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Age-hardening behavior of an Al-Mn-Mg-Sc-Zr alloy subsequent to additive manufacturing and cold working

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Laser powder bed fusion (LPBF) exhibits enormous benefits for precipitation-strengthening Al alloys by significant supersaturation and the formation very fine microstructures during manufacturing. This has led to the development of several new alloys mainly containing Sc and Zr to form L12 precipitates and Mg and Mn to further increase solid solution strengthening [1,2,3]. The L12 precipitates exhibit exceptional thermal stability and provide excellent creep resistant of these alloys at 250 °C [4]. In this work, we investigate the precipitation behavior and resulting properties of an Al-Mn-Mg-Sc-Zr alloy after introducing additional vacancies and dislocations by cold working and how these additional defects influence the thermal stability of the precipitates. For this, the LPBF processed alloy was swaged at room temperature to a true strain of 2.5. Compared to the LPBF alloy, swaging results in a refinement of the microstructure by one order of magnitude and an increased hardness and ultimate tensile strength (UTS of 705 vs. 430 MPa) which is mainly attributed to the finer microstructure and higher dislocation density in the swaged alloy. By annealing, a higher peak-aging hardness and UTS of the swaged alloy at a lower peak-aging temperature in the swaged was obtained (UTS of 720 MPa at 300

°C vs. 570 MPa at 360 °C). Significant improvement of ductility of the swaged alloy is obtained for intermediate annealing between 300 to 400 °C while strength is only moderately affected (e.g. UTS of 590 MPa at 2 % strain to failure). This significant improvement of aging kinetics is discussed alongside intense microstructural characterization of the heterogeneous grain structure and precipitate distribution.

Keywords: Al-Sc alloy, additive manufacturing, cold working, age-hardening behavior.

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