Nanofluidic Memory Devices in Solid State Conical Nanopores

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The synthetic solid-state nanochannels show a broad range of gating and rectification properties that can be further used to implement nanofluidic logic devices similar to the conventional electric logic circuits.[1]

Employed the single ion-track-etched nanochannels, which are excellent platforms for studying the ionic transport behavior in nanoscale, we experimentally characterized the nanoscale ionic transport with several different solutions, and found, for the first time, that the ionic conductivity could exhibit an intriguing hysteresis behavior. The hysteresis behavior could be further employed to realize nanofluidic memristors, which are a new type of nanofluidic logic devices[2] and have been considered as the fourth fundamental elements in conventional electrical circuitry. As nanofluidic memristors, the devices show excellent repeatability, high ON/OFF ratio, and long retention time. Then we further studied the mechanism of the system and required properties of the nanopore. Realizing the memristor concept in nanofluidic regime will not only enrich the family of nanofluidic logic devices, but also greatly enable the nanofluidic circuitry to achieve more complex functionalities.

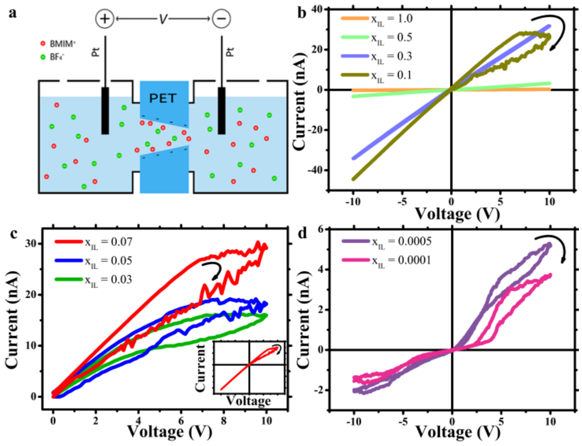

Fig.1 (a) Schematic illustration of the experimental setup with ionic transport through a conical nanochannel. The electrolyte was mixed solution of [BMIM][BF$_4$] and water. xIL indicates mole fraction of [BMIM][BF$_4$]. (b), (c) and (d) were typical I-V curves using a conical nanochannel of 6 nm tip openings immersed in the [BMIM][BF$_4$]-water mixed electrolyte solution. Arrow denotes switching direction.

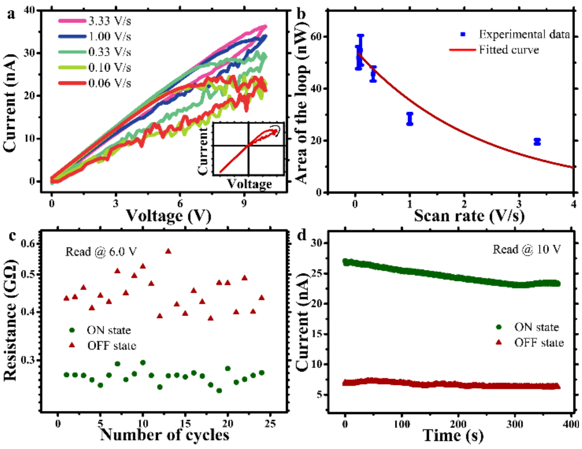

Fig. 2 A conical nanochannel (6 nm in tip diameter) immersed in the mixture electrolyte with [BMIM][BF4] molar fractions of 0.07. (a) I-V characteristics with different scanning rate. (b) The area of hysteresis loops as a function of scan rates. (c) Retention time of the ON/OFF state current of nanofluidic memristor at a positive voltage of 10 V. (d) ON/OFF resistances plotted as a function of the number of cycles.

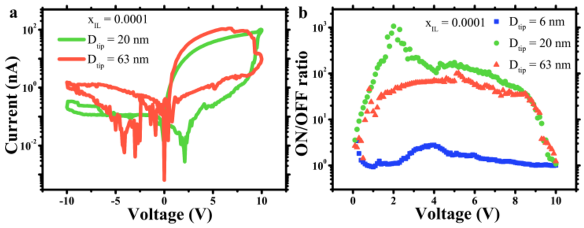

Fig. 3 (a) The resistance at ON/OFF state as a function of bias voltage, with 20 nm and 63 nm tip opening size at xIL = 0.0001. (b) The ON/OFF resistance ratio as function of positive bias voltage that has better ratio than the negative voltage.

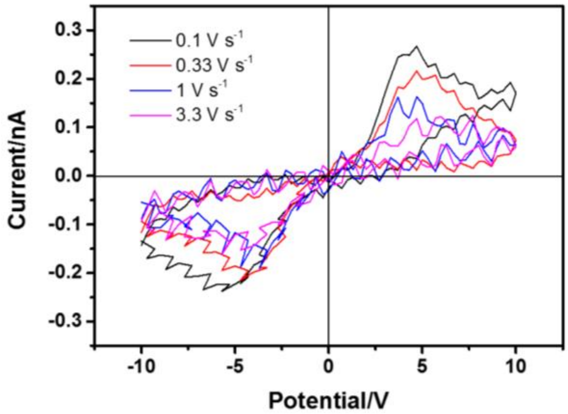

Fig. 4 A conical nanochannel (12 nm in tip diameter) immersed in the mixture electrolyte with TBLS molar fractions of 0.3. under different scan rates.

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