Characterisation of conical etched ion tracks in SiO_2

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When a highly energetic heavy ion passes through a target material, the damaged region left in its wake often exhibits preferential etching over the bulk. The etching process can create very high aspect ratio channels of up to tens of microns in length, with pore diameters as small as a few nanometres. Membranes formed by this method are ideal for many advanced applications including medical and bio-sensing, filtration and separation processes, nano-fluidics, and nano-electronic devices. The morphology of the etched channels can be cylindrical, conical or double conical, depending on the etching conditions. The resulting etched pores are highly parallel with very narrow size distributions.

The aim of this research is to develop a better understanding of the etching kinetics and the relationship between the un-etched ion tracks and the etched structures in SiO_2 to enable controlled fabrication of nano-pore membranes with size and shape-specific pores for applications such as bio and chemical sensors. 2 μm thin layers of SiO_2 were irradiated with 185 MeV ^{179}Au ions at the ANU Heavy Ion Accelerator Facility and with 1.1 GeV ^{179}Au ions at the GSI UNILAC in Darmstadt, Germany. The irradiated material was subsequently etched in diluted hydrofluoric acid at several concentrations. We have used small angle x-ray scattering (SAXS) in both transmission mode and grazing incidence to determine the track etch rate and cone angle as a function of etch time and etchant concentration. A full reconstruction of the scattering images enables detailed characterisation of the pore shape and size. An example of a transmission SAXS scattering image is shown in Fig. 1(a). A cross-section SEM image of the etched conical channels is shown in Fig. 1(b). The results of the study indicate that the track etching behavior is influenced by the ion energy, and that at short etching times the latent track damage in the radial direction becomes significant.

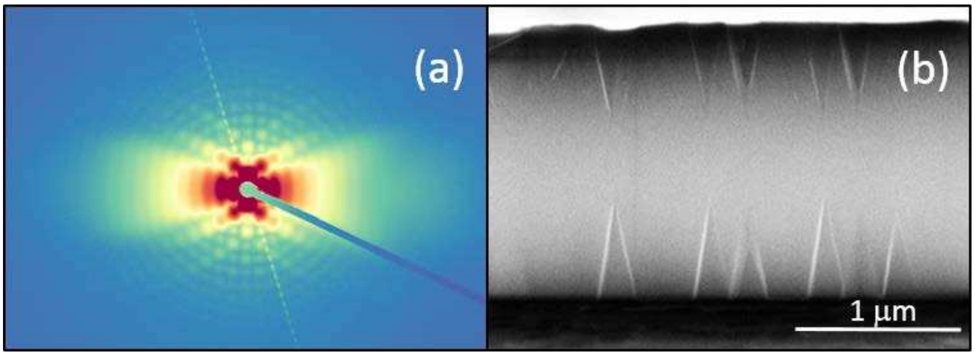

Figure 1. (a) Transmission SAXS scattering pattern from conical cones etched in both sides of SiO_2 membrane and (b) SEM cross section of etched ion tracks in SiO_2 membrane.