Influence of work function and plasmon energy on low-energy secondary electron emission

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Secondary electron emission (SEE) plays a key role in several aspects of nanolithography technology, such as scanning electron microscopy (SEM) metrology and inspection, as well as plasma-surface interactions. SEE results from the interaction of incident (primary) electrons with a material surface and strongly depends on the surface properties. In particular, surface composition, work function, and surface charge can strongly influence a material's SEE properties, such as the total electron yield (TEY), defined as the ratio of emitted to incident electrons. At low primary energies (≤100 eV), the TEY and energy distribution curves exhibit significant variations, but studies under well-defined surface conditions remain scarce in this regime[1]. Reliable experimental SEE data are essential for improving the accuracy of low-energy electron-matter interaction models for understanding and simulating SEM images for inspection and metrology.

The goal of this work is to establish correlations between low-energy SEE properties and intrinsic surface properties of metals, focusing on work function and plasmon energy. The work function is expected to be an important parameter, with previous studies suggesting that the maximum value of TEY increases with work function when comparing different metals[2]. Plasmon excitation has been identified as an important energy-loss mechanism for SEE[3]. To draw reliable conclusions of the effect of material properties governing SEE, the cleanliness of the sample is essential. Therefore, metal samples are prepared by in situ evaporation and studied under ultra-high-vacuum conditions, with their surface composition confirmed by X-ray photoelectron spectroscopy (XPS). TEY and low-energy electron energy distribution curves are measured to characterize the variation of SEE between different metal surfaces. The maximum value of TEY shows a trend across Au, Ru, and Pt consistent with the previously reported increase with work function, while the energy distribution curves show a characteristic decrease in relative SEE intensity for primary electron energies below 30 eV. Our data will provide reference measurements for validating the low-energy electron–matter interaction simulation tool[4] within our project, ultimately supporting more accurate low-energy SEM image modeling. Metals are considered first because they are more readily characterized, while available literature provides a basis for comparison despite often lacking well-defined surface conditions.

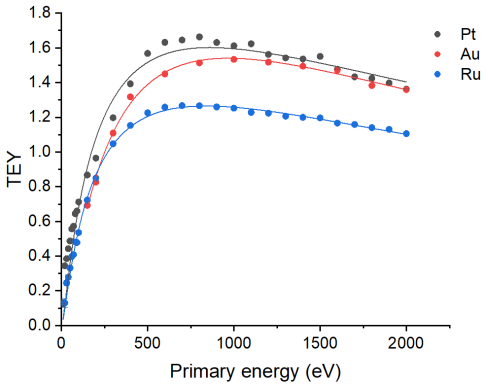


Figure 1. Total electron yield curves of Pt, Au, and Ru.

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References

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