Supplement information

Regulation of ionic current through surround-gated nanopore

via field effect control

Pariya Sornmek[a], Darinee Phromyothin[a], Jakrapong Supadech[b], Kittipong Tantisantisom[c], Thitikorn Boonkoom*[c]*

[a]College of Materials Innovation and Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok, THAILAND

[b]National Electronics and Computer Technology Center, National Science and Technology Development Agency, Pathum Thani, THAILAND

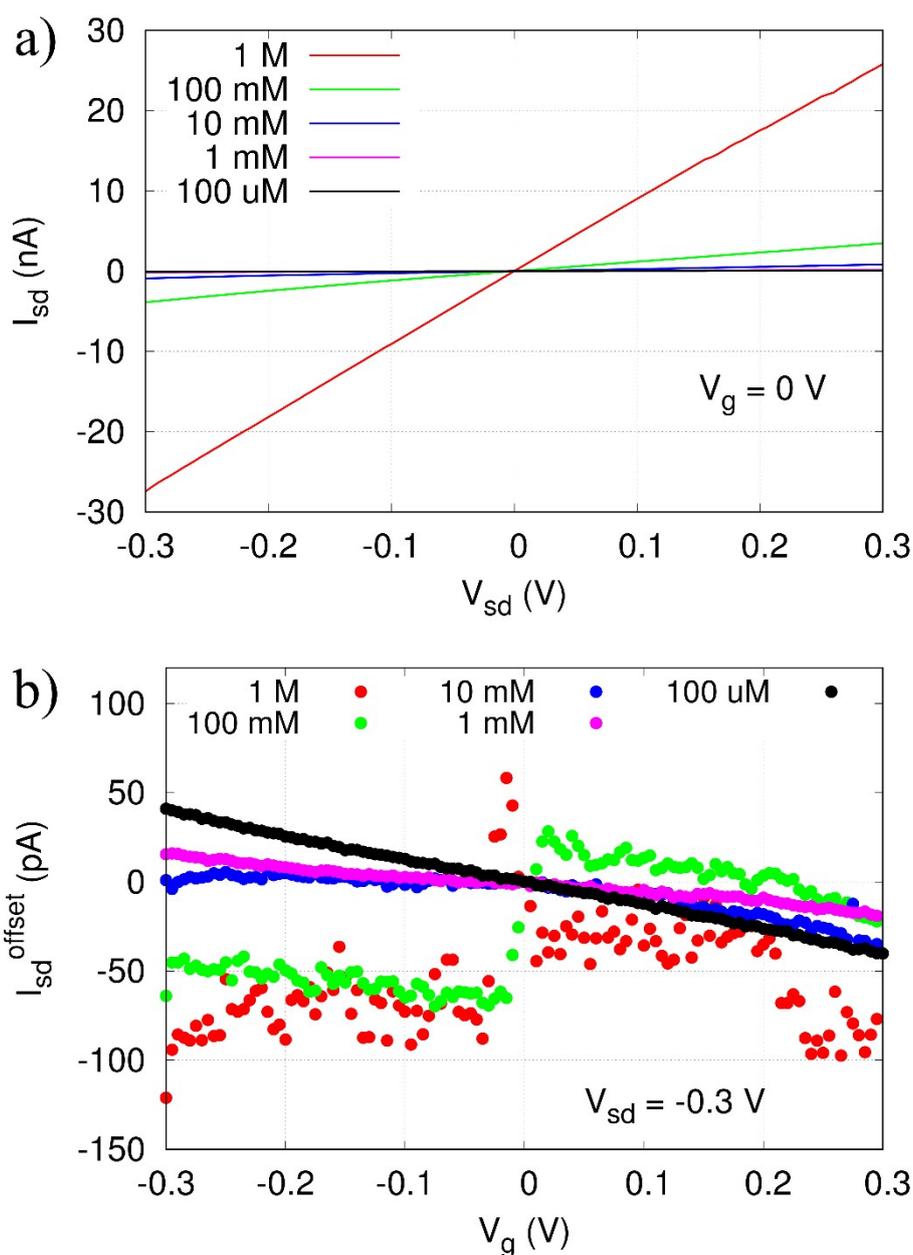[c]National Nanotechnology Center, National Science and Technology Development Agency, Pathum Thani, THAILAND

Figure S1. Ionic current dependence on KCl concentration with respect to source-drain voltage at V_g of 0 V (a) and with respect to gate voltage at V_{sd} of - 0.3 V (b). The data was collected from a nanopore with final diameter of 97 nm.

Figure S1a illustrates the dependence of ionic current on KCl concentration at $V_g = 0$ V. The data suggests the pore conductance change with respect to the KCl concentration. The lower concentration leads to smaller pore conductance, as seen from the decreasing I_{sd}-V_{sd} slope. However, when consider the ionic current dependence on gate voltage in Figure S1b, it is clearly seen that at sufficiently low electrolyte concentration, the ionic current starts to be influenced by the gate voltage, in this case when the KCl concentration is 10 mM or below. It should be noted that although the I_{sd} offsets for the 1 M

and 100 mM KCl shows relatively higher current amplitude than those with lower concentration, they do not show dependence of the ionic current on the gate voltage. These higher I_{sd} offsets are from the higher pore conductance due to high KCl concentration. As a result, the concentration of 100 µM was selected for ionic current regulation in our work as it provides the greatest gate voltage effect.
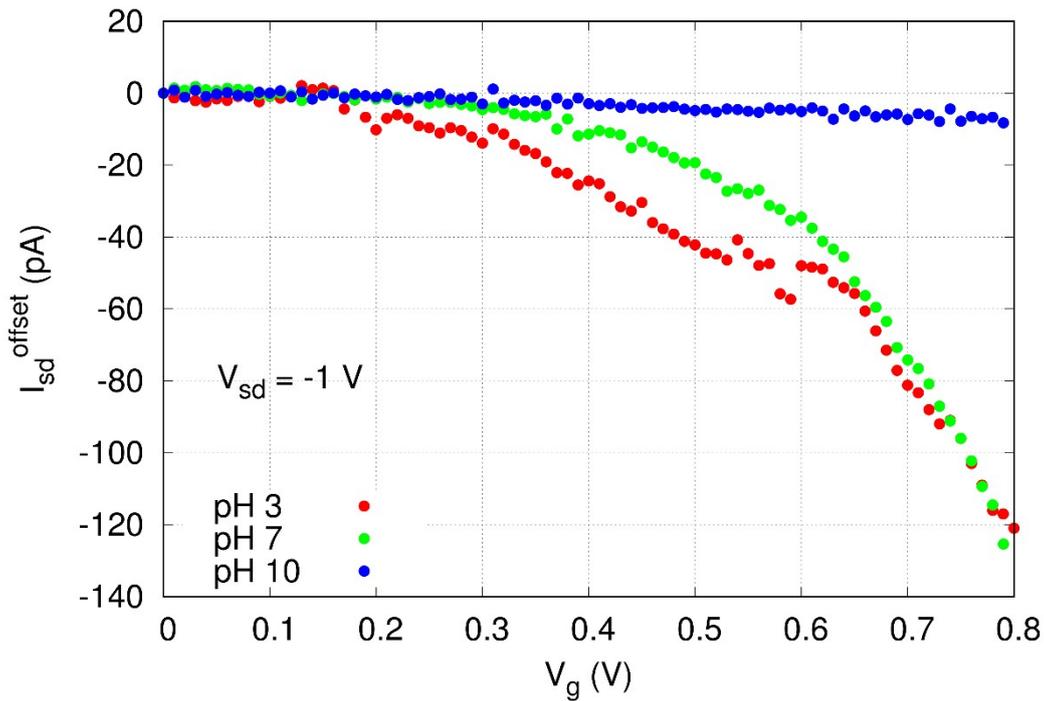
S2

Figure S2. Effect of pH on gate voltage dependence of ionic current. The data were collected from the NP-B with final diameter of 34 nm using Vsd at -1 V and KCl concentration of 0.1 mM.

Gate voltage dependence of the I_{sd} is observed at different pH as depicted in Figure S2. All the data were collected using 0.1 mM KCl at which the gate effect can be observed. At $V_{sd} = -1$ V, the device show rising of negative I_{sd} with increasing gate voltage for all pH conditions. Increasing field effect towards positive direction draws more anions to the nanopore and since the gate effect enhances the ionic current, it could be implied that surface charge in the nanopore is positive. This implication can be supported by the results of pH effect. The field effect on I_{sd} is significantly larger when lower pH is used. At lower pH, the higher concentration of H^+ exists in the solution and could undergo protonation to enhance the surface charge density, therefore results in increasing counterion accumulation in the nanopore. If the surface charge is negative, the lower pH will result in protonation of the existing surface charge which diminishes surface charge density and consequently leads to decreasing ionic current by the reduction of counterion accumulation. On the other hand, if the surface charge is positive, the

protonation will lead to higher surface charge density and hence increases the ionic current due to more counterion accumulation. From the assumptions, the pH dependence data suggest that the surface charge is positive, in agreement with the gate voltage effect results.
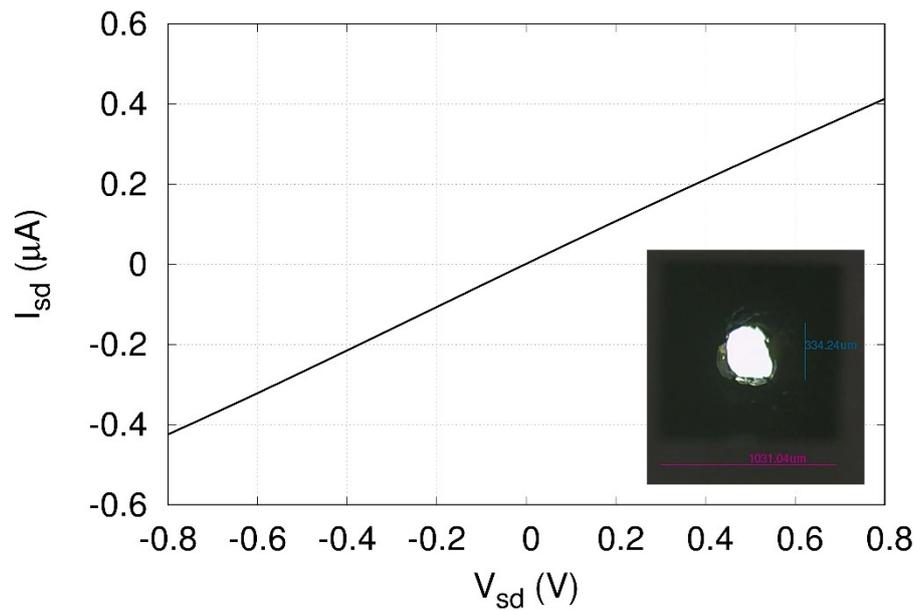
S3

Figure S3. I_{sd}-V_{sd} data collected from a silicon nitride diaphragm with a large open hole. The inset shows optical microscope image of the open hole with the diameter of approximately 334 μm.