Rectification of Ion Transport in Bipolar Nanofluidic Devices

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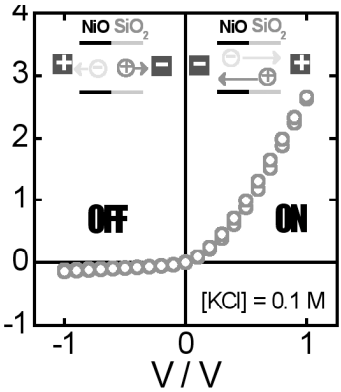
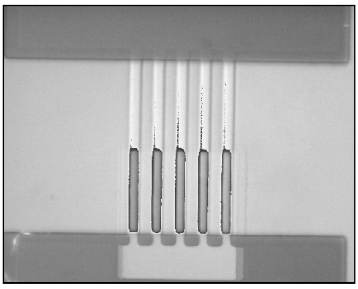
Flow of ions through nanochannels in some circumstances occurs more readily in one direction than the other. We investigate the rectified ionic current through 20nm-thick bipolar nanochannels which have asymmetric polarity of surface charge created with different oxide materials. It is found that the rectification of ion current is due to an asymmetric distribution of ions with respect to the junction. The rectifying factor, I_{on}/I_{off} at 1/-1V is about 20.

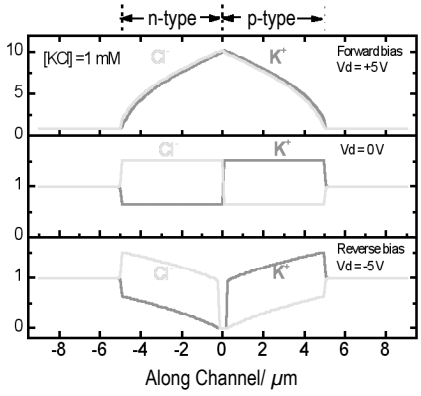


Experimental result of the rectifying I-V characteristics of a bipolar nanochannel.

Resembling a semiconductor pn-junction diode, the negatively charged SiO_2 nanochannel that enhances cations concentration is a p-type nanochannel whereas the metal oxide serves as an n-type nanochannel. When the device is forward biased, the ion concentration is enriched in the junction. On the contrary, a reverse bias depletes ions in the junction, resulting in a current drop. Unlike electrons and holes in a semiconductor diode, there is no recombination for cation-anion in fluidic system. After ions move across the junction, they keep moving to the other ends. The theoretical calculation agrees qualitatively with the experiments. This project is supported by a Riethmiller Fellowship.



Microscopic image of 20nm-thick bipolar nanochannels.



Calculated ion profiles in a bipolar nanochannel at different biases.