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X-Ray Microanalysis of a Coated Non-Conductive Specimen: Monte Carlo Simulation

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The imaging and characterization of non-conductive specimen in a electron microscope is limited by charging effects. Modeling of the mechanisms of charging as well as its effect on the electrons trajectories is needed for a better knowledge of this important effect. In this paper, we have studied this charging effect on the production and the measurement of X-ray by numerical simulation of a coated specimen.

For the simulation, we have used the Monte Carlo program WinX-Ray, which include the calculation of the X-ray production and measurement of the complete X-ray spectrum with a electric field inside the specimen. For more information on this program see the abstract of Demers et al. [1] and it references. The charging model used have been developed by Cazaux [2]. The main hypothesis for the simulation is that the coated specimen is irradiated by an incident beam scanned over a large area during analysis (uniform charge density). For a example on a complete X-ray spectrum simulated with WinX-Ray, see the abstract of Gauvin et al. [3].

The electric field repulse incident electrons toward the surface and reduce the interaction volume for the production of the X-ray. This reduction have two effects on the intensity of X-ray measured: a diminution of X–ray generation and, also, a diminution of X-ray absorption. If the diminution of X–ray generation is more important than X-ray absorption, X-ray intensity will decrease (the absorption for this energy is small). In an other hand, if the diminution of the absorption dominate (the absorption for this energy is large), the intensity will increase.

This phenomena is shown in Figure 1 and 2 with variation of the ratio of the intensity, $\frac{I}{I_o}$, for the K_α line of the Al and O respectively as a function of the incident electron energy for different values of the electric field (an alumina specimen). I_o is the intensity of the line without an electric field and I is the intensity with an electric field (charging). For the $Al\ K_\alpha$ line (figure 1), the decrease of ionization dominate in the incident energy interval (5 to 30 $k\,\mathrm{eV}$). Around 15 $k\,\mathrm{eV}$, we have the maximum of the difference between the intensity with and without electric field. At this energy the electric filed inside the specimen have a bigger effect on the x-ray emission. For the $O\ K_\alpha$ line (figure 2), the decrease of ionization dominate for incident energy under 15 $k\,\mathrm{eV}$. But over 15 $k\,\mathrm{eV}$, the diminution of the absorption is more important and we have a increase of the intensity. The energy crossover at 15 $k\,\mathrm{eV}$ can be used to measure X-ray with minimization of the charging effect on the intensity $O\ K$ line. These trends are similar to those computed by other researchers [4-5].

Acknowledgments

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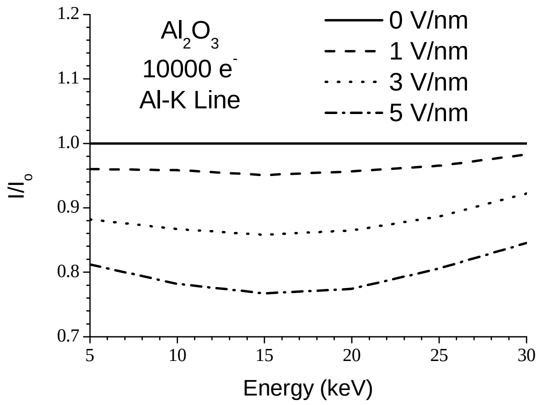

FIG 1. Ratio of the intensity for the *Al K* line in a Alumina specimen.

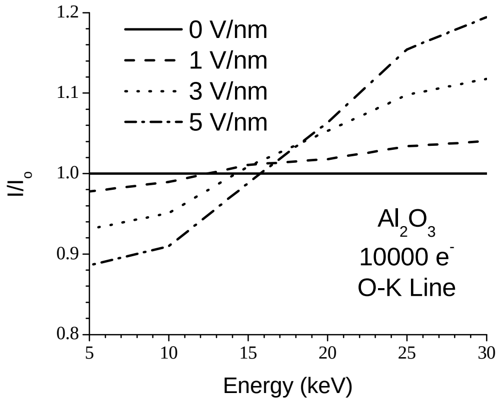

FIG 2. Ratio of the intensity for the *O K* line in a Alumina specimen.

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