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Polymer Penetration of Nanoporous Aluminum Anodic Layers – Analytical cryoTEM and Electron Tomography Analysis in Corrosion Protection

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Corrosion protection of aluminum is essential for applications in the aircraft and automotive industry. Anodisation of aluminum with chromic acid has been successfully used to generate thick, porous oxide layers, which exhibit good long-term stability with organic coatings such as paint systems or adhesives. However, due to environmental and health reasons, the chromium (VI) containing anodisation processes traditionally used for corrosion protection have to be replaced by environmentally friendly alternatives. [1]
An important aspect of the anodisation layer is its porosity and interaction with the organic coating. The organic coating must penetrate the pores of the oxide to enable a good mechanical interlock between the coating and the substrate. In addition, the organic coating also needs to fill the pores to prevent diffusion of water into the pores, which would weaken the oxide layer.
We used a combination of cryo energy filtered imaging (EFTEM) and semi-quantitative cryo STEM-EDX analysis (Figure 1a) to image the distribution of the organic coating within nanoporous anodisation layers prepared by different chromate free processes. Furthermore, electron tomography was used to characterize some of the complex nanoporous networks, which revealed significant differences in pore connectivity. However, independent of the main pore orientation, we could show by cryo STEM-EDX that the organic coating penetrates the pores down to the interface with the aluminum substrate resulting in a strong mechanical interlock. Nevertheless, electro tomography revealed a few small voids in the filled anodic layer indicating that the filling might not be complete (Figure 1).

References

[1] S. Dieckhoff et al., *Corrosion Review*, *25* (2007), 523-531.

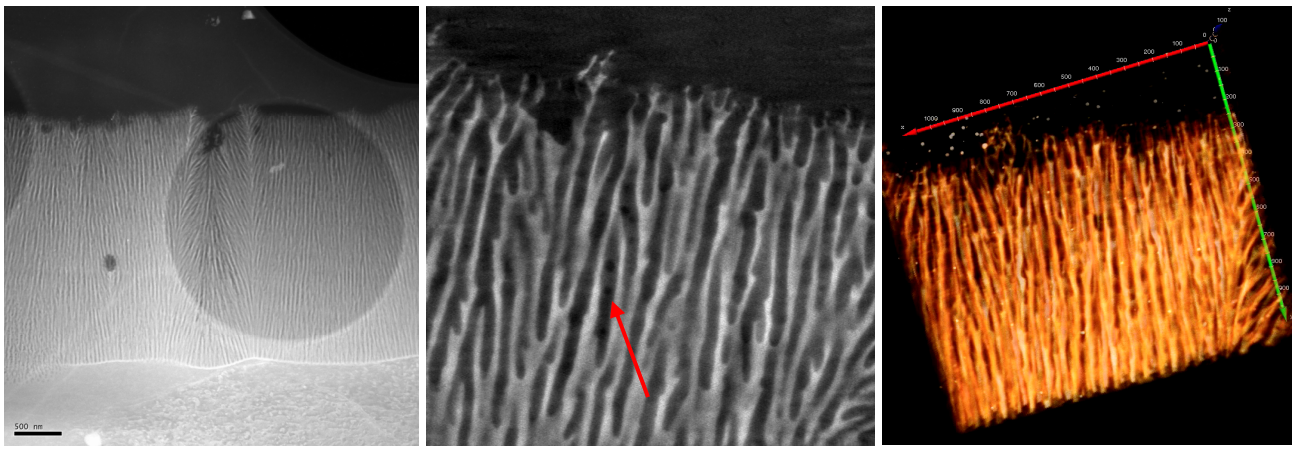

FIG. 1. (a) Cryo HAADF-STEM image of a primer filled anodic layer, (b/c) digital slice and volume rendering of a tomographic reconstruction of the top of an anodic layer. Small voids are visible in primer filled pores.

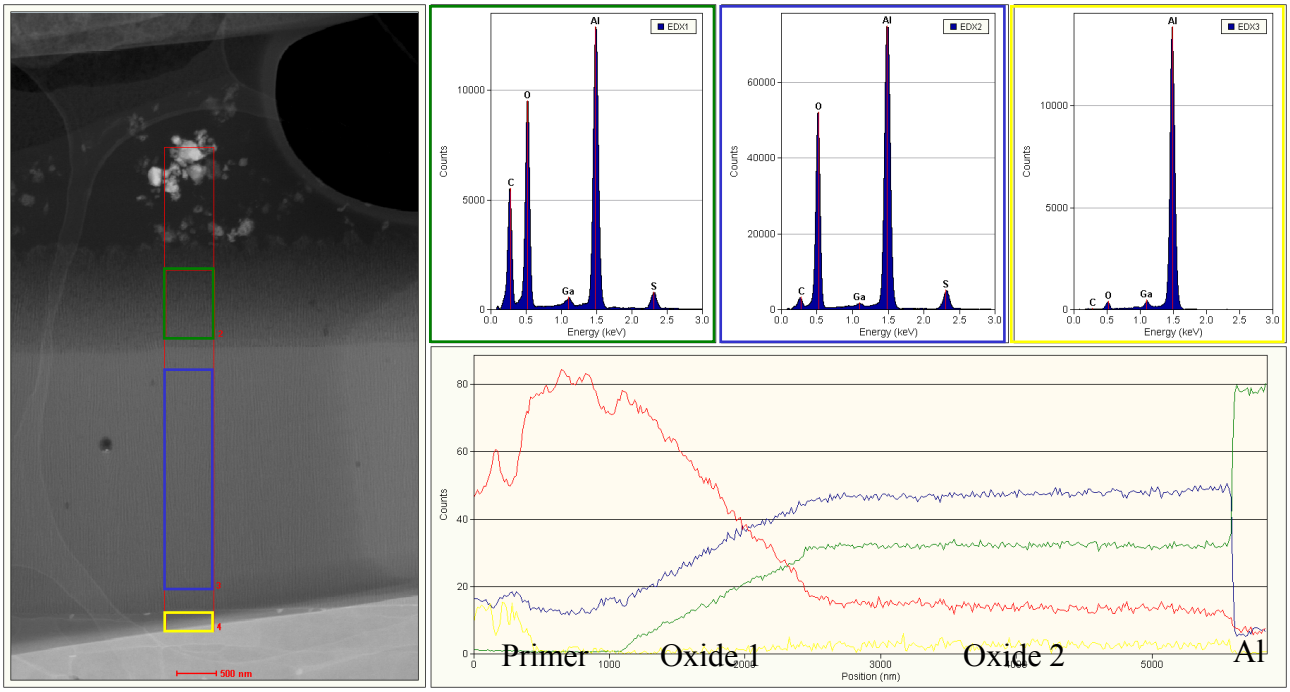

FIG. 2. Semi-quantitative cryo STEM-EDX profile of the elemental composition across the primer filled anodic layer.

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