Discharge properties of macroscopic glass capillaries after irradiation by low intensity low energy single charged Ar ions

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Synopsis The discharge properties of a macroscopic cylindrically shaped glass capillary, initially charged by a 1 keV Ar^+ beam tilted by 5° whith respect to the capillary axis is studied. Our experimental observations were compared to our Monte Carlo simulation, higlighting the importance of the surface conductivity.

While the guiding of ions through glass-capillaries due to charged patches is qualitatively understood, the complex nature of the electric conduction in such insulators makes quantitative predictions still a challenging task. Indeed, for a given ion beam, the guiding is entirely determined by the discharge dynamics of the charge patches at the surface, which in turn depend (i) on the electrical properties of insulators under ion beam irradiation and (ii) on the position and nature of grounded electrodes. In order to get some insights into the discharge dynamics of formally created charged patches, a combined experimental and theoretical study was performed. Experimentally, guiding of 1 keV Ar^+ ions through a macroscopic borosilicate glass capillary tilted by 5° with respect to the beam axis was studied. The capillary was inserted into an aluminum mount with the front surface covered with conductive paint. The current on the front surface and the transmitted current were measured, yielding absolute transmission rates. The aim was to measure the charging and discharging times for the capillary. This was done by centering the capillary on the entrance aperture and waiting until the transmitted intensity stabilized. Then the beam was blocked for varying times and the transmitted intensity was measured as a function of time. By plotting the ratio of the beam intensity immediately after the beam was re-injected with respect to the intensity just before the beam was blocked for the various blocking times, yields information about the capillary discharge time. This was done for several beam intensities ranging from 0.15 to 16 pA. Using a home-made numerical code [1], the same observables were simulated and compared to the experimental data. The theoretical model, on which the simulations are based, includes a realistic descriptions of the surface and bulk conductivity of glass capillaries. It was found that the charge relaxation of the former created patches depends strongly on the mobility of the charge carriers, giving boundary values for the effective mobility of the charge carriers. The capillary being grounded only at the entrance, surface conduction is privileged, and the simulations predict a non-linear discharge of the patches of the type $Q(t)=Q_0/(1+t/\tau)$, with τ=10s being the characteristic discharge time.

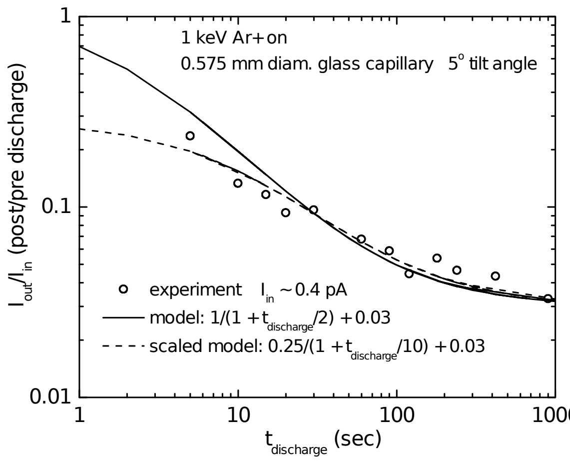

Figure 1. – Transmitted intensity as a function of the discharge time, normalized to the transmitted one, just before the beam was blocked, for a cylindrical capillary of 43 mm length, 0.575 mm inner diameter.

This work was supported by the TéT Grant No. TéT_12_FR-1-013-0007, by the Hungarian Scientific Research Fund OTKA No.NN 103279 and by the COST Action CM1204 (XLIC)

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