5 - 41 Preliminary Study of the Rectification Effect of Biconical Nanopores

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Nanopores could be a biological protein channel in lipid bilayers, a pore in a solid-state membrane or a synthetic of the organic and inorganic channels, which have promising applications in DNA sequencing and protein detecting. Biconical nanopores generally do not exhibit rectification effects due to their symmetrical structure. The preparation of single conical nanopore structure using ion track etching process is shown in Fig. 1[1]. However, in this study, we achieved the rectification effect in the biconical nanopore by modifying one side of the biconical pores with Fe^{3+} ions to change its surface charge from negative to positive.

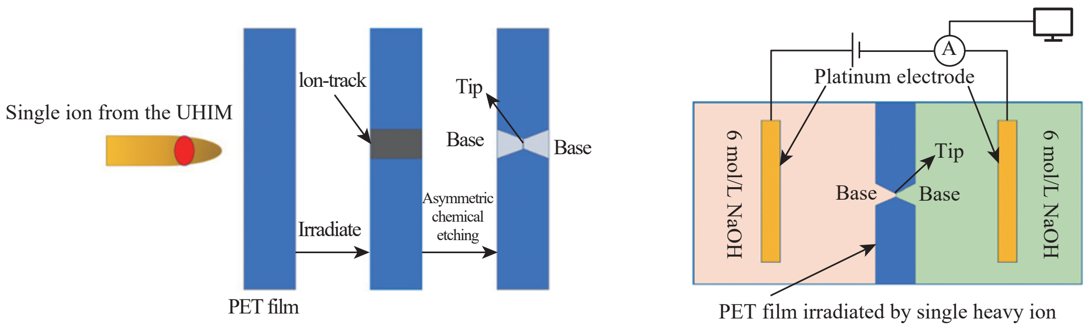

Fig. 1 (color online) (a) Single conical nanopore preparation process schematics. (b) Etching device schematic.

The details of the experimental is as follows: a PET film (with a diameter of 30 mm and a thickness of 12 μm) that irradiated with single Kr ions (25 MeV/u) was firstly chemical etched to fabricate a biconical nanopores inside. Next, we soaked one side of the biconical nanopores for 3 h using $FeCl_3$ solution (1 mol/L) so that Fe^{3+} could be adsorbed to the inner wall of the pores[2]. Afterward, the membrane was immersed in KCL solution (0.0316 mol/L) and the *I*-*V* curve was measured. As a result, the rectification effect (the rectification coefficient is defined as $=—I_{-2V}—/—I_{+2V}$) with a maximum coefficient ratio of 3.23 is achieved as shown in Fig. 2 *I*-*V* curve of C-7-6 film when Fe^{3+} is modified.

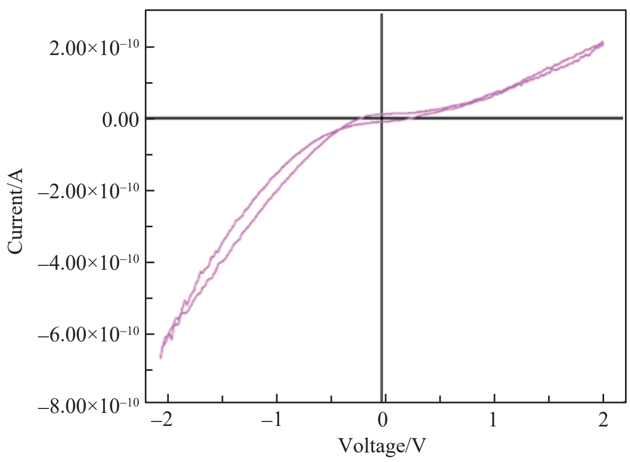

Fig. 2 (color online) *I*-*V* curve of C-7-6 film when Fe^{3+} is modified.

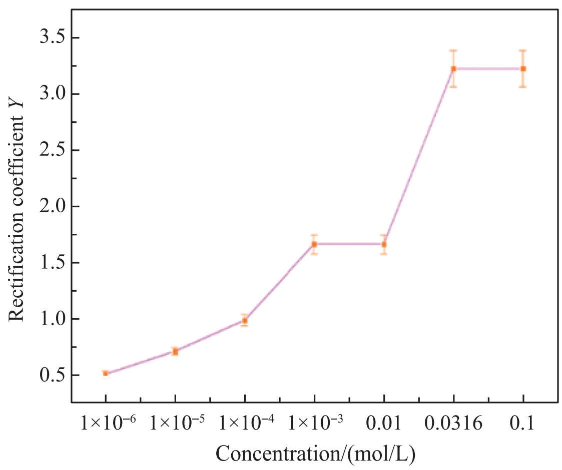

Fig. 3 (color online) The increasing of rectification coefficient is accompanied with the increasing of KCL concentration.

Moreover, the relationship between the rectification coefficient of the biconical nanopores modified by Fe^{3+} ions and the concentration of potassium chloride was also explored. The nanopore was placed in KCl solution at different concentrations, and I-V curve was measured in KCl solution from low to high concentration. The data were plotted with error bars of standard deviation. As shown in Fig. 2, the rectification coefficient increases with the KCl concentration.

We suppose that the rectification effect in the biconical nanopores is due to the adsorption of Fe^{3+} on the carboxyl group inside one of the cone pores, and this phenomenon results in the reversal of the charge state of the inner wall from negative to positive[2,3]. When negative voltage is applied to the modified cone, the anions in the cone moved under the action of the electric field are attracted by the carboxyl chain modified by Fe^{3+}, at this time the carboxyl chain is positively charged to play an acceleration role for the anions to pass through the tip of the biconical nanopores.

References

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5 - 42 Study on the Single Event Reliability of PAVLOV Neuron System

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The reliability of the AI systems to the harsh space radiation is of great concerns with the increasing application in aerospace. Because of its neuromorphic device architecture and operation mode, low-power neuron chips have enormous potentials in resistance of single event effect, which is one of the most important failures of spacecraft caused by space radiation. In this work, a mixed-signal spiking neuron chip, named PAVLOV[1], has been studied at circuit and chip level with respect to its response to single event errors. Laser and heavy ion beam irradiation were performed to evaluate the single event reliability of the neuron system. Figure 1 shows the setup of the heavy ion irradiation tests. The PALOV system was irradiated with 6 MeV/u Kr and 10.32 MeV/u Bi respectively and the output signal V_{W-23}, which is the key signal of the working state of the chip, was monitored to determine whether the chip was affected by the irradiation. The test data were summarized in Table 1, which indicate that the Pavlov neuron chip possesses excellent SEE immunity performance because there was no single event abnormal signal observed during the irradiation tests. This work demonstrates that the AI system based on neuron chip is reliable for robotic and unmanned application with nuclear radiation environments.

Table 1 The parameters of the heavy beam tests.

Ions	**LET** MeV/(mg/cm^2)	**Intensity** ions/(s·cm^2)	**Time**/min	**Effective ions in sensitive unit**
6 MeV/u Kr	36.2	1.8×10^7	30	324
6 MeV/u Kr	36.2	5×10^8	10	3 000
10.32 MeV/u Bi	98	2.7×10^5	40	6