Dynamic Ferroelectric Transistor-based Reservoir Computing for Spatiotemporal Information Processing

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Abstract

Reservoir computing (RC) architecture mimics the human brain and is a fundamentally preferred method to process dynamic systems that evolves with time.[1] However, generating rich reservoir states using two-terminal devices remains challenging, which hinders its hardware implementation.[2] Herein, we demonstrate the 1D array of ferroelectric field-effect transistors (Fe-FET) based on the 2D semiconductor a-In_2Se_3, which shows a volatile memory effect for realizing various RC systems. The ferroelectricity in this material is confirmed by PFM measurement, as shown in Figures 1 a and b. Using the read-after-write model, the dynamic polarization model sufficiently investigates the fading effect in a-In_2Se_3 (Figure 1c). Pattern recognition and waveform classification tasks are carried out with excellent training and testing accuracy to verify the ability of Ferro-RC systems (Figure 1e). Furthermore, time-series real-life chaotic systems, *e.g.*, Earth's weather, can be accurately forecasted using our Ferro-RC based on the Jena climate dataset recorded in one year. A remarkable determination coefficient (R^2) of 0.9983 and normalized root mean square error (NRMSE) of 8.3×10^{-3} are achieved using a minimized readout network. Demonstrating integrated memory and computation opens a route for realizing a compact RC hardware system.

References

[1] D. J. Gauthier, E. Bollt, A. Griffith, W. A. Barbosa, Nature communications, 12 (2021) 5564
[2] J. Moon, W. Ma, J. H. Shin, F. Cai, C. Du, S. H. Lee, W. D. Lu, Nature Electronics, 2 (2019) 480

Figures

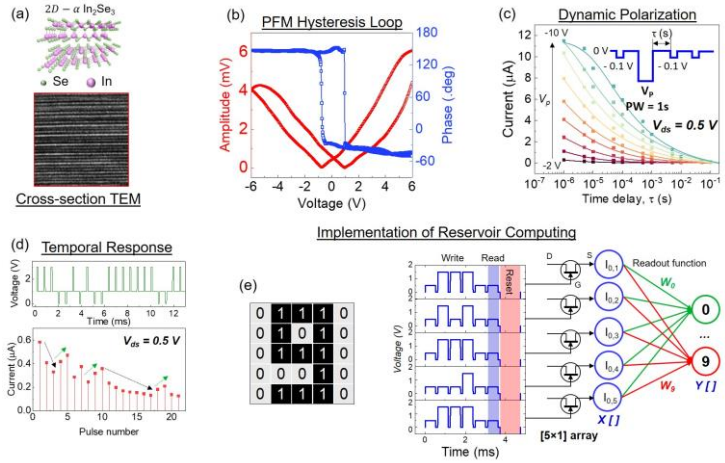

Figure 1: (a) Single crystalline Ferroelectric Semiconducting a (*R3m*) - In_2Se_3 and the layered structure indicated by HR-TEM image (b) Equivalent PFM hysteresis loops of phase and amplitude (c) Retention loss of drain current indicated by the read-after-write scheme with various V_p = -2 V to -10 V (d) Response current of dynamic a-In_2Se_3 Fe-FET on discrete V_g pulse stream (e) Measurement setup of Pattern Recognition, an example of the general machine learning task.