Guiding of low-energy electrons by Al_2O_3 nanocapillaries

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Synopsis We have investigated guiding of low-energy electrons (2-350 eV) through high aspect ratio Al_2O_3 nanocapillaries of different diameters (40, 140 and 250 nm). Various measurements of angular, energy, time and current dependence of either total or only elastically transmitted electron intensity have been performed. In addition, we have measured kinetic energy distributions of electrons transmitted through the nanocapillaries both in the straightforward direction and at large tilt angle. The present results show a more complex nature of low-energy transmission through insulating nanocapillaries in comparison with highly charged positive ions.

A great interest is devoted in recent years to the controlled transport of charged particles on a nanoscale. Particularly, the guiding of positive ions by insulating polyethylene teraphthalate (PET) nanocapillaries was first demonstrated in 2002 [1] and have been attracting a considerable attention since then. Experimental studies were performed for capillaries made in PET, PC, SiO_2 and Al_2O_3, as well as single-glass capillaries (see e.g. [2] for references). In addition, theoretical studies gave detailed information about the guiding mechanism [3].

Experimental investigation of electron guiding by insulating nanocapillaries, however, has been reported more recently [4-6]. The results on elastically transmitted electrons showed similarities with ion guiding [4,5]. Nevertheless, the experiments also suggested a more complex nature of low-energy electron transport through insulating nanocapillaries than proposed for positive ions [5,6]. This has been also confirmed in the recent theoretical study [7].

Our work on guiding of low energy electrons includes measurements of angular distributions of elastically transmitted electrons in the energy range from 100-350 eV, as well as dependence of transmission intensity on the incident electron energy [4,6]. We have also measured energy spectra of electrons transmitted through Al_2O_3 capillaries for the incident energy of 100 eV [6].

In the present contribution we also report preliminary results on energy distribution of electrons of higher incident energies, transmitted through Al_2O_3 capillaries of 270 nm diameter and 15 μm length. Figure 1 shows a spectrum taken for the incident electron energy of 250 eV and at about 0^o tilt angle defined with respect to the capillary axis. The energy resolution (FWHM) was about 1 eV**.** Except the elastically transmitted electrons (peaking at 250 eV), intensive inelastic process are clearly present.

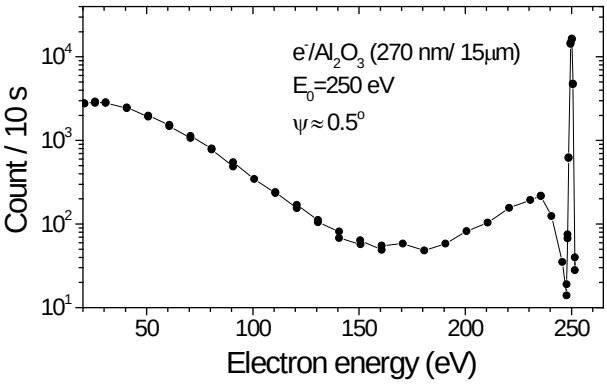

Figure 1. Energy spectrum of electrons transmitted through Al_2O_3 nanocapillaries.

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References

[1] N Stolterfoht *et al* 2002 *Phys. Rev. Lett.* **88** 133201.
[2] N Stolterfoht *et al* 2010 *Phys. Rev. A* **82** 052902.
[3] K. Schiessl *et al* 2007 *Nucl. Instrum. Methods B* **258** 150 *(and references therein)*.
[4] A. R. Milosavljević *et al* 2007 *Phys. Rev.* A **75** 030901(R).
[5] S. Das *et al* 2007 *Phys. Rev. A* **76** 042716.
[6] A. R. Milosavljevic *et al* 2009 *Europhysics Letters* **86** 23001.
[7] K. Schiessl *et al* 2009 *Physical Review Letters* **102** 163201.

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