Parallel DNA Sensing on Silicon Nanopore Array: the Role of Thermophoresis

M. Zhang , C. Ngampeerapong, I. Sychugov, and J. Linnros

Department of Applied Physics
KTH Royal Institute of Technology, Stockholm, Sweden
E-mail: miaoz@kth.se

Nanopore sensing is an emerging field where nano-fabrication technology meets bio-molecular applications. The nanometer-sized pore has been used as a platform to perform single-molecule studies on various DNA strands and proteins and is considered promising to realize a revolutionary DNA sequencing technique with fast speed, long read and low cost. In order to achieve a high throughput, parallel sensing, using fluorescence detection on a large array of nanopores seems a preferable way.

In our group, we take advantage of silicon processing technology to obtain nanopores in large arrays on silicon membranes by electrochemical etching with controlled pitch distance, relatively small pore size distribution and low photoluminescence background [1,2]. 20000 pores are made at the same time in a batch of 10 minutes etching with an average pore entrance diameter down to 18 ± 4 nm. The nanopore array is then subjected to fluorescence-labelled DNA sensing on a wide-field optical microscope. A CMOS camera is employed for parallel detection with high temporal resolution up to 1 KHz. PL signals from arriving DNA are successfully observed on each single pore. Interestingly, we find that the molecule migrations are influenced substantially by the laser-induced thermal gradient at the pore vicinity, due to the large light absorption of silicon in the visible range. Because of the thermophoresis of molecules, DNA molecules are depleted from the membrane to a degree characterized by the Soret coefficient. This is related to multiple parameters, including molecule size, Debye length, salt type, etc. Thereby, we demonstrate that DNA size can be distinguished by the capture rate on nanopores of a diameter much larger than the size of a single molecule. This can be potentially used as a molecule sorting platform.

References

[1] T. Schmidt, M. Zhang, I. Sychugov, N. Roxhed, and J. Linnros, Nanotechnology, **26**, 314001 (2015)

[2] M. Zhang, T. Schmidt, A. Jemt, P. Sahlen, I. Sychugov, J. Lundeberg, J. Linnros, Nanotechnology, **26**, 314002 (2015)