Measurement of Object Height in Emission Electron Microscopy

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Emission Electron Microscopy (EEM) allows to study objects with lateral resolution of several nanometers [1-3]. It can be much higher in time-of-flight EEM [4]. At the same time, there is also the possibility of measurement of height of objects under investigation. Really, the principal element of emission electron microscope is the immersion objective, a part of which is the specimen itself under investigation. There is a homogeneous electrical field $E_{ext}=V_{ext}/l$ between sample (cathode) and extractor (anode). (E_{ext} is voltage on the extractor and l is distance between the object and the extractor). In the event if the specimen is characterized by an equipotential surface with relief $h(x,y)$, it can be substituted for a specimen with ideal smooth surface and distribution of the potential on it $\varphi_r(x,y)=-E_{ext}h(x,y)$ [5]. In consequence of interaction with microfields gradφ (x,y), the trajectories of electrons forming the image become deformed, which leads to its distortion. From EEM images obtained with different voltages of the extractor, $\varphi_r(x,y)$ is calculated [6] and thus $h(x,y)$ is reconstructed. If the surface of the specimen is characterized as distribution of the potential $\varphi(x,y)$, that is, is not equipotential, as by the relief $h(x,y)$, then for the reconstruction one needs an additional EEM image with one more voltage of the extractor. To discriminate the contributions $\varphi(x,y)$ and $\varphi_r(x,y)$, it is allowed by the circumstance that the first one does not depend on V_{ext}, whereas the second one depends linearly on V_{ext}. The maximal sensitivity to microfields/relief is when using the electron microscope in the mirror operation mode. When increasing the defocusing, though the lateral resolution drops, the sensitivity to height difference increases. The estimations show that in EEM research, it is possible to observe atomic steps on surface of crystals.

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