Recent progress in solid-state nanopore-based biomolecule sensing

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Solid-state nanopore is being actively researched for fast and low-cost sequencing of single-strand DNA by ionic current measurement as DNA passes through a nanopore fabricated in a thin SiN membrane. While the idea sounds straightforward, there still remain several hurdles to achieve such goal. One such issue is the relatively high noise signal generated by the Si substrate. Recently, we proposed a new nanopore structure based on highly insulating Pyrex substrates. With the low dielectric constant of the materials and low dielectric loss, the RMS noise signal is drastically down from 100 pA to below 10 pA. Moreover, by employing an extremely thin SiN membrane of about 5 nm in thickness, we have demonstrated the successful identification of 40 nucleotide homopolymers of poly-A_{40}, poly-T_{40} and poly-C_{40}.

Based on the solid-state nanopore device fabricated on a highly insulating substrate, we further developed the sensitivity of our device using 2D membrane materials, such as graphene and BN. While the high flicker noise is still an issue, the utilization of this atomically thin membrane significantly enhances the signal level. Also, we demonstrate synchronized optical and electrical detection of biomolecules using the nanopore on a highly insulating substrate. As compared to the device fabricated on Si, which exhibits large electrical signal fluctuations due to the generation of electron and holes by the incident optical energy, our device does not show any fluctuation of the electrical signal. Thus, the simultaneous optical and electrical detection of biomolecule translocation is now possible.