Memristive Behavior in Silicon-Based Nanopores

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Nanofluidic memristors, inspired by biological neurons, use ions as charge carriers and its nonlinear transport characteristics to realize memory effects [1]. Robin *et al.* [2] and Xiong *et al.* [3] demonstrated typical memristive behavior in nanofluidics by using two-dimensional materials and surface-modified nano channels, respectively. However, their fabrication processes limit large-scale applicability. Here, we propose, to the best of our knowledge, the first CMOS-compatible silicon-based nanopore device that exhibits typical hysteretic behavior (see Figure 1(a, b)). By varying the electrolyte composition, concentration, and voltage sweeping frequency, three types of memristive behaviors can be realized within the same device, as shown in Figure 1(c-e)). A minimal physical model incorporating adsorption successfully reproduces the observed memristive behaviors. This work paves the way for the development of more complex and large-scale iontronic devices on nanofluidic chips with advanced circuitry.

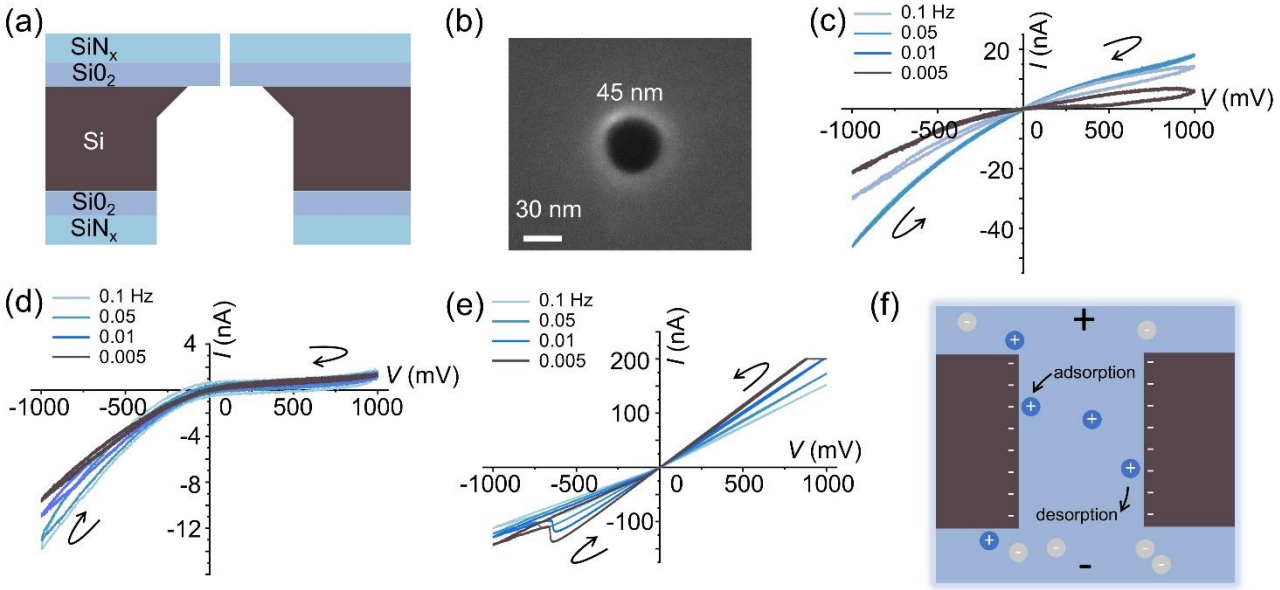

Figure 1: Structure and measurement results of the silicon-based nanopore device. (a) Schematics illustrating the nanopore structure. (b) SEM image showing the top view of the nanopore. (c) I–V curves measured at different voltage sweeping frequencies in 100 mM KCl, exhibiting crossing at the origin. (d) I–V curves measured at different voltage sweeping frequencies in 10 mM KCl, exhibiting non-crossing at the origin. (e) I–V curves measured at different voltage sweeping frequencies in 500 mM $AlCl_3$, exhibiting crossing at the origin. (f) Schematics illustrating the mechanism of the memristive behavior based on surface adsorption-desorption.

[1] Y. Hou, X. Hou, Science, 373,628-629, 2021.

[2] P. Robin et al. Science, 379,161-167, 2023.

[3] T. Xiong et al. Science379,156-161, 2023.