2 - 7 Energy Dependence of H_2^+ Ions Guided through Tapered Capillaries in PC

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Since 2002, experimental and theoretical studies of ion and electron transmitted through insulating capillaries, both straight and tapered ones, have become one of the important areas of atomic and surface physics[1-4]. Focusing and guiding ion beams in nanometer sized can be used a unique tool in surface modification and irradiation of single living cell, even DNA recombinant.

In this work, we firstly fabricate tapered capillaries with entrance/exit diameters of 4 μm/2 μm and a length of 30 μm in polycarbonate (PC) membrane. The capillary density is 2×10^4 mm^{-2}. To avoid charging up of both the front and back sides, the PC foil was evaporated with Au under 45° producing conducting films with a thickness of 30 nm. H_2^+ ion beams with kinetic energies ranging from 7° to 200 keV are collimated to a divergence angle of 0.7 and transmitted through a transmission Faraday cap with final aperture of 1 mm in front of the target holder. Transmitted ions are measured by a Gated Ion/Electron Counting System (GICS) with micro channel plates and a CCD.

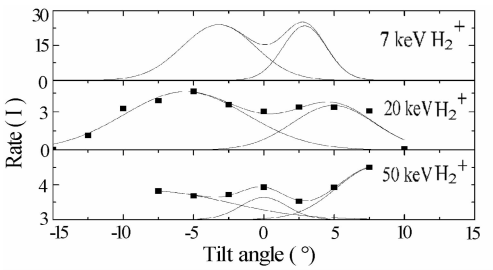

Fig. 1 Transmission fraction of H_{2+} ions with energies of 7, 20 and 50 keV guiding through tapered capillaries. Tilt angles range from −15 to 15 degree.

Fig. 1 shows the transmitted ion fraction for different energies ranging from 7 to 50 keV as a function of the tilt angle. It is surprisingly found the fraction curve has 2 peaks on the left and right side of 0 for energies of 7 and 20 keV, while for 50 keV H_2^+ ions the curve has 3 peaks,one of which is at 0° and the other two symmetrically lie on both sides. The multi-peaks phenomena might be attributed to the existence of nonlocal charge patches caused by the spread due to the preceding deflections. The nonlocal charge patches are more easily produced at small tilt angle, especially for the tapered tubes. However, when the ion energy is low and the capillary is tilted by large angle, the charge patch at exit of the capillaries would highly likely not be local, because the low energy ions could be easily deflected, thus introducing a spread. The nonlocal charge patch inside capillary would produce a transverse potential barrier corresponding to axial field to block the ion transmission, while the local charge patch produce a axial potential barrier corresponding to transverse field to deflect ions. Hence, there are preferable tilt angles at which the major transmission is achieved. But if the ion energy is so high that the potential barrier cannot block the transmission, there is still only one peak at 0, as observed in 200 keV H_2^+ ions incidence.

References

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