Characterisation of precipitates in a Friction Stir-Welded AA2098-T351 alloy

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Friction Stir Welding (FSW) is a solid-state joining process that was developed as an alternative for conventional welding process and found appropriate for welding Aluminium alloys. FSW is performed by inserting a non-consumable rotational tool with a pin and shoulder along the material's joint line and weld the two sides together. Due to the intense plastic deformation and high temperatures from the stirring process, the welded surfaces form microstructurally different regions such as Stir Zone (SZ), Heat Affected Zone (HAZ), Thermo-Mechanically Affected Zone (TMAZ), and Base Metal (BM). Understanding the local precipitation sequence in these regions is very important for determining the mechanical and corrosion properties of the welded joints.

In the present work, using Selected Area Electron Diffraction (SAED) primarily, the distribution of precipitate phases in a complex third-generation Al-Li alloy AA2098-T351 welded by FSW was investigated [1]. In the BM region of the alloy wide variety of precipitates (T_1, θ', δ'/β', Ω) can be observed. In [110] zone axis (Figure-1a), due to almost similar morphologies (formed as thin plates on {111} habit planes of Al matrix) and having same lattice parameter in one direction (a = 0.496 nm), differentiating T_1 and Ω phases is quite difficult. However, due to small differences in the position of spots of [112] zone axis, it is possible to identify them. T_1 phase precipitates being a 4-layered structure, in [110] orientation two variants produce superlattice spots at 1/3, 2/3 of <220> and other two variants appear as continuous streaks along <111>. Streaks along <001> indicated the presence of θ' precipitates and in [110] zone axis they coincide with the spots from δ'/β' precipitates. In such situations, other low index orientations such as [100] or [112] can demonstrate a subtle difference between θ' and δ'/β' precipitates.

With the changes in the temperature across the different regions of FSW, the precipitate formation is also varied. δ'/β' precipitates were observed in all FSW regions while θ' precipitation was limited only for BM region. Other than in TMAZ region, Ω precipitates were found in BM, HAZ and SZ regions. T_1, the prominent strengthening precipitate phase in Al-Cu-Li alloys was perceived in all regions except TMAZ-Advancing side (Figure-2e). Although T_1 is observed in all FSW regions, from the TEM Bright field images (Figure-2), it is qualitatively apparent that there is a significant change in precipitate distribution and density.

References

[1] Mariana X. Milagre; Vishnu Mogili; Uyime Donatus; Rafael A.R. Giorjão, Maysa Terada,

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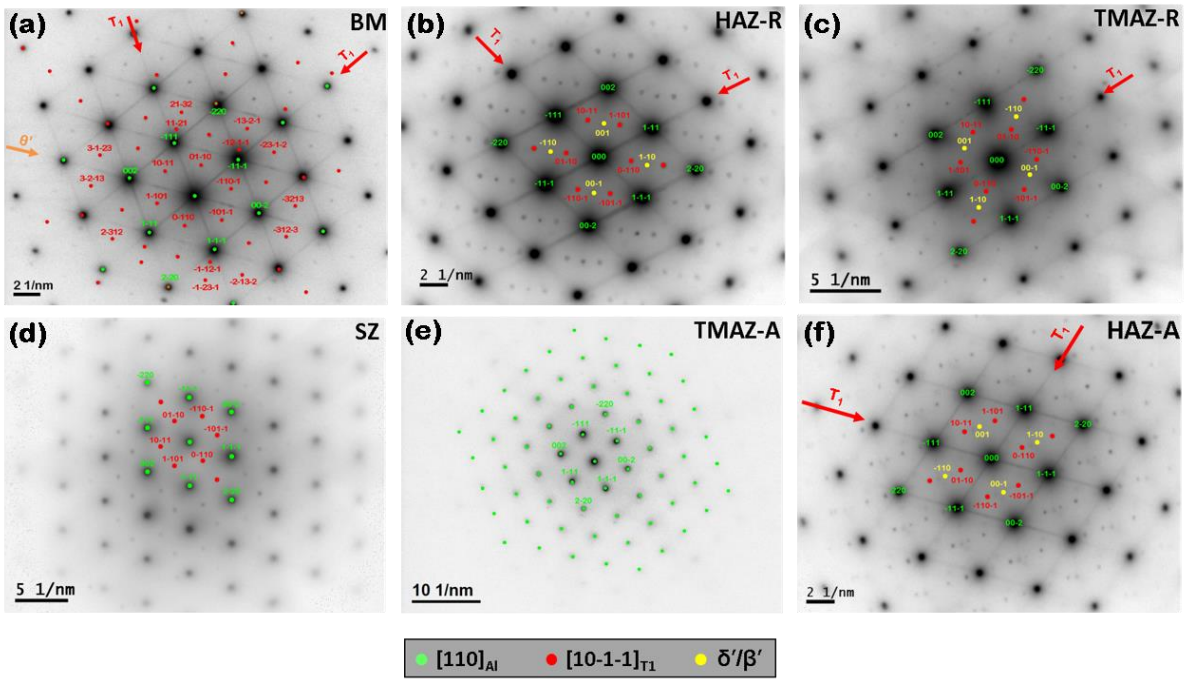

Figure: (1) SAED patterns obtained in [110] zone axis orientation of various microstructurally different regions of Friction Stir Welded AA2098 alloy

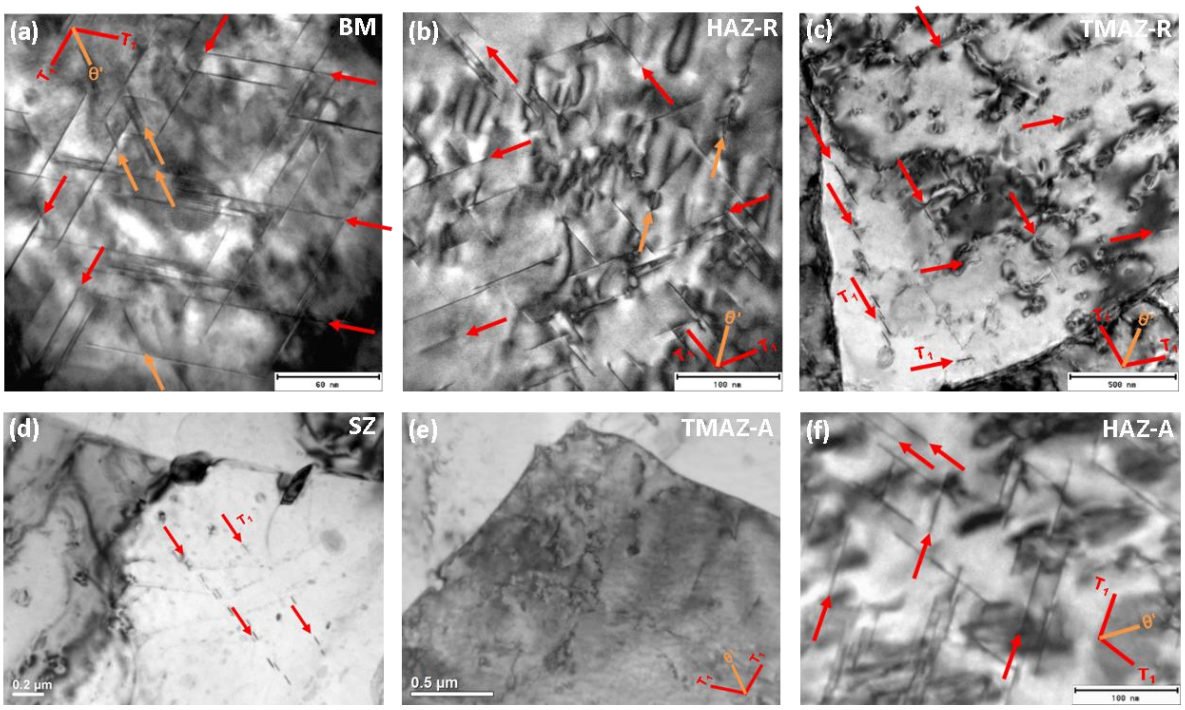

Figure: (2) TEM Bright Field images acquired in [110] zone axis orientation showing a variation of T1 phase precipitates in various regions of Friction Stir Welded AA2098 alloy