Supplemental Information

Silk Fibroin/Graphene Quantum Dots Composite Memristor with Multi-level Resistive Switching for Synaptic Emulator

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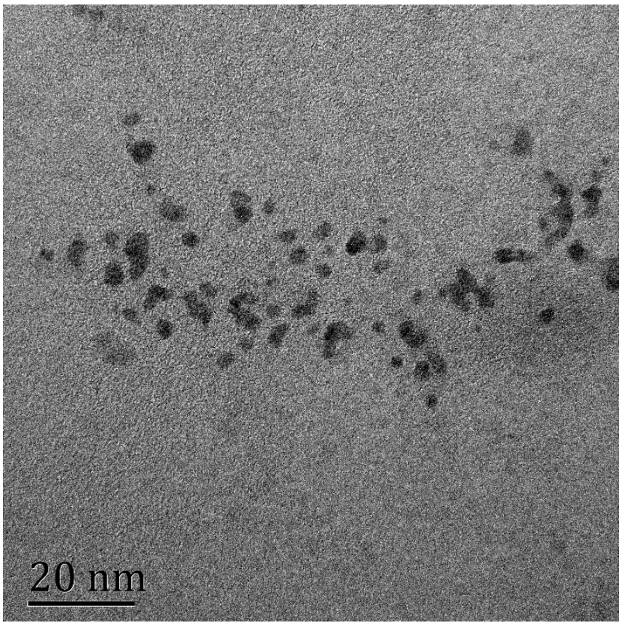

Fig. S1. TEM image of GQDs. The GQDs have a good dispersibility, and the average diameter is about 3-5 nm.

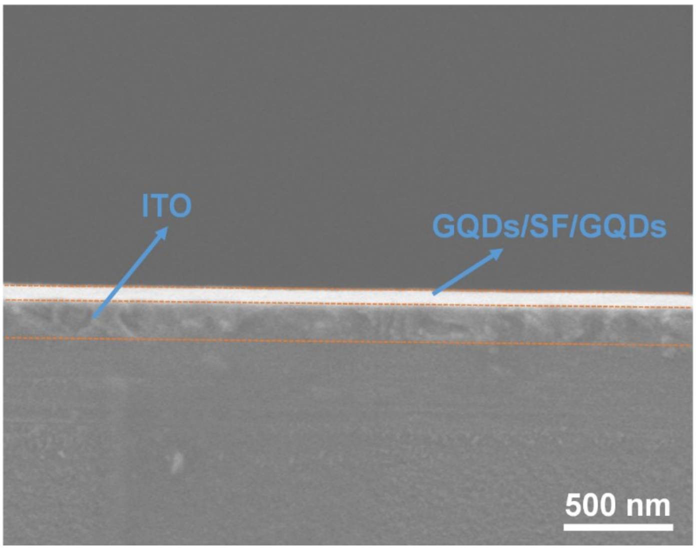

Fig. S2. The cross-sectional SEM image of GQDs/SF/GQDs layer. The thickness of GQDs/SF/GQDs layer is about 58 nm.

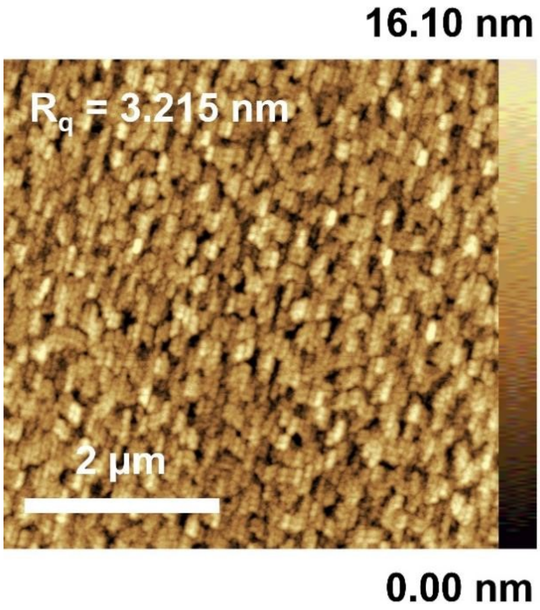

Fig. S3. AFM image of pristine SF films. The root mean square (RMS) of the surface roughness of pristine SF is 3.215 nm.

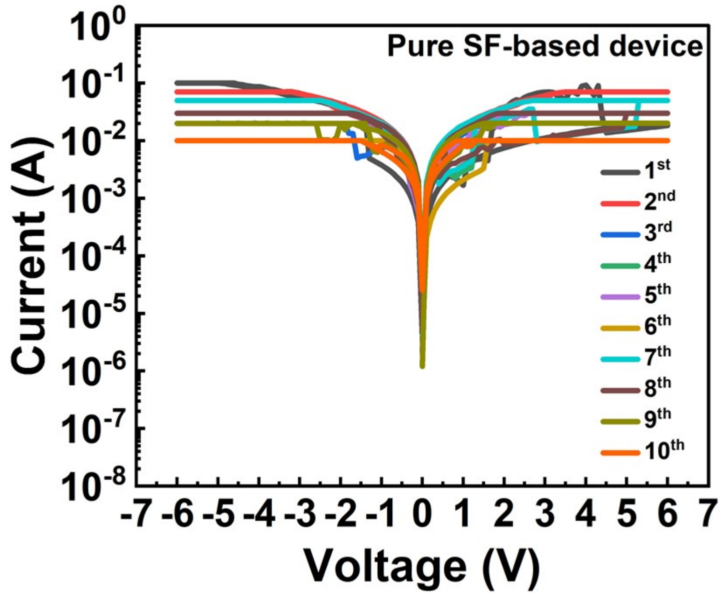

Fig. S4. The *I-V* characteristic curves of pristine SF-based memristor. It can be observed that the memristive switching behavior of pristine SF-based memristor is lack of stability, which is against the application.

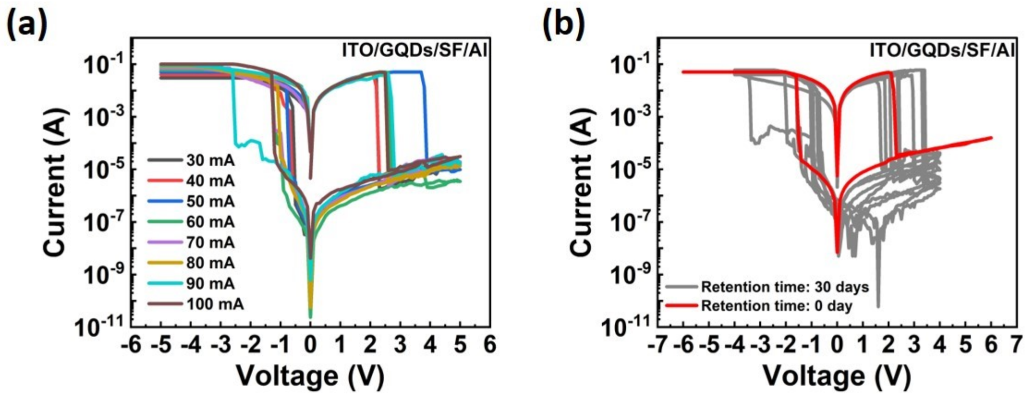

Fig. S5. Memristive performance of GQDs/SF-based memristor. (a-b) *I-V* characteristic curves (a) under different compliance current (I_{cc}) and (b) after placed at room temperature for 30 days. The memristive performance of GQDs/SF-based memristor is free from influence of I_{cc}, and can be remained for at least 30 days without degradation. This indicates that the GQDs/SF-based memristor has good durability and can be used for non-volatile information storage.

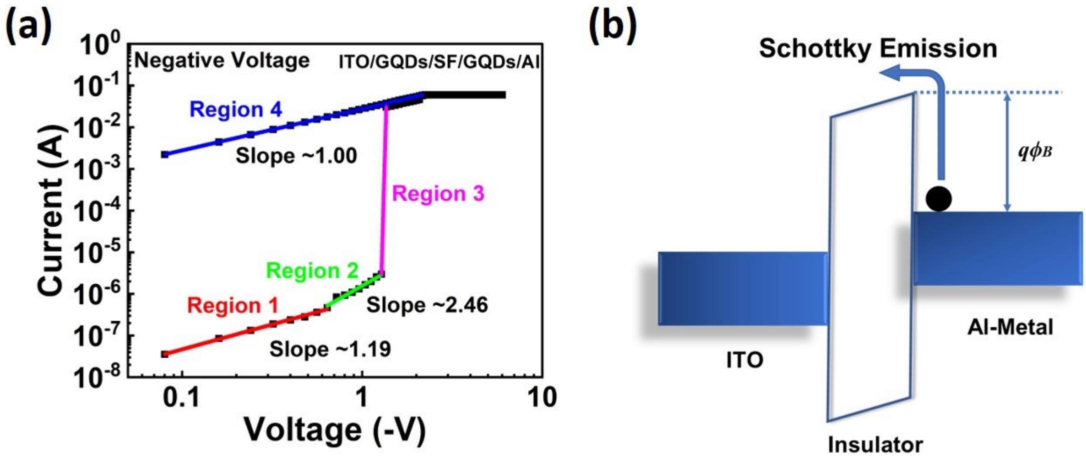

Fig. S6. (a) The experimental (black spots) and fitted (color lines) *I*–*V* curves in a log–log scale during the SET process of GQDs/SF/GQDs-based memristor. (b) Schematic diagram of the energy band of Schottky emission mechanism. From Fig. S6a, it can be observed that HRS and LRS conform to SCLC mechanism and Ohmic mechanism, respectively. In addition, thermally excited electrons are released from the barriers and injected into the conduction band of memristive functional materials (Fig. S6b), completing Schottky emission.

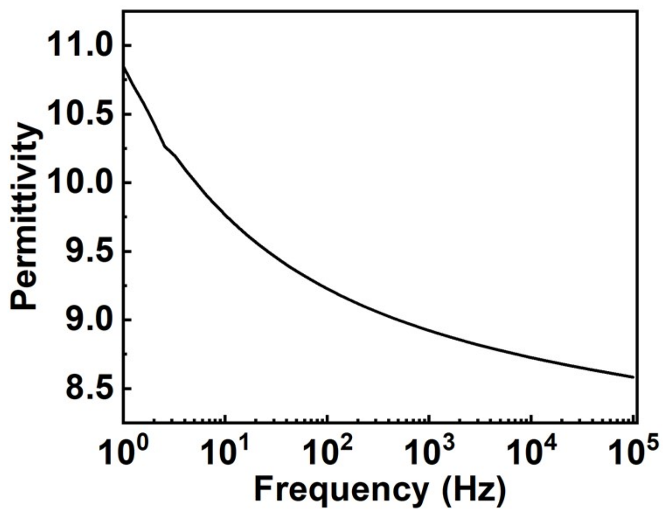

Fig. S7. Frequency-dependent permittivity of GQDs/SF/GQDs memristive functional layer. The permittivity increases with decreasing frequency from 100 kHz to 1 Hz. The dielectric constant of the GQDs/SF/GQDs film at 1 Hz is 10.85.

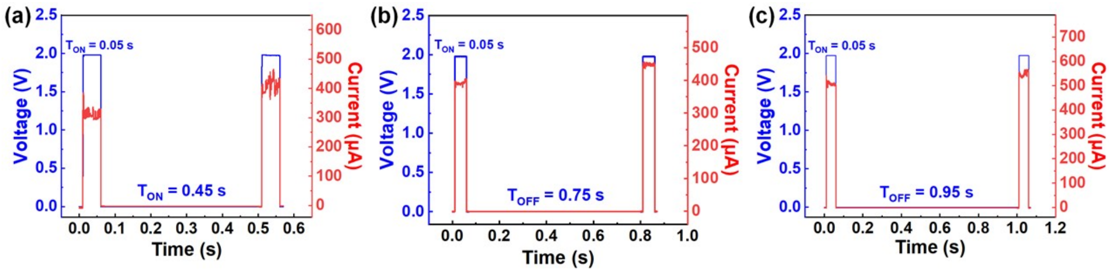

Fig. S8. The paired pulse facilitation (PPF) effect corresponding to different interval times. With the increase of the interval time, the PPF index gradually decreases, which is consistent with the characteristics of neural synapses.