Calcium-induced voltage gating in single conical nanopores

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NANO LETTERS 6 (2006) 1729-1734

We examine time signals of ion current through single conically shaped nanopores in the presence of sub-millimolar concentrations of calcium ions. We show that calcium induces voltage-dependent ion current fluctuations in time in addition to the previously reported negative incremental resistance (*Nano Lett.* 2006, 6, 473-477). These current fluctuations occur on the millisecond time scale at voltages at which the effect of negative incremental resistance was observed. We explain the fluctuations as results of transient binding of calcium ions to carboxyl groups on the pore walls that cause transient changes in electric potential inside a conical nanopore. We support this explanation by recordings of ion current in the presence of manganese ions that bind to carboxyl groups 3 orders of magnitude more tightly than calcium ions. The system of a single conical nanopore with calcium ions is compared to a semiconductor device of a unijunction transistor in electronic circuits. A unijunction transistor also exhibits negative incremental resistance and current instabilities.