# Charging and error budgets in electron beam lithography tools

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Given a set of end user requirements that establish the overall performance goals of a system, the error budget allows a system architect to seek an optimum balance between various subsystems to achieve the most efficient design. When factors that contribute to the overall error budget are poorly understood the result is likely a sub-optimal design that relies on the designer's knowledge of the "art" as opposed to the desired but absent scientific understanding. This typically leads to over engineering of other subsystems to compensate.

It is well known that electron beam lithography tools are prone to drift. Some of the sources of drift are well understood and can be readily folded into a quantifiable error budget. Examples include electronic drift which can be addressed via stability requirements placed on the constituent components or thermal drift which can drive material selection and environmental constraints. One source of drift which has not been strongly quantified is drift due to charging. It will be assumed in this paper that all sources of charging due to bad practices are absent (no bulk insulators or floating conductive elements within line of sight of the beam). We will also not consider substrate charging here, it is assumed that the error budget comprehends a "standard" resist and substrate type which is well understood from a beam induced charging perspective. What will be examined explicitly are contributions due to particle contamination, voids in conductive coatings that expose insulating material and contamination induced insulating films on conductors.

Figure 1 shows the model developed for a particle on a conducting surface such as a deflection plate. The particle acquires a charge Q and generates a dipole field with its image charge that perturbs the beam trajectory as shown in Figure 2. The maximum charge on the particle is estimated from the size and breakdown voltage of the material and is found to be in good agreement with the experimental results of Belhaj et. al.[1]. Figure 3 shows examples of calculated displacement errors vs. particle size over a 50mm flight path for a 50KV beam and a conducting plate 5mm from the beam axis. If this system represents a 16 bit deflector with a 0.5nm lsb we can set a ½ lsb threshold and see that a single particle in the 3-10um size range is capable of introducing significant error depending upon the material type.

The manuscript will examine all contributions in additional detail. By systematically addressing all of these effects in an electron optical column, it becomes possible to assign quantitative contributions to the system error budget due to charging.

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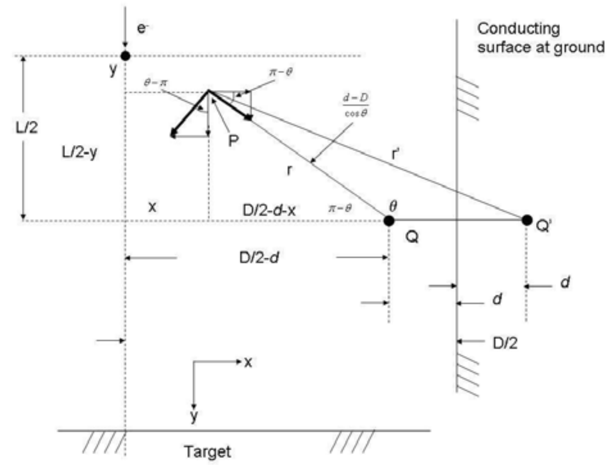
[1] M. Belhaj, S. Odof, K. Msellak and O. Jbara, J. Appl. Phys. **88**, 2289 (2000)

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| Figure 1: Dipole model for charge on a conducting surface |

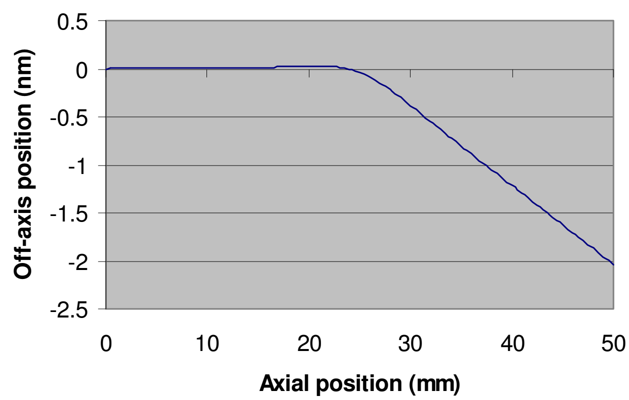


Figure 2: Path of a 50Kev electron under the influence of a 10um glass sphere holding a 1pC charge located 5mm off axis and at 25mm axial position.

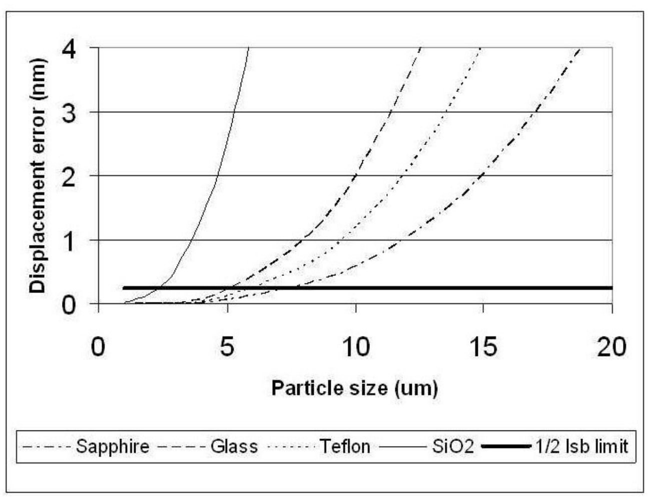


Figure 3: Displacement of 50Kev electrons for various particle types and sizes.

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