2 - 14 Transmission of 200 keV H_2^+ Ions through Tapered Capillaries Etched in PC Foils

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Ion guiding through insulating capillaries has attracted much attention since 2002[1]. The guiding phenomenon can qualitatively be explained by charge patches formed on alternating sides of capillary wall, producing electric field to deflect subsequent ions, inhibiting close interaction with the capillary walls and charge exchange[1,2]. Inspired by this, a method to produce a microbeam of slow highly charged ions with a tapered glass capillary as ion beam focusing lens was developed[3]. In the present work, we firstly utilize tapered capillaries with a density of 2×10^4 mm^{-2} etched in polycarbonate (PC) to study the guiding and focusing effect for 200 keV Hi_2^+ ions.

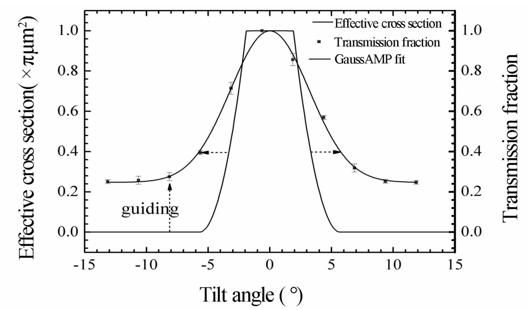

Fig. 1 The effective geometric cross section and normalized transmission fraction for 200 keV H_2^+ ions through tapered capillaries as a function of tilt angle.

Fig. 1 shows the fraction of 200 keV H_2^+ ions transmitted through the tapered capillaries. The experimental data, normalized to unity for tilt angle of ~0°, are shown as square dot, fitted with Gaussian function (solid line). The effective geometric cross section (black solid line) also represents the theoretical geometric transmission fraction in the absence of guiding. The capillaries are tilted up to ±2.5° relative to the ion beam direction in steps of 2.5° so that the data between −2°~2° where the geometric cross section changes little (see Fig. 1) were unavailable. It is clearly seen that while the foil was tilted by angles ⩾ 6° for which the tapered capillaries are not transparent for incident ions, there were still some H_2^+ ions through capillaries, which lead to a broad tilt angle distribution. This finding is remarkable, since with angles ⩾6° the fraction of transmitted H_2^+ ions should be virtually zero, but it is not zero. Thus, we conclude that H_2^+ ions can be guided to the exit of capillaries by the electric field produced by the preceding deposited charges in a self-arranged manner on the inner walls of capillaries.

Due to the significant guiding effect mentioned above, the tapered capillaries could certainly focus the ion beam. The counts with tilt angle of about 0° were ~50 cps per current while the counting rate of incoming H_2^+ ions of ~60 pA on the detector is approximately 10164 cps. The focusing factor can be defined by the current density ratio of N_t/S_o to N_i/S_i, where N_t and N_i is the counting rate per current of transmitted ions and incident ions, respectively, and S_i is the area of the 1 mm aperture before the foil, S_o is the total outlet cross section of the capillary. In consideration of the capillary density, the enhancement of the current density, therefore, is estimated to be ~3.7 times. This factor mainly depends on the ability to guide the ions and the geometrical size of the tapered capillary.

References

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[3] T. Ikeda, et al., Appl. Phys. Lett., 89(2006)163502.