Chapter 9

CONCLUDING REMARKS

The purpose of the whole work was to study the role of $\text{Al}_3\text{Sc}$ and $\text{Al}_3\text{Zr}$ on the mechanical properties of Al–6Mg alloy due to minor additions of Sc and Zr. The primary study on the effect of $\text{Al}_3\text{Sc}$ dispersoids on the fracture toughness of Al–6Mg alloy reveals that the plane strain fracture toughness of the alloy has improved significantly due to modification of the microstructures; though it is seen that higher density of the aluminides due to high Sc content promotes slip bands and thus deteriorates the toughness of the alloy. It is further noted that, particle coarsening leading to homogeneous deformation improves the fracture toughness to a certain extent. The quaternary addition of Zr influences the toughness property of the alloy. The TEM study has revealed that the rod like precipitates of $\text{Al}_3\text{Sc}$ matrix are reduced substantially due to formation of $\text{Al}_3\text{Sc}_{1-x}\text{Zr}_x$ dispersoids, mostly precipitating on the sub–grain boundaries. The refined sub–grain structure leads to improvement of fracture toughness.

As the mechanism of precipitation of aluminides due to Sc and Zr addition is controlled by their interaction with the vacancies, positron annihilation studies were done to find the formation of
Al\textsubscript{3}Sc as well as Al\textsubscript{3}Sc\textsubscript{1-x}Zr\textsubscript{x} dispersoids. In the binary Al–6Mg alloy, it is seen that, positrons are entrapped at interfaces of Mg\textsubscript{5}Al\textsubscript{8} precipitates and a significant precipitation of magnesium aluminide takes place at higher temperature. In case of Sc–bearing alloy, formation of Al\textsubscript{3}Sc depends on dissociation of scandium atom–vacancy complexes. These dissociation depends on the heat treatment, temperature and time. But, Zr addition to Al–Mg–Sc alloy leads to formation of Al\textsubscript{3}Sc\textsubscript{1-x}Zr\textsubscript{x}. The morphology of such precipitates do not vary with heat treatment. They also stabilize the sub–grain boundaries by pinning the dislocations. Heat treatment of this Zr–bearing alloy leads to clustering of Zr-atoms around the precipitates and the faceted morphology of the aluminides is modified.

In course of understanding the effect of precipitation on the textural behaviour and in–plane anisotropy of annealed Al–6Mg alloy with trace additions of Sc and Zr, it is observed that, needles of Al\textsubscript{3}Sc precipitates in solidified and annealed Al–6Mg–Sc alloy reduce in–plane anisotropy and improve fracture toughness. Maximization of both Goss component and rotated Cube component on addition of 0.6 wt.% Sc reduces the fracture toughness. Zirconium addition leads to reduction in the intensity of Goss and other texture components but exhibits high anisotropy due to intense Rotated Cube. Notwithstanding the low intensities of all texture components except Rotated Cube, the high anisotropy in Zr–doped alloy brings out that, in–plane anisotropy in Al–6Mg alloy with or without minor additives is influenced mainly by Rotated Cube texture. Though the majority of the texture components does not influence the in–plane anisotropy in the experimental alloy system, the specific nature of precipitates and its habit do influence it and needles of Al\textsubscript{3}Sc precipitates are found to reduce anisotropy.
In a nutshell, it may be concluded that mechanical properties of the Al–6Mg alloy could be improved by minor addition of Scandium and Zirconium.