Summary

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Aluminium is the second most used metal by weight after iron, and aluminium alloys are some of the most important structural light alloys. Motivated by reducing weight, energy, and cost, many manufacturers are replacing steel with aluminium alloys. For example, more and more automotive exterior panels are now made of aluminium alloyed with magnesium and silicon, and most beverage can bodies are made of aluminium alloyed with magnesium and manganese. We can control the strength, formability, and other mechanical properties of these alloys by selecting a combination of alloying additions and work hardening and annealing processes. For example, industrial drawing of beverage can bodies from thin rolled sheets requires strict control of the sheets' microstructure during processing. It follows that a good understanding of microstructural changes during this thermomechanical processing is key to achieving desired properties.

The microstructure is here described by the crystalline aluminium grains and their non-random orientations, known as texture, and particles rich in alloying elements. At elevated temperatures, a deformed microstructure, such as in rolled sheets, may undergo a drastic transformation from smaller (sub-micron) strained subgrains to larger strain-free grains. This complex transformation is called recrystallization, or softening. Larger particles generally promote recrystallization by stimulating nucleation, while smaller dispersoids may pin (sub)grain boundaries to slow down or even stop the transformation.

The main result of this work is a quantitative study of surprising textures during the softening of a supersaturated aluminium-manganese alloy affected by simultaneous precipitation of dispersoids. The nucleation and growth advantages of the dominant texture components in the presence of particles are quantified. This study confirms earlier observations of orientation-dependent pinning by dispersoids but brings the analysis on a quantitative footing. Importantly, we present dispersoid pinning pressures as a function of texture component.

The analysis needs correlation of particle locations and (sub)grain orientations. We use the scanning electron microscope to investigate these features separately. The particle and orientation datasets are afterwards correlated in a multimodal data fusion routine. Crystal phases and orientations are characterized by electron backscatter diffraction indexing using pattern matching with dynamical simulations. An open-source Python software for the analysis of electron backscatter patterns named kikuchipy is developed. The software is built with an emphasis on a flexible and iterable indexing workflow. Its capabilities are demonstrated in three application examples: analysis of orientation relationships in a super duplex stainless steel, phase differentiation of aluminium and silicon in a cast, modified aluminium-silicon alloy, and phase differentiation of particles in the aluminium-manganese alloy.

Overall, this work bolsters the materials scientist toolbox of quantitative methods for the characterization of structural materials.