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Controlling DNA Translocation Speed through Solid-State Nanopores by Surface Charge Modulation

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The Nanopore method is an emerging technique, which extends gel-electrophoresis to the single-molecule level and allows the analysis of DNAs, RNAs and DNA-protein complexes. The strength of the technique stems from two fundamental facts: First, nanopores due to their nanoscale size can be used to uncoil biopolymers, such as DNA or RNA and slide them in a single file manner that allows scanning their properties. Consequently, the method can be used to probe short as well as extremely long biopolymers, such as genomic DNA with high efficiency. Second, electrostatic focusing of charged biopolymers into the nanopore overcomes thermally driven diffusion, thus facilitating an extremely efficient end-threading (or capture) of DNA. Thus, nanopores can be used to detect minute DNA copy numbers, circumventing costly molecular amplification such as Polymerase Chain Reaction. A critical factor, which determines the ability of nanopore to distinguish fine properties within biopolymers, such as the location of bound small-molecules, proteins, or even the nucleic acid's sequence, is the speed at which molecules are translocated through the pore. When the translocation speed is too high the electrical noise masks the desired signal, thus limiting the utility of the method. Here I will discuss new experimental results showing that modulating the surface charge inside the pore can effectively reduce the translocation speed through solid-state nanopores fabricated in thin silicon nitride membranes. I will present a simple physical model to account for these results.