Supporting Information

Nonvolatile Memory Devices Based on Carbon Nano-Dots Doped Poly(vinyl alcohol) Composites With Low Operation Voltage And High ON/OFF Ratio

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Materials and Methods:

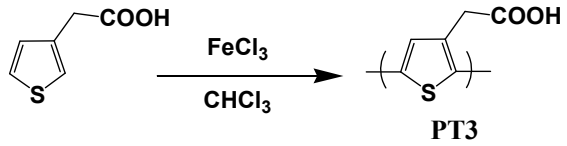
All UV-vis and fluorescence spectra in this work were recorded in Hitachi U3010 and Hitachi F4500 fluorescence spectrometers. The water was purified by Millipore filtration system. The gel-permeation chromatography (GPC) was performed using Polystyrene as the standard, and THF was employed as eluent. Transmission electron microscopy (TEM) images were taken on a JEOL JEM-2100F operated at an acceleration voltage of 150 KV.

Surface morphology and roughness were characterized with atomic force microscopy (AFM) (Bruker MultiMode 8) in tapping mode. Chemical composition and electronic structure of the films were determined by ultraviolet and X-ray photoelectron spectroscopies (UPS and XPS) using a Kratos AXIS Ultra-DLD ultrahigh vacuum (UHV) surface analysis system with a monochromatic aluminum Ka source (1486.6 eV), an

unfiltered HeI (21.2 eV) gas discharge lamp, and a hemispherical analyzer. Raman spectra was collected by inVia-Reflex with a 532 nm laser.

Synthesis of poly(3-thiophene acetic acid)

$CHCl_3$ was distilled from CaH_2 under nitrogen. Dry $FeCl_3$ (6.6 g, purchased from Alfa Aesar) was dissolved in 30 mL of dry $CHCl_3$ under nitrogen, and then 3-thienylacetic acid (1.42 g) dissolved in 20 mL dry $CHCl_3$ was added dropwise. The reaction mixture was stirred at room temperature for 2 days. The resulting precipitate was collected, washed with methanol, and finally dried under vacuum to give the desired poly(3-thiophene acetic acid) as a brown solid (0.85 g, Yield: 59.8%). 1H NMR (400 MHz, NaOD-D_2O, TMS, ppm): δ 3.23~3.82 (Br), 6.83~7.32 (Br). IR (KBr pellet, cm^{-1}) 3430, 2924, 1706, 1628, 1398, 1200. Gel-permeation chromatography analysis (GPC): Mn=32,952 g mol^{-1}, PDI=1.67.



Scheme S1 Synthetic Routs of poly(3-thiophene acetic acid) (PT3)

Synthesis of carbon nano-dots

Carbon nano-dots were prepared by hydrothermal treatment of polythiophene. In generally, PT3 (30 mg) was dispersed in 40 mL 2.5 mM NaOH aqueous solution, and then heated to 210 °C for 6 hours. After cooling to room temperature, the solution was transferred to the dialysis bag and dialyzed with deionized water for 3 days to remove the

sodium ions. Then the resultant carbon nano-dots solution was filtered through Millipore 0.22 μm filter membrane and then dispersed in water for further characterization and evaluation.

Fabrication of Memory Devices

The memory devices were fabricated on Patterned ITO-coated glass substrates with a sheet resistance of 15 Ω/□. Before the device fabrication, the ITO substrates were cleaned with de-ionized water, ethonal and dried in an oven at 80 °C, and treated with oxygen plasma. After that, the cabon nano-dots/PVA composites (2.2 wt%) were spin-coated onto the substrates. The 100 nm Ag electrode was deposited through thermal deposition with a rate of 3 Å/s. The electrical characterization of the device in this work was recorded by Keithley 2400 under ambient conditions.

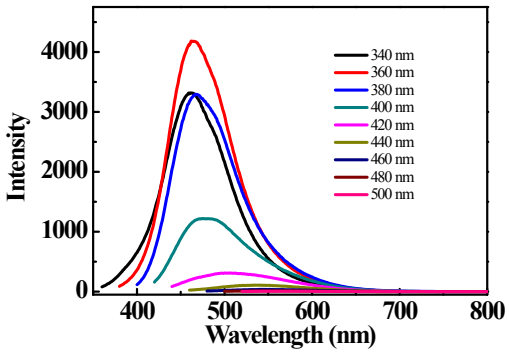


Fig. S1 Photoluminescence spectra of carbon nano-dots.

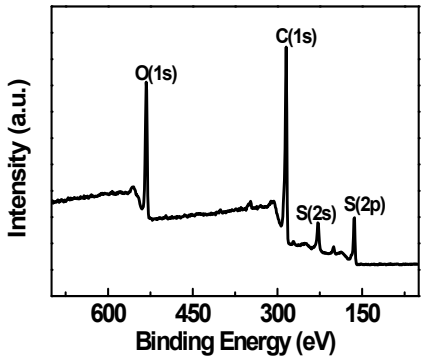


Fig. S2 XPS spectra of as-prepared carbon nano-dots.

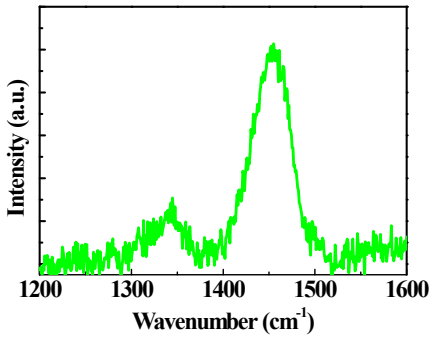


Fig. S3 Raman spectra of as-prepared carbon nano-dots.

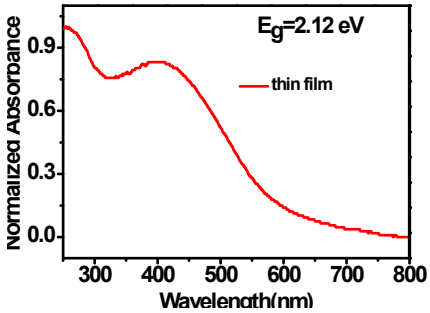


Fig. S4 Absorption of as-prepared carbon nano-dots thin film.

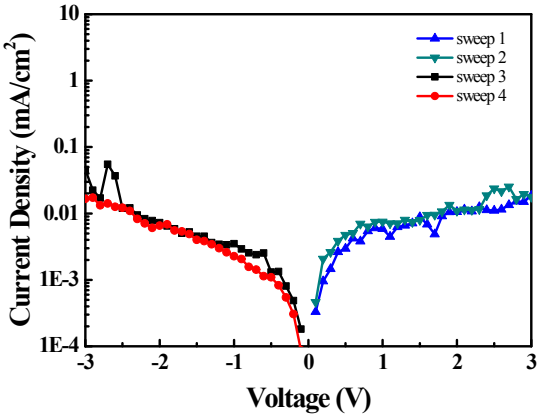


Fig. S5 I-V characteristics of the ITO/PVA/Ag devices.

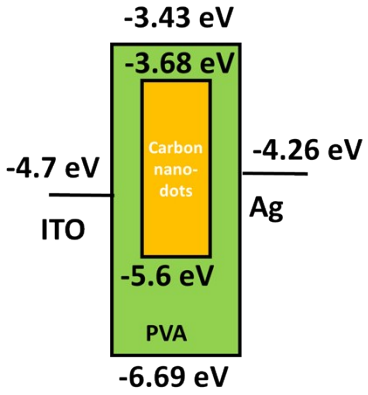


Fig. S6 The energy band diagram of the memory devices.