# Density effects on the blocking of ions guided through insulating PET capillaries

**N. Stolterfoht*[1], R. Hellhammer*, B. Sulik[§], Z. Juhász[§], V. Bayer[&], C. Trautmann[&], E. Bodewits[#], G. Reitsma[#], and R. Hoekstra[#]**

*Helmholtz-Zentrum Berlin für Materialien und Energie, 14109 Berlin, Germany
[§]Institute for Nuclear Research (ATOMKI), 4001 Debrecen, Hungary
[&]GSI Helmholtz-Zentrum für Schwerionenforschung, 64291 Darmstadt, Germany
and Technische Universität Darmstadt, 64287 Darmstadt, Germany
[#]KVI Atomic Physics, University of Groningen, 9747 AA Groningen, The Netherlands

**Synopsis** Guiding of 3-keV $Ne^{7+}$ through untilted nanocapillaries in polyethylene terephthalate (PET) has been measured. The fraction of the transmitted ions is found to decrease with increasing charge insertion into the capillaries. This blocking effect is shown to be strongly dependent on the capillary density.

In the past decade investigations of ion guiding through insulating capillaries have received considerable attention. The incident ion beam deposit charges so that repulsive electric fields are created, which guides the following ions in the direction of the capillary exit [1,2]. This guiding occurs at relatively large distances from the capillary wall so that the incident charge state of the ions is maintained during their passage through the capillary.

With increasing charge insertion, the ion transmission rises to a maximum where stationary (equilibrium) conditions are expected to be reached for which the fraction of transmitted ions remains constant. Only recently, experiments with capillaries in polycarbonate (PC) [3] have shown that after reaching the maximum the transmitted ion fraction decreases with increasing charge insertion. This observation has been interpreted as blocking effects on the ion transmission.

In the previous study [3] it has also been found that blocking effects are absent for PET capillaries even for a considerable amount of inserted charges. However, the PET capillaries had more than an order of magnitude smaller density in comparison with the PC capillaries. Hence, the question arouse whether the blocking effects are produced by the difference in the PC and PET materials or by the difference in the capillary number densities.

In the present work, we performed experiments with 3-keV $Ne^{7+}$guided through capillaries of different densities. The results are shown in Fig.1. The experiments were performed with PET to find out whether blocking effects exist also for this material. The data are acquired for the tilt angle of zero degree, since the blocking was found to be largest for untilted capillaries[3]. From Fig. 1 it is seen that the blocking is sensitively dependent on the capillary density varied from $3\times10^6$ to $6\times10^7$ $cm^{-2}$.

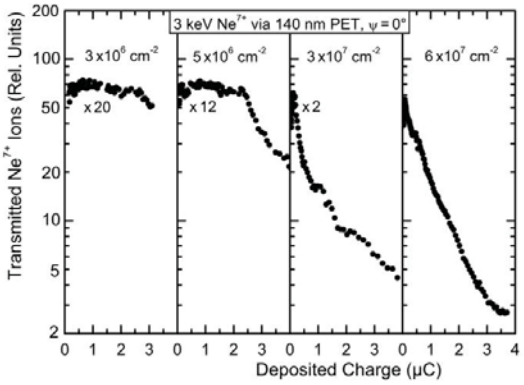


**Figure 1.** Number of transmitted $Ne^{7+}$ ions as a function of the deposited charge for a tilt angle of $\psi = 0°$. The capillary density is indicated in each panel. The capillary diameter amounts to 140 nm.

The dependence on the capillary density indicates that the ion blocking is affected by the neighboring capillaries. Such collective effects have been ascribed theoretically as a result of the charges accumulated in the neighboring capillaries [2]. Experimentally, the neighbor effect can be observed when the distance to the capillary neighbors is changed. i.e., by varying the capillary density. In summary, it is confirmed here that the ion blocking exists for PET and is strongly dependent on neighbor effects.

This work was supported in part by the Hungarian OTKA Grant (K83886).

## References

[1] N. Stolterfoht *et al.*, Phys. Rev. Lett. **88**, 133201 (2002).
[2] K. Schiessl et al., Phys. Rev. A 72, 062902 (2005).
[3] N. Stolterfoht *et al.*, A **83**, 062901 (2011)

*[1] E-mail: nico@stolterfoht.de