Effect of scanning strategy on the texture of Fe-3.5%Si electrical steel processed by laser powder bed fusion

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Abstract

Grain-oriented (GO) Fe-Si electrical steels are soft magnetic materials with applications in the manufacture of high-permeability electric motors and transformers. The conventional processing route consists of hot rolling followed by intermediate annealing, cold rolling to small thicknesses to minimize hysteretic losses, and box annealing under a hydrogen atmosphere for long periods to promote abnormal grain growth. Fe-3.5%Si parallelepipedal blocks (35 x 6 x 70 mm^3) were processed by laser powder bed fusion (LPBF) using three different scanning strategies to yield different as-built microstructures and textures. Strategies varied the rotation angle of the scan vector between layers from 0^o to 90^o. A nominal laser power of 200 W, a hatch distance of 100 μm, a scan speed of 1000 mm/s and a layer thickness of 30 μm were the main process parameters. Dislocation structures can be visualized throughout the microstructure of as-built samples and consist of free dislocations, dislocation tangles and subgrain boundaries. Following, the as-built slabs were cold-rolled down to about 90% thickness reduction in multiple passes and annealed for 4 hours at 800^oC and 1200^oC to investigate primary recrystallization and abnormal grain growth behaviors, respectively. The build direction (BD) was made parallel to the rolling direction (RD) during thermomechanical processing. Texture was determined by electron backscatter diffraction. The as-built microstructures consist of coarse grains that grow parallel to the BD. The as-built texture depends on the adopted strategy, varying from cube ({001}<001>) to Goss ({011}<001>). The scanning strategy influences both rolling and recrystallization textures as well as the abnormal grain growth behavior.

Keywords: Fe-Si electrical steels; laser powder bed fusion; additive manufacturing; crystallographic texture; abnormal grain growth