Modulated 1/f$^{\alpha}$ Noise Behavior by Bias Voltage and Concentration Gradient in Conically Shaped Quartz Nanopipettes

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1/f$^{\alpha}$ noise in various nanopores has attracted wide studies resulting from its huge effect on single molecule sensing and scanning ion conductance microscope (SICM) with high temporal resolution[1]. Earlier work investigating on the formation mechanism of 1/f noise in PET and SiN_x naopores has found that the origin of 1/f noise is either from ion current fluctuation or change of surface charge of inner wall[2], which depends on the constitute of nanopore. However, the generation of 1/f noise is still in debate. In addition, the above mentioned studies mainly focus on the same concentration of electrolyte solution inside and outside nanopores, which mostly shows a constant slope of 1/f noise closed to 1. The effect of concentration gradient (CG) on the 1/f noise is rarely investigated. Actually, the existence of concentration gradient has been found to have large contribution for single DNA sensing and SICM imaging resulting from their enhanced signal to noise ratio[1]. Therefore, the characterization of 1/f noise in novel nanopore system under CG condition is greatly needed.

In this work, we explore the 1/f noise behavior of ion current in a conically shaped quartz nanopipette fabricated by using a laser-puller. These nanopipettes have a pore size of 12 nm as shown in fig.1. Comparing to our previous report, we examined the frequency range from 1 Hz to 4000 Hz for three cases ($C_{pip}>C_{bulk}$, $C_{pip}<C_{bulk}$ and $C_{pip}=C_{bulk}$). Our finding is that the slope of 1/f$^{\alpha}$ noise has a clear bias-dependence relationship under CG condition while an almost constant slope in the condition without CG (not shown). The slope change displays a specific 'V' shape with bias voltage under CG condition, which has not been observed in PET nanopore without CG. To explain the slope change, we hypothesize that the generated 1/f noise in nanopipette follow a non-Markovian behavior, in which CG acted as a feedback system to tune the open and close states of nanopore. A schematic in fig.1 displays that the CG generated current i_d has opposite direction with the one from bias i_e. The modulation of i_d on i_e determines the different current states in nanopore, which results in the generation of different slopes.

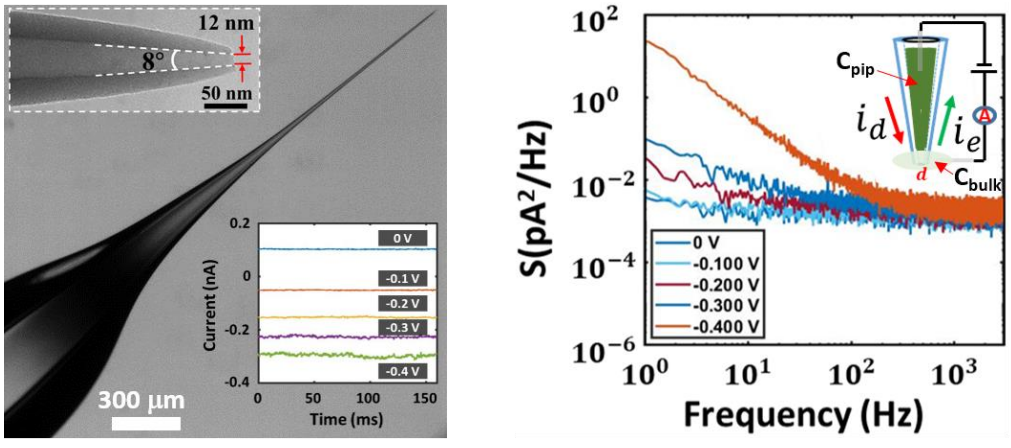

Figure.1 1/f$^{\alpha}$ noise in a conically shaped nanopipette

Reference

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