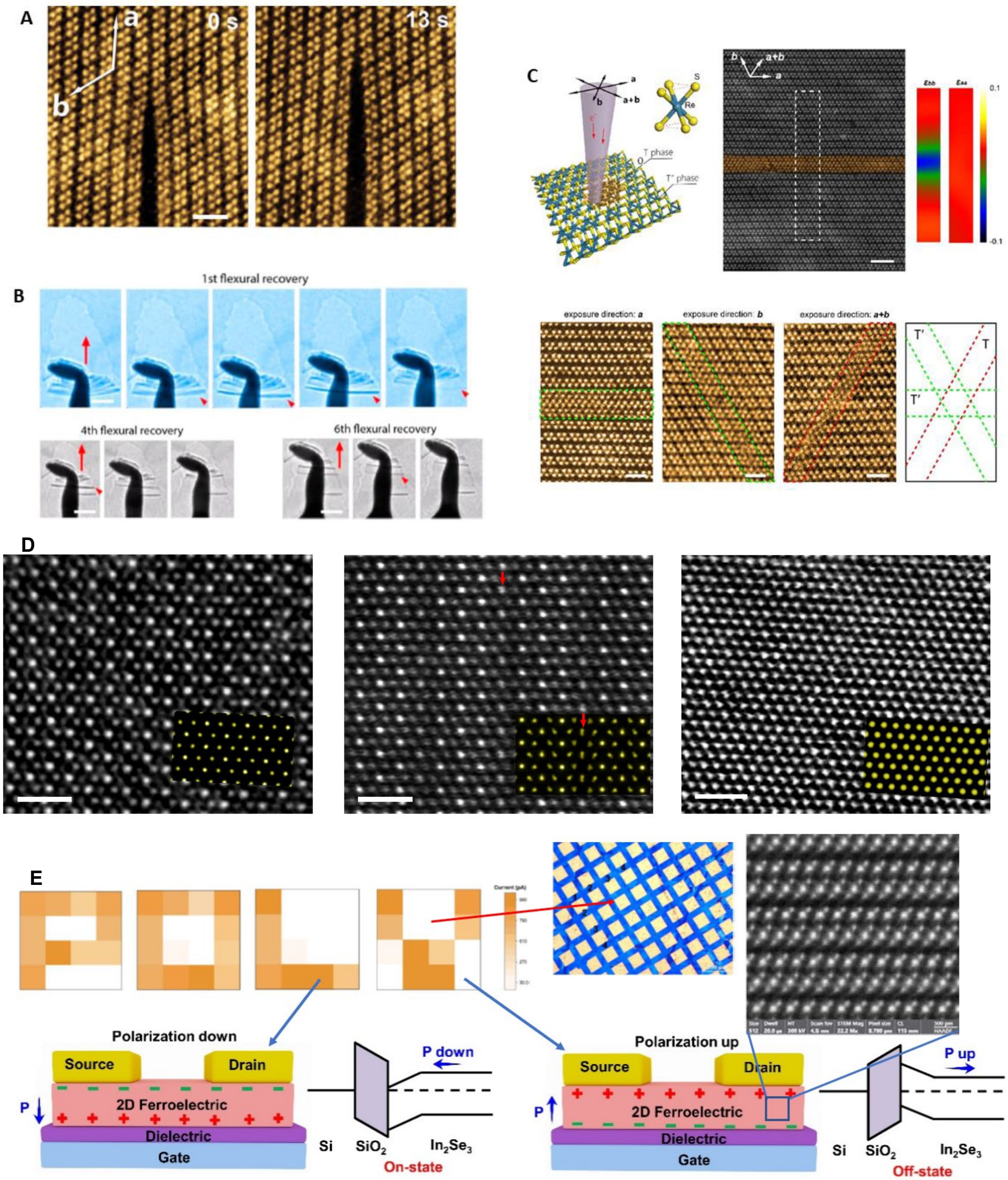

Fig.1 A-C, *in situ TEM study on 2D materials.* ***D****, phase engineering on 2D In2Se3.* ***E****, memory transistor devices build on 2D In2Se3.*

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