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Effect of grain boundary character and network of special boundaries on the thermal stability of electrodeposited nickel layers

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Recent improvements in understanding both the growth of electrodeposited layers and the kinetics of post-deposition microstructure evolution allow tailoring the internal structure of electrodeposited metals for advanced applications. Grain refinement on the nanoscale to gain mechanical strengthening has been applied in the past decades; however, sole grain refinement is detrimental for the thermal stability of the material. Manipulation of the grain boundary characteristics has drawn particular attention as a viable method for enhancing mechanical properties without deteriorating thermal stability. It has been shown that electrodeposits comprising a high density of special boundaries (in particular, coherent twin boundaries) have superior mechanical properties and are more thermally stable compared to their nanocrystalline counterparts. Thus, understanding the underlying mechanism of twin formation and their influence on thermal stability is of particular scientific interest and of importance for advanced applications of electrodeposits.

Very often, the microstructure and preferred orientation of electrodeposited layers evolves with the layer thickness. Thus, top-view electron backscatter diffraction (EBSD) analysis which does not require dedicated sample preparation, does not provide the full characteristics of the microstructure. Hence, it is crucial to investigate the microstructure over the entire layer thickness, in spite of difficulties of the sample preparation.

In this work, electrodeposited nickel layers, which have to meet high demands on mechanical and thermal stability, are investigated. By rigorous control of the electrodeposition parameters, the preferred crystallographic orientation, the grain boundary character and the network of special boundaries are deliberately tailored. EBSD analysis on cross-sections of the as-deposited layers and after thermal treatment at various temperatures is applied. Based on the obtained results possible mechanisms for the formation of twins in the as-deposited state are discussed. Moreover, it is demonstrated that the grain boundary character including the network of special boundaries have a pronounced influence on the thermal stability of the as-deposited microstructure.