Nanotomography of materials degradation - new insights by high resolution 3D analysis of electrical contacts

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The precise characterization of the local volume of microstructures is a precondition to investigate and to understand degradation effects in switches due to electrical discharges, the mechanical impact and related phenomena. It is well known in Materials Science, that the microstructure is the unique and authentic monitor and the "memory" of all materials processing as well as operational load effects. However, it could not be fully exploited so far due to the lack of adequate 3D characterization techniques.

The recently developed FIB-Nanotomography may solve this problem. It is based on the automatic and nano scale serial sectioning of the volume of interest (e.g. a discharge crater) by the focused ion beam (FIB) and offers an optimum nano scale resolution in x-y-z and at the same time a relevant field of view up to (100x100x100)µm³. For the serial imaging procedure the whole variety of well established contrasts of Scanning Electron Microscopy (namely EDS for chemistry, EBSD for phase composition, grain shape, size and orientation and to some extend also stress and strain) is available. After imaging, a detailed 3D image analysis enables the comprehensive quantitative evaluation of local microstructure degradation effects such as local pores per volume distribution, oxide clustering and grain size effects. Once the microstructure is quantitatively known, also the detailed simulation of local effective properties becomes possible.

This will be demonstrated by using the 3D voxel data set of the crater region for FEM simulations on the local electrical and thermal conductivity. Some verification using a test facility (DC, single break test) proofed the relevance of the simulated data. In general - Nanotomography in close combination with advanced 3D image analysis and micro/nano scale measurement of mechanical and functional data should significantly help to understand the complex microstructure degradation in the "operational multi load" of contact materials.

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