Fabrication and characterization of metal electrode embedded nanopore device

Min-Hyun Lee, Hyun-Mi Kim and Ki-Bum Kim
Dept. of Materials Sci. and Eng., Seoul National Univ., Seoul 151-742 Korea
eljja1@snu.ac.kr

Sub-10nm sized nanopore devices have promising possibility in electrical manipulation and sensing of charged species including DNA. The demonstration of single molecule sensing is mostly researched by using biological nanopores, most notably α-hemolysin protein. But they have lack of the mechanical stability from the lipid bilayer that embedded α-hemolysin. So many methods in solid state area were proposed to form sub-10nm, preferably down to 2nm scale nanopores on the membrane structure utilizing either ion beam or electron beam perforation. These structures were successfully utilized to monitor the flow of DNA molecules by measuring the ionic current through nanopore.[1]

Recently, our group reported the formation of nanofluidic structure, nanopores[2] and nanochannels[3] by electron beam lithography, reactive ion etching (RIE) and atomic layer deposition which provided us high throughput and desired dimension on various metal electrodes. These structures has built-in gate electrode, just like MOSFET for semiconductor device. Also, this embedded gate electrode can control the transport of positive or negative ions like electrons and holed in semiconductor device.

In this presentation, we demonstrate the fabrication of metal electrode embedded nanopore in Si_3N_4 membrane with CMOS compatible technology and ALD process with designed diameter. Figure 1 shows the fabricated nanopore using e-beam lithography and RIE process with various diameters. Different nanopore sized served the different ionic conductance and the tendency on nanosize has disparate to that in microsize by Debye screening effect. Subsequently, metal embedded nanopore can be used to sensing the translocation of single charged molecules including DNA.

1. D. Branton *et al.*, *Nat. Biotechnol.* 2008, *26*, 1146
2. S.-W. Nam, M. J. Rooks, K.-B. Kim, S. M. Rossnagel, *Nano Lett.* 2009, *9*, 2044
3. S.-W. Nam, M.-H. Lee, S.-H. Lee, D.-J. Lee, S. M. Rossnagel, K.-B. Kim, *Nano Lett.* 2010, *10*, 3324

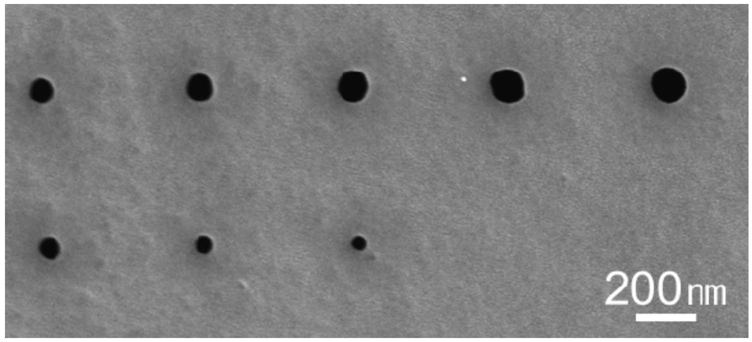

Figure 1. SEM image shows the diameter variation nanopore fabricated by e-beam lithography and reactive ion etching process. The diameter had range from 40nm to 150nm and these nanopores were contracted by atomic layer deposition method.

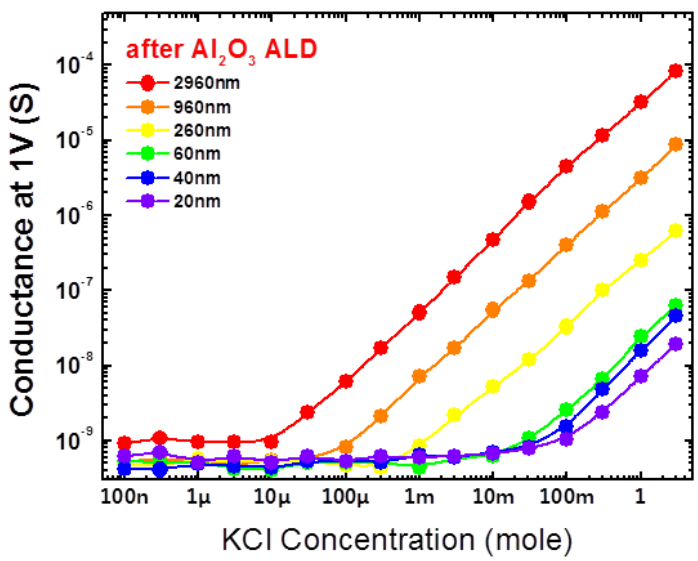

Figure 2: Conductance as function of KCl concentration plot at 1V with different diameter nanopore. The nanopore has completely encrusted by ALD Al2O3 layer. The conductance has linearly decreased with KCl concentration and has proportionality to square of diameter in microsize, but in nanosize, has linear proportionality to diameter.