Supplementary Materials

Deep learning-enhanced cellular automaton framework for modeling static recrystallization behavior

Yulong Zhu[1,2], Yu Cao[2,*], Boyang Xu[1], Jieke Zhang[2], Qubo He[3,4], Rui Luo[5,6], Xuhong Jia[1,7], Quanyi Liu[1,7], Ziyong Hou[2,8]

[1]College of Civil Aviation Safety Engineering, Civil Aviation Flight University of China, Guanghan 618307, Sichuan, China.
[2]College of Materials Science and Engineering, Chongqing University, Chongqing 400044, China.
[3]Chongqing Materials Research Institute Co., Ltd, Chongqing 400707, China.
[4]National Engineering Research Center for Instrument Functional Materials, Chongqing 400707, China.
[5]School of Materials Science and Engineering, Jiangsu University, Zhenjiang 212013, Jiangsu, China.
[6]State Key Laboratory of Mechanical Transmission for Advanced Equipment, Chongqing University, Chongqing 400044, China.
[7]Civil Aircraft Fire Science and Safety Engineering Key Laboratory of Sichuan Province, Civil Aviation Flight University of China, Guanghan 618307, Sichuan, China.
[8]State Key Laboratory of Mechanical Transmission for Advanced Equipment, Chongqing University, Chongqing 400044, China.

[*]**Correspondence to:** Prof. Yu Cao, College of Materials Science and Engineering, Chongqing University, Chongqing 400044, China. E-mail: yucao928@cqu.edu.cn

MATERIALS AND METHODS

The as-received INCOLOY alloy 925, with a chemical composition of 42.4Ni-28.08Fe-21.42Cr-2.8Mo-2.24Cu-2.16Ti-0.5Al-0.34Si-0.05P-0.01C (wt.%), was first solution-annealed at 1,100 °C for two hours, followed by water quenching to obtain a homogeneous microstructure. The rod was then cut into small strips with dimensions of 50 mm × 16 mm × 4 mm as the base material (BM). Afterward, the BM samples were cold rolled with the height reductions of 5%, 7%, 10%, 15% and 20%, after which the plates were annealed at 1,050, 1,075, and 1,100 °C for one hour and then quenched in water.

Deformed and annealed samples were cut to obtain a cross-section parallel to the RD-ND surface for optical microscopy and electron backscattered diffraction (EBSD) analysis. The metallographic observation was conducted on an Axiovert 200 MAT Zeiss optical microscope. The EBSD samples were electrolytically polished using a reagent composed of 90 mL sulfuric acid and 10 mL hydrofluoric acid. Afterward, the EBSD tests were performed on a TESCAN MIRA3 scanning electron microscope (SEM) equipped with an HKL-EBSD system with an accelerating voltage of 20 kV and a work distance of 12 mm. It is worth noting that the EBSD scanning step size was uniformly set to 1 μm. On the one hand, a larger step size is suitable for materials with relatively large grain sizes, allowing for improved scanning efficiency. On the other hand, it aligns with the cell size used in the subsequent cellular automaton model. The calibration rate of each EBSD mapping was higher than 95%. Finally, MATLAB and the corresponding MTEX toolbox were used in the picture rendering and data analysis. In addition, a self-written MATLAB program was introduced to learn the grain characteristics and dislocation distribution based on machine learning.