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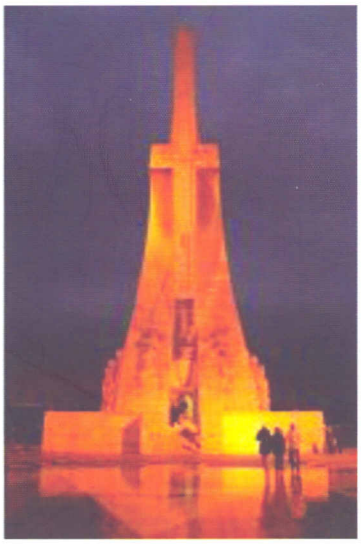

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Guiding of low-energy electrons through insulating nanocapillaries

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We report an experimental study of guided transmission of low-energy (≈10–350 eV) electrons through highly ordered Al_2O_3 nanocapillaries with large aspect ratio (diameters of approximately 40, 140 and 250 nm and 15 μm length). The nanochannel array was prepared using self-ordering phenomena during a two-step anodization process of a high-purity aluminum foil [1]. Our recent experimental results [2] clearly showed for the first time the existence of the guiding effect for electrons, as found for highly charged ions (HCI) [3]. The guiding of the electron beam was observed for tilt angles up to 12°. As seen for HCI, the guiding efficiency increases with decreasing electron incident energy. However, the transmission efficiency appeared to be significantly lower than observed for HCI (see [2]). Furthermore, the transmission appeared to decrease significantly with decreasing electron energy, so limiting the lowest used incident energies to about 200 eV. The electron guiding has been also investigated more recently for the highly insulating polyethylene teraphthalate (PET) nanocapillaries [4], where authors reported results for the incident electron energies of 500 eV and 1000 eV. The most recently, we have performed experiments using a new improved setup, in order to investigate transmission of electrons through insulating Al_2O_3 nanocapillaries of different diameters at very low energies down to below 10 eV. We were focused on finding a dependence of the transmitted electron signal as a function of the incident electron energy, tilt angle (the angle between the incident electron beam and the nanocapillary axis), charging time and incident current, as well as electron energy loss spectra of transmitted electrons.

The guiding of charged particles through insulating nanocapillaries has been attracting a considerable attention, since Stolterfoht *et al.* [3] reported an unprecedented experiment of transmission of 3 keV Ne^{7+} ions through nanocapillaries of PET. Besides the investigation of hollow-atom formation at large distances from the surface, these studies might gain important information about the properties of the inner walls of the capillaries and for possible applications (e.g., manipulation of charged particles on the nanoscale). Using the electrons as projectiles gives new possibilities both for a fundamental understanding of the guiding phenomenon and applications. The interaction of the projectile with the inner walls, the insulator charge-up and discharge processes are expected to be different; also, the low-energy electrons are more affected by the electric field than ions, so representing a more sensitive tool for the characterization of the nanotubes.

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