Rectification of ionic current in asymmetric dielectric coating solid-state nanopore under salt gradient

([1]*The Institute of Scientific and Industrial Research, Osaka University*) ○Iat Wai Leong,[1] Makusu Tsutsi,[1] Masateru Taniguchi[1]

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Understanding ion transport and hydrodynamic in restricted nano-space are of crucial importance for developing iontronics. Ionic current rectification (ICR) has recently been observed in salt-gradient-biased nanopore caused by electroosmosis (EOF).[1,2] The phenomenon is due to the asymmetric EOF on both sides of a relatively large pore, particularly on the sub-100 nm scale. Herein, we present a simple method that can be employed to modify surface charge using a metal oxide coating (Figure 1a). We fabricate a 10 nm thick layer on a 300 nm-sized nanopore using RF-sputtering a series of dielectric materials targets (SiO_2, HfO_2, TiO_2, Al_2O_3, and ZnO).

The results of current-voltage characteristics will be significantly different in multiphysics simulation if the surface charge density is set to the corresponding surface (Figure 1b). Because the positive or negative charge on the surface can be adjusted by the pH value of electrolyte solution, each of the three surfaces (suface$_{cis}$, wall$_{inner}$, and surface$_{trans}$) will have a different surface charge by the materials. In view of the simulated result, we adjust the sequence of the photolithography processes, and four possible coating patterns are fabricated and used to perform I-V characteristics (Figure 1c). The present findings allow a simple method for controlling ion transport in nanopore by using the dielectric coating.

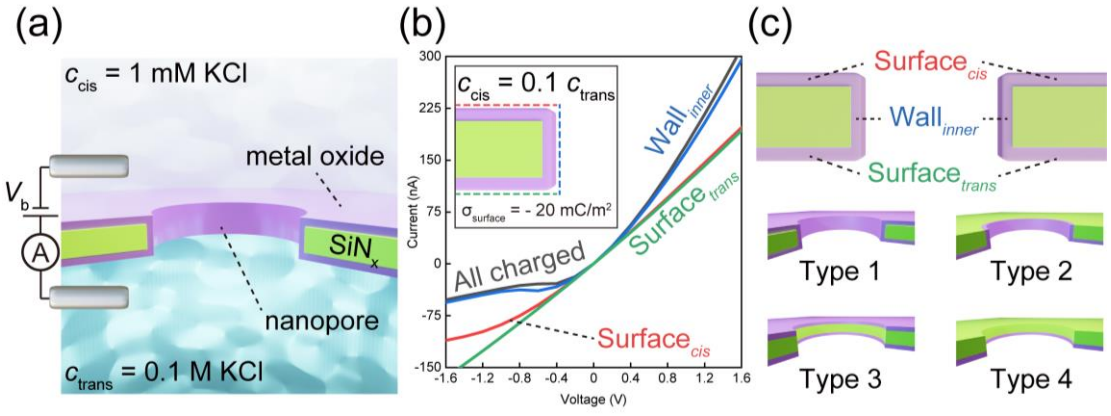

Figure 1. (a) Schematic model of a 300-nm sized pore with metal oxide coating layer, top, and bottom chamber are filled with low and high concentration solution correspondingly. (b) Simulated current-voltage characteristics with fixed charges of the surface in multiphysics software. (c) Possible compositions of nanopore by arranging the fabrication processes.

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