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Characterization of T8 Tempered Al-Li-Cu alloy (AA2195) by Using AC- STEM

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Al-alloys are excellent materials for aerospace applications because they exhibit high strength, low density, good corrosion resistance, and high fracture toughness at cryogenic temperatures. There are a number of tempering recipes that are available for improving the desired properties of these alloys namely T4, T6, and T8. However, the T8 tempered Al-alloys are particularly found to be superior in terms of their mechanical properties and weldability [1]. In this paper, we present a study on the determination of phases as well as strains around those phases in a T8 tempered Al-Li-Cu alloy by using aberration corrected scanning transmission electron microscopy (AC-STEM) analysis. Complete details on T8 tempering and alloy composition are available in Ref. [2]. AC-STEM analysis was carried out by operating a probe-corrected Titan 80-300 ST instrument at an accelerating voltage of 300 kV. Moreover, high-angle annular dark-field (HAADF) detector was employed to generate DF-STEM as well as high-resolution STEM (HR-STEM) images of AA2195 alloy. Geometrical phase analysis (GPA) was also applied to several HAADF-STEM images for determining the strain fields around the phases present in the Al-matrix [3].

Figure 1 contains the results, which are compiled by utilizing bright-field TEM (BF-TEM) and DF-STEM techniques. Both the BF-TEM image and the corresponding [110] zone-axis (ZA) selected electron diffraction (SAED) pattern reveal the presence of platelet shape (T1 phase along {111} planes and θ' along {002} planes) and spherical shape (β' phase) in the Al-matrix. However, the "dynamical diffraction contrast" in BF-TEM image makes difficult to visualize β' phase. Owing to the removal of such diffraction effects in HAADF-STEM images, the contrast from both platelet and spherical shapes precipitates in Figure 1C becomes far superior than that of BF-TEM image in Figure 1A. By the same token, the HR-STEM image in Figure 1D is free of lens-focusing effects and hence enabling a direct interpretation of atom contrast in HR-STEM images [4]. This is why the application of GPA to the HR-STEM images is considered more suitable than that of HRTEM images. Figure 2 contains HR-STEM images of three representative phases which were selected for investigating the strain in their vicinity by employing GPA. It can be noticed from Figure 2, true for all precipitates, the strain along x-axis (<002> direction) is of tensile nature while it is compressive along the y-axis (<-220> direction). Whereas the strain within β' phase is uniform because no dislocations were present implying an enhancement in the mechanical strength of the alloy [5]. In summary, the presented results prove that the STEM-analysis leads to superior quality investigations on the structural and mechanical properties of metal alloys. It can also achieve the same high quality results on the other properties such as composition (e.g. the direct imaging of Li atoms in T1 phase).

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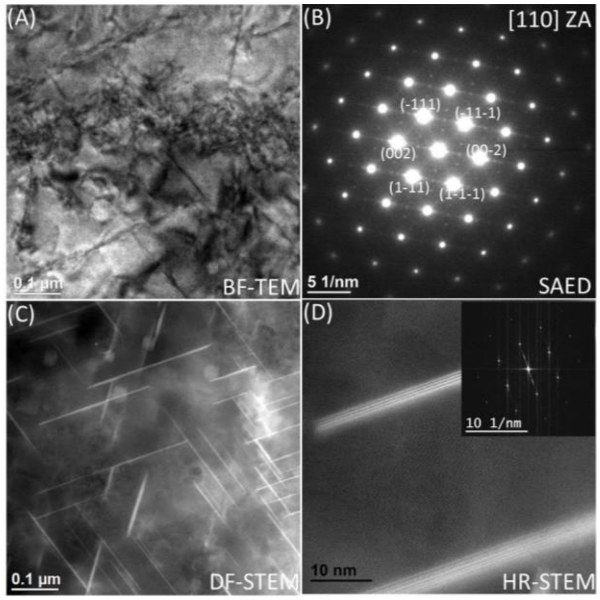

Figure 1. TEM analysis of T8 tempered Al-Li-Cu (AA2195) alloy. (A) BF-TEM images acquired in [110] ZA of Al matrix. (B) SAED pattern of [110] ZA demonstrating the reflections from the lattices of both Al and phases. (C) DF-STEM image shows an improved contrast from T1, θ’, and other phases. (D) HR-STEM along with its corresponding calculated Fast-Fourier Transform (FFT) reveals structural details on Al-phases interfaces.

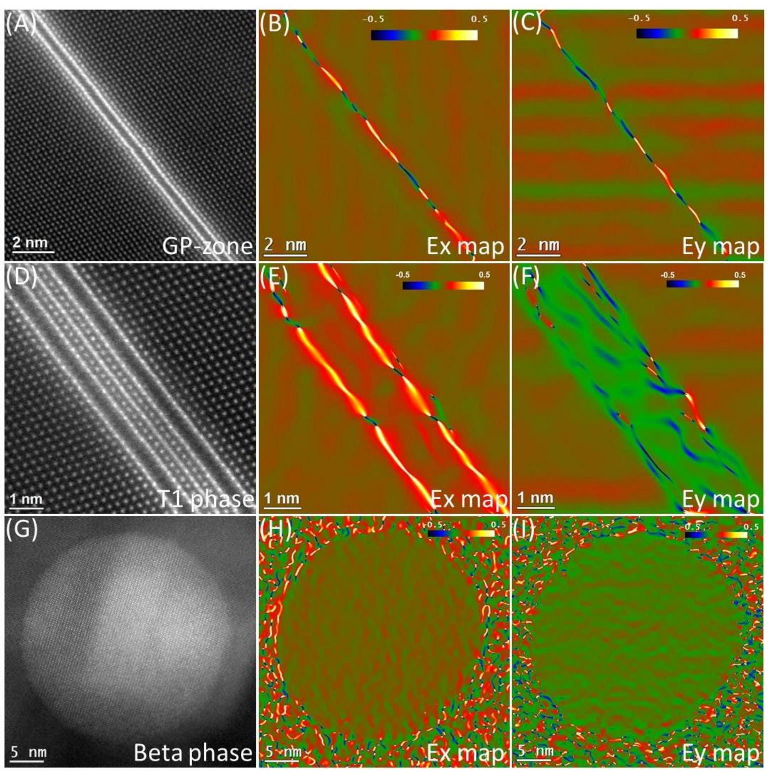

Figure 2. GPA analysis applied to HR-STEM images for the determination of strains around the phases in Al-Li-Cu alloy. (A-C) Strain analysis of a GP zone which is lying on the (1-11) matrix-plane. (D-F) Strain analysis of a T1 platelet which is also lying on the (1-11) matrix-plane. (G-I) Strain analysis of a β’-phase.

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