4 - 14 A Real-time Beam Current Density Meter

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Information about beam current and current density is very important in many experiments, such as ion sputtering, beam guiding and irradiation studies[1-3]. The interceptive Faraday-cup or Faraday-cup array therefore is widely employed to obtain absolute beam current and profile[4,5]. However, real-time non-interceptive monitoring is more needful when the beam intensity is highly requisite. Although the residual gas monitor technique can provide non-interceptive beam monitoring by measuring the ionized products of the residual gas, it is vacuum dependent and needs careful calibration[6,7]. Moreover, it is can't be used in some situations when a beam with a big cross section is cut into a smaller one to fit the small samples. For this case, the beam on the sample can be treated as uniform, and we have constructed a real-time beam current density meter which is useful when a big beam cross section needed to be limited for a smaller sample.

The schedule drawing of the beam current density meter is shown in Fig. 1. It is built of 7 aligned brass electrodes with different central apertures, and alternately insulated by Teflon. The shield electrodes E1 and E7 are grounded and employed to prevent the leakage of electrostatic field. Moreover, E1 also serves as an entrance of the current density meter, which defines the cross section of the entering beam. The suppressor electrodes E2 and E6 are negative biased to suppress the secondary electrons generated from the measurement electrode E4. The interception electrodes E3 and E5 are also grounded to intercept the leakage current from E2 and E6 to E4, respectively. The inner part of the beam (inside the aperture of E4) passing though the density meter will interact with the sample, while the outer part of the beam (in the annular region between the aperture of E1 and E4) will be stopped on E4. Under the uniform beam approximation, the beam density is $J=I_m/(A_1-A_4)$, where J_m is the beam current measured on the electrode E4, A_1 and A_4 are the areas of the aperture of E1 and E4, respectively.

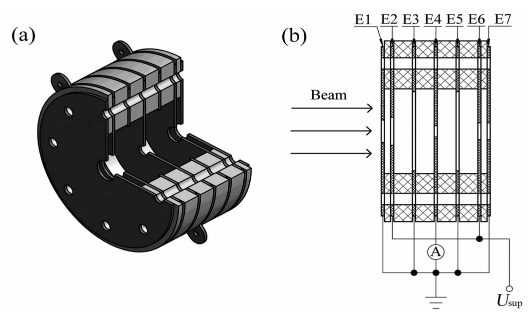

Fig. 1 (a) cutaway view; (b) schematic view.

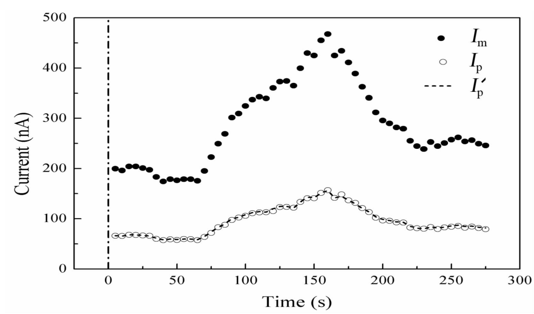

Fig. 2 Test measurement of real-time beam current.

Owing to the suppressing voltage, the beam current density meter, also acting as an electrostatic lens, could deflect the beam. Therefore, we simulated the trajectories of the proton and electron beam utilizing the SIMION 8.0 program. Simulation results indicate that the deflection of the beam is neglectable in our applications. The suppression effect of the secondary electrons is also simulated by the SIMION 8.0 program. As can be seen in the simulation, all the electrons are deflected back to the measurement electrode E4, indicating a remarkable suppression effect.

The test measurement is carried out at the 320 kV platform for multi-discipline research with highly charged ions at the Institute of Modern Physics, with a beam of 105 keV Ar^{7+} ions. The real-time measurement beam current I_m on electrode E4 and the passing current I_p were recorded simultaneously. I_m, I_p, and the deduced passing current $I'_p=I_mA_4/(A_1-A_4)$ are illustrated in Fig. 2(• the measured currents on the measurement electrode E4 of the density meter, ◦ the direct measurement of the passing currents by Faraday-cup behind the meter, and --- superimposed on ◦ the deduced passing current.), where the aperture diameters of E1 and E4 are 4 mm and 2 mm, respectively. By adjusting the parameters of the ion source, the beam intensity is changed, and I'_p agrees with I_p very well, as seen in Fig. 2. So far, the constructed meter has been exposed to the beam for more than 200 h in total at different beam intensities and energies.

References

[1] M. P. Seah, T. S. Nunney, J. Phys. D43,25(2010)253001.
[2] J. Chen, Y. Xue, J. Liu, et al., Nucl. Instr. Meth., B281(2012)26.
[3] O. Lehtinen, T. Nikitin, A. V. Krasheninnikov, et al., New J. Phys, 13, 7(2011)073004.
[4] C. E. Sosolik, A. C. Lavery, E. B. Dahl, et al., Rev. Sci. Instrum., 71, 9(2000)3326.
[5] L. Panitzsch, M. Stalder, R. F. Wimmer-Schweingruber, Rev. Sci. Instrum., 80(2009)113302.
[6] W. Bohne, S. Hessler and G. Rijschert, Nucl. Instr. Meth., B113(1996)78.
[7] T. Giacomini, S. Barabin, P. Forck, et al., AIP Conference Proceedings, 732(2004)286.

4 - 15 Guiding of Electrons through a Paired Parallel Glass Plates

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Interaction between charged particles and insulating capillary has become more and moreimportant in the fundamental study of ion-surface collision processes. What's more, it alsoprovides a possible new method to produce micro/nano meter sized beams, which may bewidely used in nanotechnology. Particular attention has been paid to the transmission of HCIs though insulating capillaries[1-5]. However, in contrast to the case of HCIs, study of transmission of electrons through insulating capillaries is still deficient.

In the present work, the transmission of 800 eV electrons through a paired parallel glass plates was investigated. The glass plate used in this study was 21 mm in length, 30 mm in width and 4 mm inthickness, which was made of soda lime glass. The gap in thepaired plates was set to 0.6 mm. To avoid macroscopic charge-up of the entrance surfaces of the glass, they were covered by the sample holder. The measurements were focused on the angular distributions of electrons transmitted through capillary.

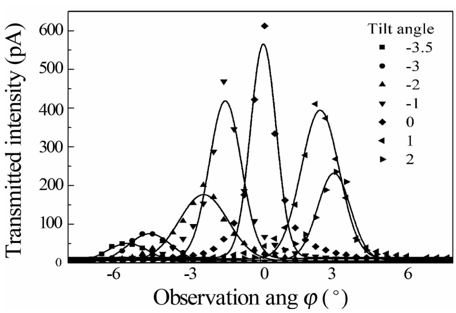

Fig. 1 Angular distributions of 800 eV electrons transmitted through a paired parallel glass plates for different tilt angles ψ.

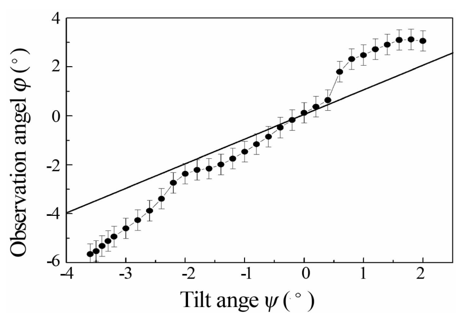

Fig. 2 Observation angle φ of the transmitted beamas a function of capillary tilt angle ψ. — represents a direction of $\varphi=\psi$.

The intensity and angular distribution of the transmitted electrons for various tilt angles were measured using a one-dimensional position sensitive detector. Fig. 1 shows the angular distributions of 800 eV electronstransmitted through a paired parallel glass platesfor different tilt angles ψ. From the figure it is evident that electrons are guided through the paired plates. Transmission of 800 eV electrons was observed for tilt angles of up to roughly 3° as well.

Fig. 2 shows the observation angle of the transmitted beam as a function of capillary tilt angle ψ with respect to the beam direction. In the figure, the observation angle φ is the center of the transmitted electrons profile and the solid line represents the observation angle being equal to the tilt angle. According to Fig. 2, the observation angle φ is larger than the tilted angle ψ when increasing the tilt angle of the capillary. This behavior has not been observed in the previous studies.

The present results indicate the existence of guiding effect and the guiding effect is observed to be enhanced at lower incident energies. Moreover, when the capillary was tilted with respect to the direction of the incident beam, a unique phenomenon that the observation angle φ related to the center of the transmit-