Investigation of Recrystallization Processes in an AA6016 Aluminum Alloy - *in situ* Electron Backscatter Diffraction optimized for Annealing at constant Heating Rates

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Introduction

The study of recrystallization processes is central to understanding material properties after thermomechanical treatment. While *in situ* electron backscatter diffraction (EBSD) has been successfully used for recrystallization characterization for some time [1,2], the conventional approach is to use isothermal annealing or stepwise heating. In this work, a method for *in situ* EBSD using continuous heating at a constant rate is presented. The method is based on optimized acquisition parameters and an improved strategy for evaluating the in situ EBSD scans. Here, the capabilities of the method are demonstrated in recrystallization studies of a cold rolled AA6016 aluminum alloy.

Experimental

The EBSD measurements were conducted on a Zeiss Ultra 55 equipped with a Thorlabs Fast Frame Rate Scientific camera and the OIM DC V7.3.1 software. For in situ heating the CH0-4 heating stage from Kammrath & Weiss was used.

Recrystallization shows a very fast transformation in a short temperature interval. Therefore, fast EBSD scans are required to capture the process. Fig. 1 shows the effects of EBSD exposure time when recording the microstructure of cold rolled aluminum alloys in the deformed state (a, b) and in the partially recrystallized state (c). Deformed grains cannot be recorded at low exposure times, while recrystallized grains are well recorded at low exposure times (i.e., fast scans).

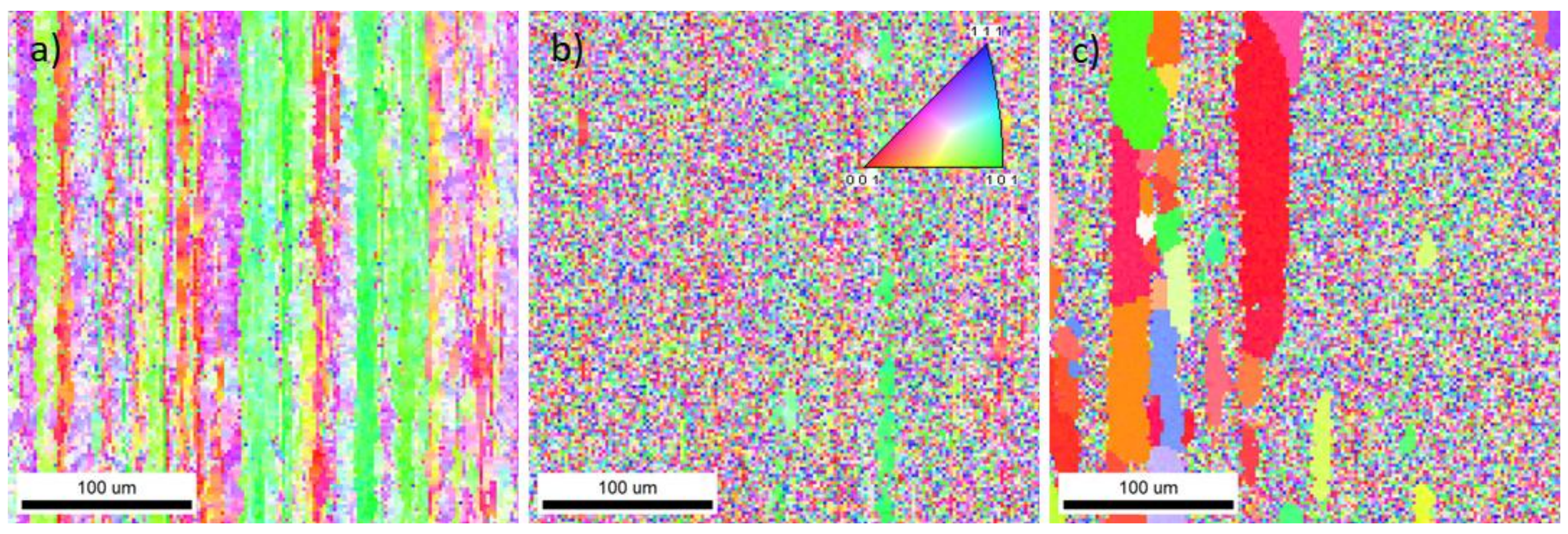

Fig. 1: Influence of exposure time on the EBSD scan: a) t_e = 20 ms; b) t_e = 2.5 ms; c) t_e = 2.5 ms

Results and Discussion (1)

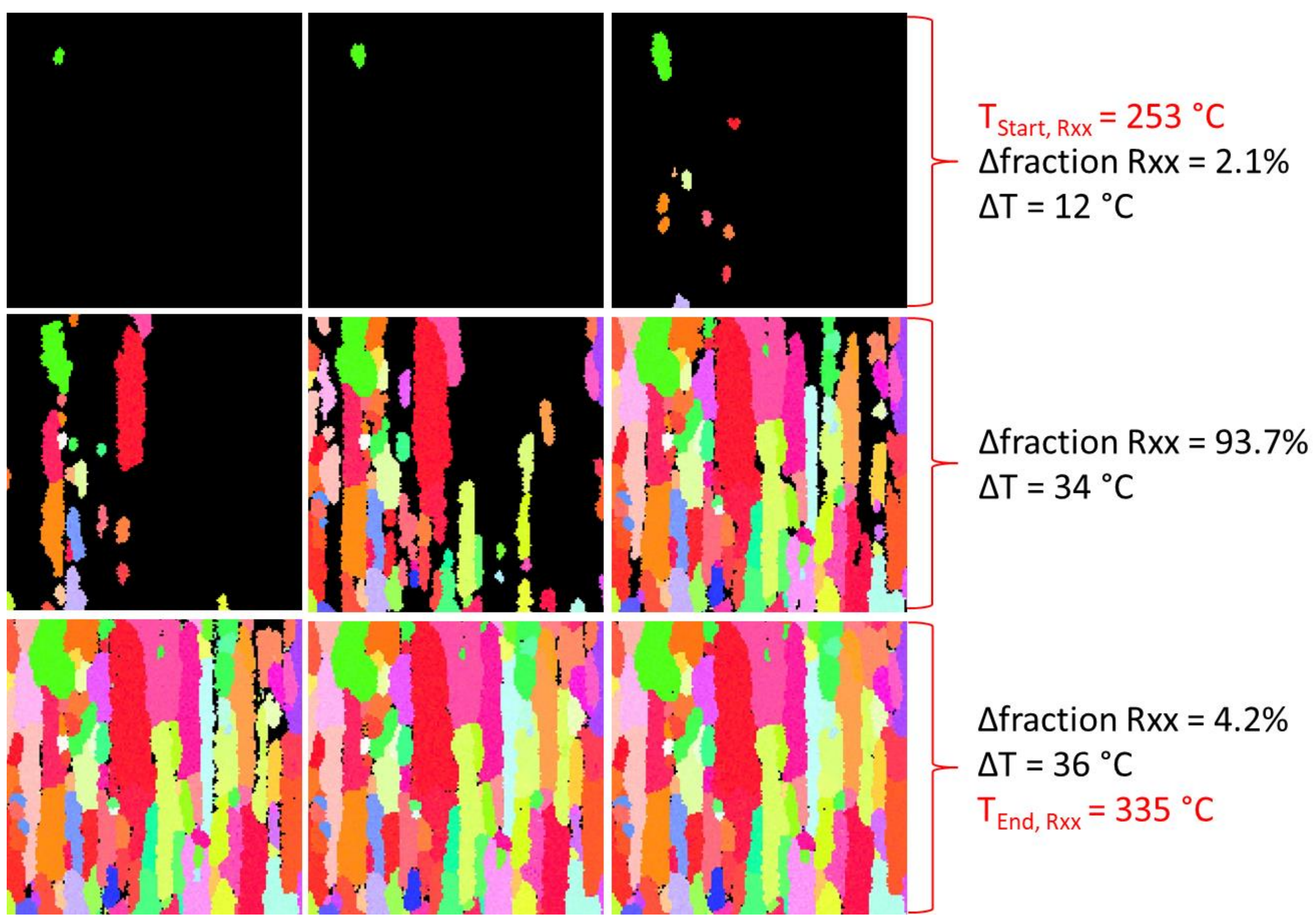

Fig. 2: Evolution of recrystallization during heating with 4 K/min.

Results and Discussion (2)

The evolution of recrystallization during annealing at 4 K/min is shown in Fig. 2. From the *in situ* EBSD maps, the so-called Avrami curves (Fig. 3) were extracted for different heating rates. While the curves for 1, 4 and 7 K/min follow the expected behavior, the recrystallization at 10 K/min takes place at too low temperatures. One explanation for this is concurrent precipitation (Fig. 4) that occurs in parallel with the recrystallization process. When heated at 10 K/min, the Mg_2Si precipitates preferentially form at the grain boundaries, i.e., recrystallization precedes precipitation. Therefore, the precipitates are not an obstacle for newly formed grains (low Zener drag). Annealing at 1 K/min gives an opposite picture.

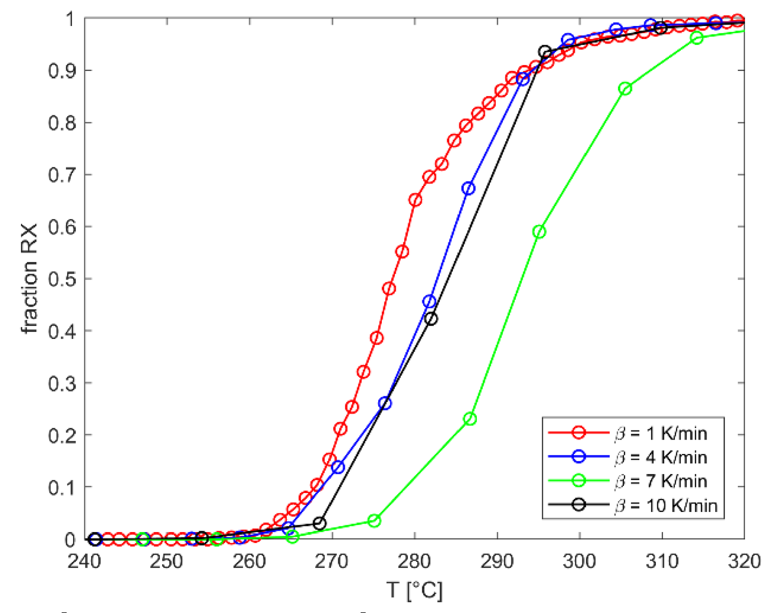

Fig. 2: Avrami curves

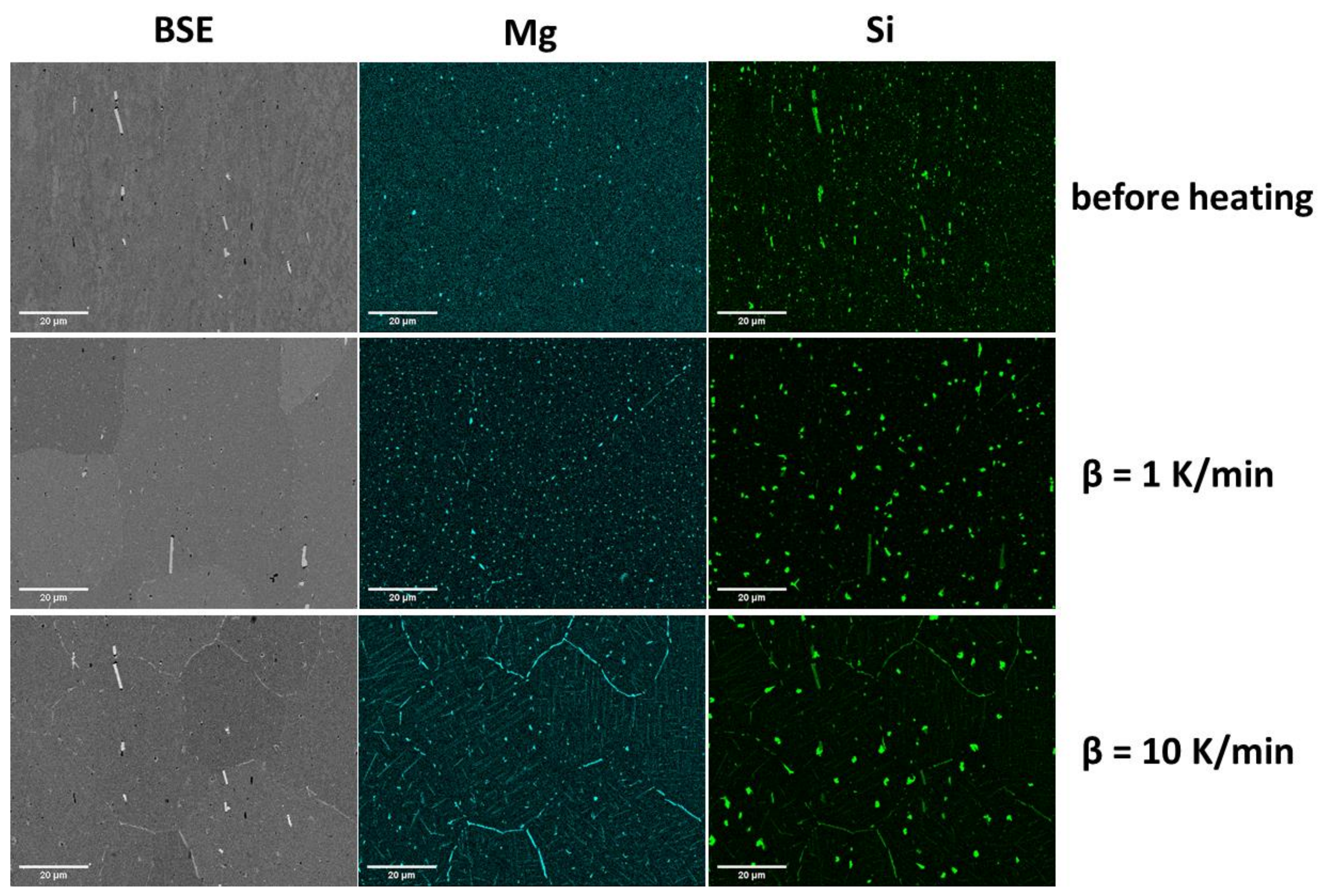

Fig. 4: Precipitation characterization with BSE, Mg K EDX element maps and Si K EDX element maps for different annealing states.

References/ Literature

[1] F. J. Humphreys et al., Texture, Stress, and Microstructure, vol. 26, pp. 281-301, 1970
[2] A. Helbert et al., Advanced Engineering Materials, vol. 14, no. 1-2, pp. 39-44. 2012

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