KINETIC ENERGY DISTRIBUTION OF ELECTRONS SCATTERED INSIDE A PLATINUM TUBE AT THE INCIDENT ENERGY OF 200 eV

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Abstract. We have measured the kinetic energy distribution of electrons escaping a macroscopic platinum (Pt) tube (3.3 mm diameter and 40.8 mm length). The 200 eV incident electron beam of about 800 nA was directed into the capillary entrance at a large tilt angle of 5.5^{o}, with respect to the capillary axis. The results show a dominant fraction of elastically scattered electrons, accompanied by inelastic losses.

1. INTRODUCTION

Insulating micro- and nano-capillaries made of different materials have been extensively used to investigate the so-called *guiding* phenomenon, which was first revealed with the pioneering work of Stolterfoht and coauthors in 2002 [1]. Briefly, the beam of charged particles, particularly highly charged ions (HCI), dinamically deposit charge on the inner capillary surface, thus providing a Coulomb field that deflects the particles and efficiently guides them towards the capillary exit. Large attention has been devoted to this phenomenon due to both an interesting physics and possible applications, such as the possibility to introduce a micro/nano HCI beam directly into a biological object [2]. The first results on electron guiding through insulating capillaries have been reported more recently [3,4], followed by a more detailed investigations [5,6]. A comprehensive review on the subject can be found in the recent paper by Lemell et al. [7].

In contrast to the HCI, the electron transmission through insulating capillaries appeared to be much more complex [5,6,7]. Particularly, electrons can be closely elastically scattered from the surface (not only deflected by deposited charge), inelastically scattered and can produce secondary electrons (which thus affect the Coulomb interaction). Moreover, it has been suggested that even metallic (conductive) capillaries could be used for the electron guiding [6].

In the present work, we investigate electron transmission through metallic macroscopic capillaries. Our aim is both to learn about fundamental properties of the electron guding by metallic capillaries, governed by electron-surface interaction, and to investigate the potential application of metallic high-aspect ratio capillaries as a robust, spatially well-determined, low-energy electron carier/source, which could be efficiently applied to study electron driven molecular processes under different environmental conditions. We started investigation with a large-diameter Pt tube, in order to compare the obtained results to the electron interaction with a plane Pt surface and theoretical simulations. In the present work, we have investigated transmission of 200 eV incident electrons through a single Pt macrocapillary (3.3 mm diameter and 40.8 mm length – the aspect ratio of about 12.4). The intensity of the outgoing electron current has been measured as a function of both the incident beam angle with respect to the capillary axis (tilt angle) and the kinetic energy of outgoing electrons.

2. EXPERIMENTAL SETUP

The experiment has been performed in the Laboratory for Atomic Collision Processes, at the Institute of Physics Belgrade (IPB) by using the electron spectrometer UGRA [8], which has been modified to perform the present experiment. The electron gun produces a well collimated electron beam, with a diameter and an angular divergence estimated to be approximately 1 mm and 1^{o} at 200 eV of the incident energy, and with an energy spread of about 0.5 eV. The Pt tube has been fitted inside the entrance electron lens system (see Figure 1), in front of the electron gun, which can be rotated around the capillary entrance in the angular domain of about -15 to +15 degrees. The angle between the capillary axis and incident electron beam direction is denoted as the tilt angle.

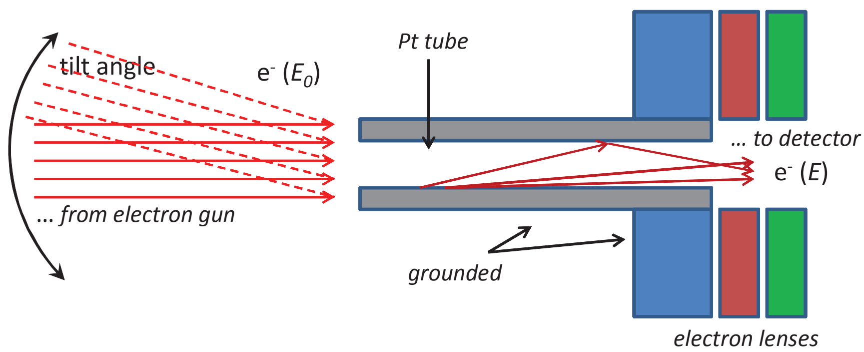

Figure 1. Schematic drawing of the experimental setup.

The electrons escaping the capillary were focused by an electrostatic lens (Figure 1) into a double cylindrical mirror energy analyzer (DCMA), followed by a single channel multiplier used as a detector. Since the entrance lens of the analyzer is fixed to have its axis parallel to the capillary axis, the observation angle is fixed at 0^o and the acceptance angle also depends on the focal properties of the entrance lens. The kinetic energy distribution of the electrons escaping the capillary was measured by recording the electron current at the detector (count rates) as a function of the retarding potential at the entrance of the DCMA that worked in a constant pass-energy mode, thus providing a constant energy resolution over the whole scanned energy domain [8]. Still, it should be noted that the recorded kinetic energy distribution can be affected by the transmission of the entrance lens [8].

3. RESULTS

The preliminary obtained kinetic energy distribution of electrons escaping the Pt tube at the tilt angle of about 5.5^o and for the incident electron energy of 200 eV is shown in Figure 2.

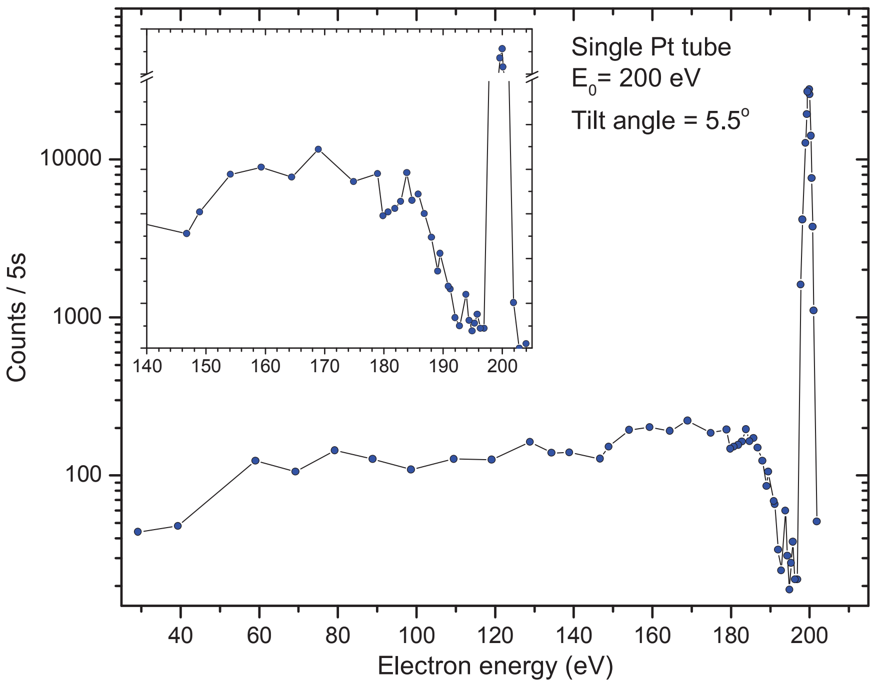

Figure 2. The kinetic energy distribution of electrons escaping the Pt tube at the tilt angle of 5.5^o and the incident electron energy of 200 eV.

The aspect ratio of the Pt tube defines the tilt angle of 4.6^{o} as a maximum angle to transmit the direct electron beam. Moreover, even at smaller tilt angles down to only a few degrees, the electron detection should not be possible due to the aspect ratio of the entrance lens stack and the DCMA (see Figure 1), which also depends on the electrostatic field. Therefore, the present results suggest that 200 eV electrons can be directed and transmitted along the metallic Pt tube. The dominant fraction of the transmitted electrons seems to suffer only elastic surface collisions. Inelastically scattered electrons are also detected and further work is in progress to compare the present results with the electron scattering from a plane Pt surface and calculations that include cylindrical geometry.

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