Nucleation mechanisms leading to different recrystallization textures in ferritic ultra-low carbon steels in relation to the prior deformation substructure.

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Abstract

This work investigates the recrystallization-texture formation during annealing for differently deformed microstructures, obtained from high resolution electron backscatter diffraction (EBSD) maps. Starting from cold-rolled interstitial-free (IF) steel, we increase the deformation temperature to 550 (IF steel), and 900 (Fe-Si) steel. These temperatures of rolling are well-known to affect the crystallographic texture during subsequent annealing, leading to the industrially suitable / desired microstructural outcome, e.g. {001}< 010> (cube) texture in electromagnetic applications resp. < 111> // normal direction (ND) orientations in deep-drawing applications. Nevertheless, the reasons associated with the preferential growth of specific orientations during the early stages of recrystallization, in relation to the prior deformed substructure, remain unclear, especially due to the latter entailing thousands of subgrains that may potentially nucleate in favorable microstructural / deformation conditions. Following the theory of subgrain formation and competitive capillary-driven grain- and subgrain-growth, we simulate recrystallization by means of discontinuous / abnormal subgrain coarsening, in a full-field cellular automaton description of the microstructure. Considering recrystallization nucleation, a topological or kinetic advantage of certain subgrains does not only pertain to their initial status in comparison to the surrounding microstructure (i.e. nucleation is not imposed), but is actually revealed as it is simulated naturally throughout its continuous competitive growth within its continuously changing microstructural neighbourhood (e.g. adjacent recrystallized volumes, large subgrains being still intact, etc.). Thus, we extract the simulated recrystallized grains and study their preferential nucleation. The discussions involve: (a) establishing for each texture component (e.g. fibres < 111> //ND, < 100> //ND, as well as of specific orientations (e.g. {110}< 001> , and {311}< 136> - {411}< 148>) the dominant nucleation mechanism, and (b) comparing the occurrence / competition of these mechanisms (including in-grain discontinuous subgrain growth, in-grain shear band nucleation, bulging at flat grain boundaries, bulging at triple junctions) to explain the overall texture formation trends in the differently deformed materials.

Keywords: recrystallization, nucleation, texture, full, field modeling, steel

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