doi:10.1017/S1431927622002653
Microsc. Microanal. 28 (Suppl 1), 2022

Using 3D Reconstruction Technique Along with Monte Carlo Modelling for Quantitative Characterizations of Fracture Surface of Monel Alloy

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Quantitative microanalysis of rough surfaces is difficult in the scanning electron microscope. Although X-Ray microanalysis can be a useful tool for preliminary characterization, it is not quantitative because the complicated geometry of the rough surface introduces problems that are not present in the current models of quantitative microanalysis of a flat sample. The problem with the quantitative microanalysis of rough surfaces is that electrons can be scattered from all sides due to different slopes on the surface, so the generated x-rays depend on the roughness. Moreover, the orientation of slopes makes it difficult to correctly consider the path of characteristic x-rays between their generation locations and the surface [1, 2] making difficult to compute an absorption correction. Therefore, the geometry of the rough surface impacts the measured x-ray intensities and thereby the quantitative analysis of the sample. We propose to measure the geometrical information of the rough surface in the electron microscope and to compute X-Ray detection from the measured rough surface with Monte Carlo simulation to overcome this problem.

In this work, we present preliminary results using a fracture surface of a Monel alloy (69%Ni-29%Cu-1%Fe-1%Mn, C, and Si). The 3D reconstruction of the rough surface was obtained using backscattered electron (BSE) images via the 4-Quadrant backscatter detector [3]. The existing Monte Carlo software MC X-ray [4] was incorporated into the image processing software Dragonfly developed by Object Research Systems (ORS) Inc [5]. The incorporation of the MC X-ray in Dragonfly allows users to do Monte Carlo simulation for any complicated geometry.

Figure 1 shows SE, BSE images and EDS map of Ni Kα and Cu Kα of the fracture surface (Monel alloy) acquired with the Hitachi SU-3500 Electron Microscope equipped with an Oxford X-MAX SDD EDS detector. As it can be seen, the roughness of the fracture surface (for example the shadowing parts in the EDS maps for Ni and Cu) does not allow some X-Ray signals to reach the EDS detector, and this matter makes problems in quantitative characterization of fracture surfaces. Figure 2 displays simulation data of the same surface used in Figure 1. There is an excellent qualitative agreement between experimental data and Monte Carlo simulation. Table 1 lists the ratio of net X-Ray intensity of Ni and Cu measured with experimental analysis and the Monte Carlo simulation. A good agreement is observed with data obtained from the simulation for the overall intensity. More results from various fracture surfaces will be presented.

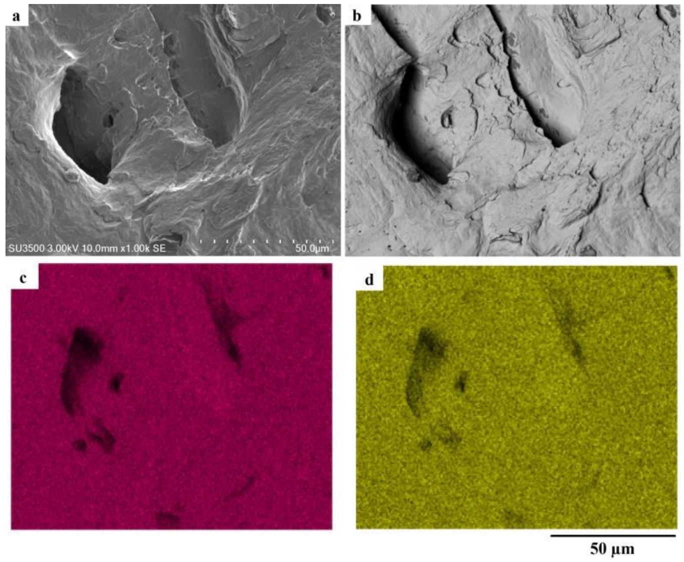

Figure 1. SE, BSE images, and EDS maps for the fracture surface of Monel alloy, a) SE, b) BSE, c) EDS map Ni Kα, and d) EDS map Cu Kα.

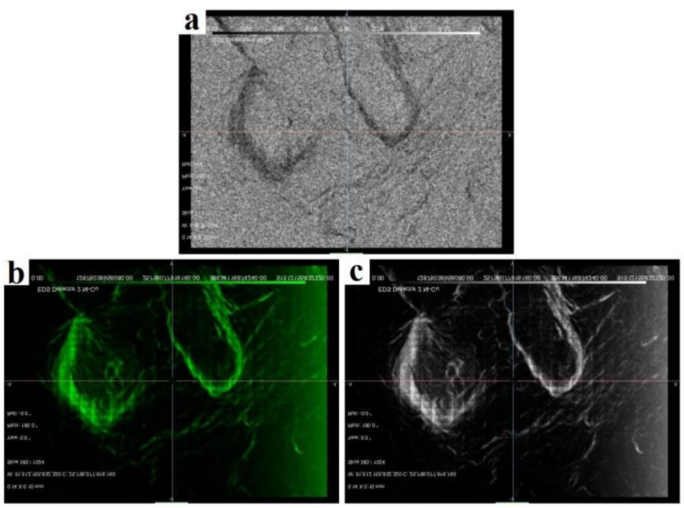

Figure 2. Simulation data for the same surface used in Figure 1, a) BSE image, b) EDS map Ni Kα, and c) EDS map Cu Kα.

Method	**Net X-Ray Intensity Ratio**
	I_{Ni}/I_{Cu}
Experimental EDS Map	0.409
Monte Carlo Simulation	0.419

https://doi.org/10.1017/S1431927622002653 Published online by Cambridge University Press

Table 1. Comparison of the ratio of the net X-Ray intensity (I_{Ni}/I_{Cu}) for experimental EDS map and Monte Carlo Simulation.

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https://doi.org/10.1017/S1431927622002653 Published online by Cambridge University Press