Broadening in the energy distribution of electron beams transmitted through a micrometer-sized tapered glass capillary

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Synopsis The transmission of electrons through a tapered glass capillary was observed for 1000 eV incident electrons up to tilt angles of ~9.5°. Tilt angle dependence of the energy loss broadening shows clear correspondence of elastic and inelastic processes. Both were found for smaller tilt angles.

In the area of capillary experiments tapered glass has received much attention [1]. Studies from our laboratory reported electron transmission through single cylindrically straight [2] and tapered [3] glass capillaries of macroscopic dimensions.

Tapered glass capillary samples made of borosilicate glass with inlet/outlet diameters of 800 µm/100 µm were subjected to bombardment by 1000 eV electrons. The samples were prepared by the RIKEN laboratory in Japan and the measurements were conducted at Western Michigan University.

Angular distributions for electron transmission through the tapered glass capillary were obtained for 1000 eV by tilting (angle denoted by ψ) the capillary axis with respect to the incident beam direction. The experimental method and a schematic of the set up can be found elsewhere [3]. Considerable transmission was observed from ψ = +1.0° to -9.5°. The angular distribution consisted of three peaks in the range ψ = 0.0° to -0.8°. One of the peaks disappeared in the range ψ = -1.0° to -4.0° following which only one peak continued up to -9.5°. Detailed description of these peaks can be found in Ref. [4].

To analyze the characteristics of the transmitted spectra further, variation of the full width at half maximum (FWHM) energy vs. sample tilt angle is shown in fig. 1. The colors (green, red, blue) are used to represent the three peaks described above. The FWHM (eV) can be divided into regions of direct and indirect transmission, and the transition between them. The green points (direct) have a FWHM ~35 eV and the energy spectra (not shown) show no energy loss, indicating the transmission occurred without colliding with the capillary wall. Indirect transmission occurs for ψ < -3.5° with FWHM (eV) values > 75 eV (blue points) indicating inelastic transmission, as shown by the energy spectra. In the transition region (red points) between direct and indirect transmission the FWHM (eV) was about 50 to 75 eV. The transmission spectra in the transition region were found to have both elastic and inelastic contributions. The indirect and transition regions constitute guiding with some energy loss as the beam interacts at least once with the wall before exiting.

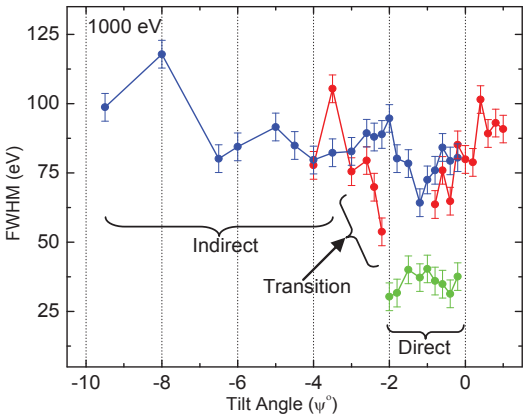

Figure 1. FWHM (eV) vs. sample tilt angle (ψ) for incident 1000 eV electrons.

References:

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[2] B. S. Dassanayake et al. 2010 Phys. Rev. A **81** 020701(R)
[3] S. J. Wickramarachchi et al. 2011 Nucl. Instrum. Meth. Phys. Res **B 269** 1248
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