Effects of electrons on the shape of nanopores prepared by focused electron beam induced etching

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The fabrication of nanometric pores with controlled size is important for applications such as single molecule detection. We have recently suggested the use of focused electron beam induced etching (FEBIE) for the preparation of such nanopores in silicon nitride membranes. The use of scanning probe microscope as the electron beam source makes this technique comparably accessible, opening the way to widespread fabrication of nanopores. Since the shape of the nanopores is critically important for their performance, in this work we focus on its analysis, and study the dependence of the nanopore shape on electron beam acceleration voltage. We show that the nanopore adopts a funnel-like shape, with a central pore penetrating the entire membrane, surrounded by an extended shallow-etched region at the top of the membrane. While the internal nanopore size was found to depend on the electron acceleration voltage, the nanopore edges extended beyond the primary electron beam spot size due to long range effects, such as radiolysis and diffusion. Moreover, the size of the peripheral etched region was found to be less dependent on the acceleration voltage. We also found that chemical etching is the rate-limiting step of the process and is only slightly dependent on the acceleration voltage. Furthermore, due to the chemical etch process the chemical composition of the nanopore rims was found to maintain the bulk membrane composition.

References
1. Y. Liebes, B. Hadad and N. Ashkenasy, Effects of electrons on the shape of nanopores prepared by focused electron beam induced etching, Nanotechnology (accepted).