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Blocking effect on transmission of Ne^{7+} ions through nanocapillaries

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Synopsis Systematic investigation was carried out on the guided transmission of $^{22}Ne^{7+}$ ions through nanocapillaries in polycarbonate (PC) foil from 3 to 6-keV kinetic energy range. At 3-keV energy a strong blocking effect was observed contrary to the 6-keV case, where a stable transmission was developed.

Ion guiding by nanocapillaries attracted increasing interest in the last decade [1-8]. This capability is due to the self-organizing electrostatic charging up of the inner walls. Initially the incident ions collide with the surface and deposit their charge. Do to this repulsive electrostatic field is developed, by which the subsequently incoming ions are deflected and guided through the capillary.

Originally, the time development of the transmission of the incident ions was found be monotonically increasing until a stable transmission was developed for polyethyleneterephthalate (PET) capillaries [1,2]. Later, decaying transmission was observed for polycarbonate (PC) capillaries after a maximum transmission was reached [3,4]. At higher ion energies, however, the transmission was stable for PC too [5]. At the other end, blocking was also found for some PET samples [6]. The blocking effect for capillary samples can be attributed to the over-charge of capillary interior [6].

In this work, we systematically measure the transmission of $^{22}Ne^{7+}$ ions through nanocapillaries in a PC foil in the kinetic energy range of 3-6-keV. At 3-keV incident energy a strong blocking effect was observed (see Fig. 1.). After a short sudden increase, the development of the transmission stops slightly above 0.2%. Then it suddenly decreases and drops almost to zero. At 6-keV incident energy the increase is slower but monotonous (see Fig. 1). A stable transmission rate is being approached at the end.

At 4-keV kinetic energy, the blocking effect is still observable. However the transmitted portion of the beam is higher than at 3-keV, so the capillaries are only partially blocked.

The relatively small ion-energy range of the transition from blocked to non-blocked transmission suggests that there exists a characteristic voltage for the sample depending on its geometry and the electric properties of the insulating material. If the ion beam energy is lower than this critical voltage, the capillaries are blocked, while above it regular transmission develops. Partial blocking may be due to the fact that the potential distribution is not uniform along the radius of the beam spot at the sample.

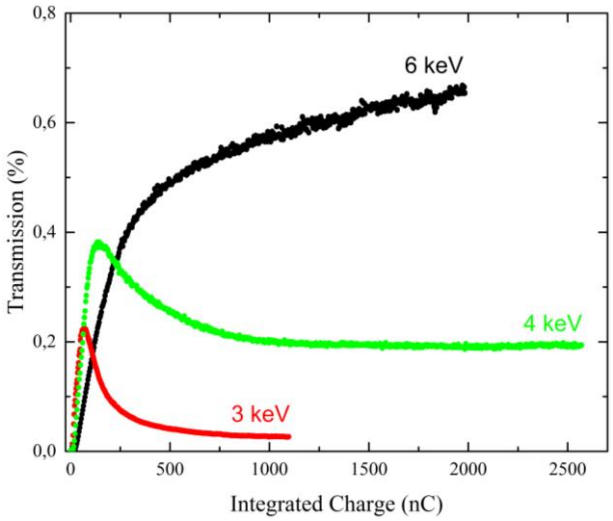

Figure 1. The measured transmission at around Ψ=4.2° tilt angle as a function of integrated charge at 3, 4 and 6-keV kinetic energies, respectively.

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