Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Guiding of high-current electron beam by macro-insulating units

To cite this article: Mingwu Zhang *et al* 2017 *J. Phys.: Conf. Ser.* **875** 052027

Guiding of high-current electron beam by macro-insulating units

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Synopsis The guiding effect of high-current electron beams transmitting through different macro-insulating materials has been investigated by following our previous study. It is very surprised that the guiding effect by different materials was found to be very similar, which may be due to the combined contributions of the individual atom scattering and the repulsive field on material surface.

Since the unexpected guiding effect of low energy ions by PET nanocapillaries was reported, considerable work [1, and references therein] has been done to investigate slow highly charged ions (SHCIs) interacting with inner surface of various insulating capillaries. Now it is clear that the preceding SHCIs will deposit positive charges on the surface, building up an electric field by forming a charged patch and therefore preventing the succeeding ions from close contact with the surface. The deposited charge patch more than one may be created until stable guiding is achieved. However, when an electron beam passes through an insulating capillary, besides the low energy secondary electrons, a notable portion of the transmitted electrons suffers significant energy loss, and the transmission efficiency is much lower than that of SHCIs. The current studies of electron guiding indicate that it is essentially different from that of SHCI [2, and references therein].

In our previous work [2], using a pair of grooved SiO_2 parallel plates, we had obtained stably guided electron beams without energy loss in the incident energy range of 800-2000V. Different beam fluxes and different ground boundaries were employed to explore the discharge mechanisms, but no obvious influences have been observed. It shows that the self-organizing repulsive electric field played the dominant role to guide the electrons, by comparing with a pair of asymmetric parallel plates that were constructed by replacing one of the plates by a ground metal. This is similar to the case of SHCI beams. However, our results suggest that the complicated mechanisms involved in charging and discharging of insulators bombarded by electrons.

Following the above investigation, we used several insulators which were all made into grooved plates as same as the above grooved SiO_2 plates, to study the dependence relative to the guiding beams on different materials. As shown in Figure 1, it is very surprised that, because the conductivities of these materials may differ several magnitudes from each other, the guiding behaviors among these different insulators are quite same. Moreover, we found that the gap between two symmetric plates might play significant role in guiding process of electron beams. The present results suggest that the guiding effect of high-current electron beams by macro-insulating units may be due to the combined contributions of the individual atom scattering and the repulsive field on material surface.

This work was supported by the National Natural Science Foundation of China (Nos. 11205224, 11275240, and U1332206).

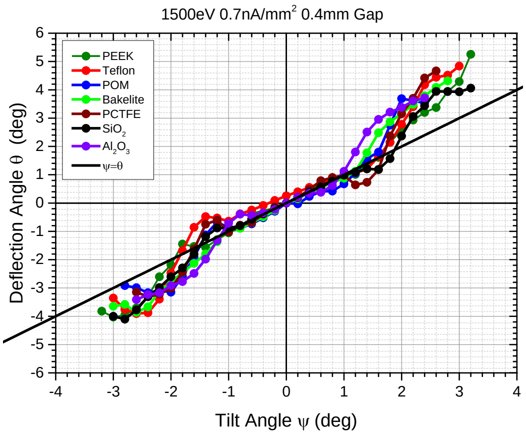

Figure 1. Deflection angle as functions of the tilt angle for 1500 eV, 0.7 nA/mm^2 electrons passing through different parallel plates with 0.4 mm gap.

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