Al alloys have important applications in the automotive and aerospace industries because of their high specific strength for the weight reduction and better fuel economy. However, mechanical properties of conventional Al alloys are often not suitable for some extreme applications. High pressure torsion (HPT) has been found to be effective to refine the grain size, enhance the precipitation hardening, and finally improve the performance of Al alloys. The enhanced precipitation hardening can be directly correlated to the different type precipitates formed during HPT and subsequent aged treatments. Full characterisation and quantification analyses of the precipitates evolution is thus of great importance to optimize conventional Al alloys in service and develop new Al alloys.

In this contribution, advanced electron microscopy was employed to characterise the evolution and chemistry composition of precipitates formed along grain boundary and/or within the matrix in Al alloys subjected to HPT. Furthermore, in situ heating and cooling in high resolution TEM (STEM) was also employed to elucidate the evolution of precipitates, thereby optimize the heat treatment and finally improve the mechanical properties. It was demonstrated that advanced electron microscopy is of great necessity to reveal mysteries in conventional research fields, e.g. casting and/or solidification. However, more attentions have to be paid to the differences caused by the size effects. For example, the temperatures of precipitates observed by in situ heating of thin TEM foil is slightly higher than that measured by DSC heating of bulk samples. An combined application of advanced electron microscopy and other analysis techniques (i.e. DSC) can provide a comprehensive information of the precipitation of Al alloys.

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