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Microstructure Tomography in the Micro, Nano and Atomic scale – Advanced Access to Understand Local Formation as well as Degradation of Materials Microstructure

F. Muecklich, M. Engstler

Functional Materials, Saarland University, *and* Materials Engineering Center Saarland (MECS), Campus D3 3, 66123 Saarbruecken, Germany

Materials microstructure is the unique and authentic monitor and the "memory" of all materials processing as well as operational load effects. Additionally, materials properties are strongly influenced by their microstructure (Fig. 1). Three dimensional microstructure characterization at different scale plays the key role for understanding the relationship between processing, microstructure and properties. However, it could not be fully exploited so far due to the lack of adequate 3D characterization techniques in different scale. The microstructure tomography may solve this problem. It is based on the nano scale serial sectioning of the volume of interest by the focused ion beam (FIB) and offers a nano scale resolution in x-y-z and at the same time a statistically relevant field of view size up to about (100x100x100)μm^3. For the serial imaging procedure the variety of well established SEM contrasts (namely SE contrast for morphology, EDS contrast for chemistry [1], EBSD contrast for phase composition, grain shape, size and orientation and more qualitatively, even stress and strain [2]) is available. Consequently, microstructure tomography also includes the ultimate resolution of atom probe tomography with "serial extraction" of individual atoms and their quantitative chemical analysis.

It will be demonstrated, that 3D images analysis has essential advantages in comparison with stereology and statistical analysis from 2D analysis [3,6], particularly in the case of complex microstructures and local arrangements. After imaging and 3D reconstruction procedures, a detailed 3D image analysis enables the comprehensive quantitative evaluation of local microstructure evolution as well as degradation effects in different scale. Once the microstructure is quantitatively known, also the detailed volume simulation of local effective properties such as for instance stiffness and thermal as well as electrical conductivity becomes possible [4]. Using the example of local electro-erosion by discharge phenomena in silver based contact materials, the combination of microstructure tomography with modern 3D analysis and simulation techniques provides new prospects for precise target preparation and understanding of local microstructure formation and load effects (Fig. 2) [5]. The presentation gives an overview of these new possibilities and its useful combination in Materials Science.

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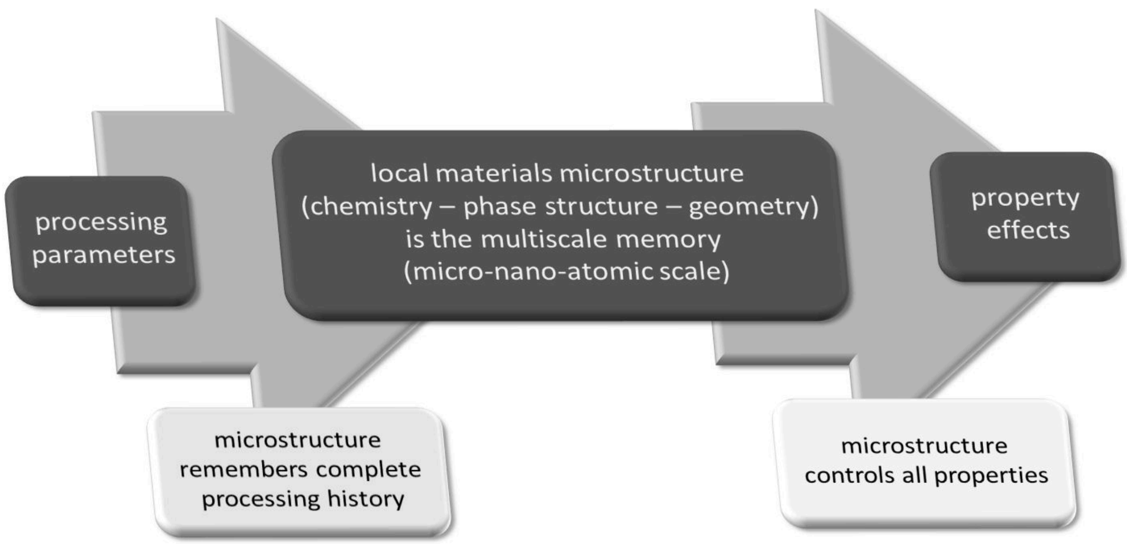
FIG. 1. Materials microstructure is a multi scale memory of all materials processing and fully



controls the properties. Multiscale 3D microstructure analysis in the micro, nano and atomic scale enables complete read-out of this memory

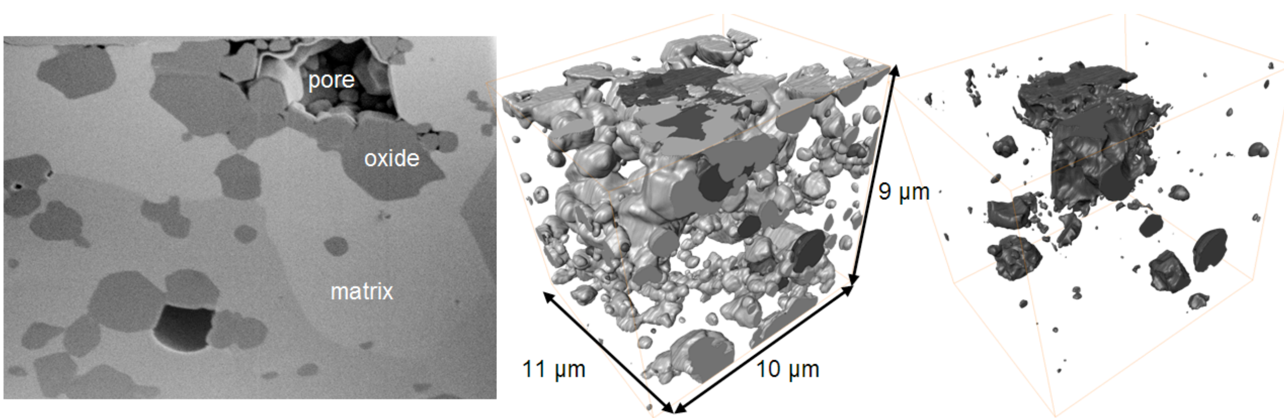


FIG. 2. Silver-based contact material after electrical discharge (electro-erosion). FIB cross section (left), reconstruction of oxides (middle) and pores (right)

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