The aim of the conducted study was to evaluate the effect of minor solute elements (in particular Mg and Ag) on the precipitation kinetics of the plate-like phase T_1 (Al_2CuLi) in an Al-Cu-Li based alloy. In fact, these minor solute elements are known to play an important role in controlling the nucleation of this phase, which in the fully precipitated state controls the mechanical properties of the alloy used for aerospace applications.

Small Angle X-ray scattering (SAXS) experiments were performed since they are a useful technique to analyse precipitation kinetics in Al-Cu-Li alloys. In order to study the effect of minor alloying elements on the precipitation kinetics a new approach was chosen. It combines thermal treatment with the variation of composition of the alloy. This could be achieved by fabricating diffusion couples, which contain a diffusion gradient of width 1 cm after homogenisation at sufficient high temperature (allows diffusion) and rolling (to enlarge the gradient). Different positions on the gradient correspond to different concentrations of the diffusing element. A furnace, made in the laboratory, was large enough to set in the diffusion couple and to heat it homogeneously to the artificial aging temperature. By moving the furnace during the experiment and at the same time heating up the sample, in-situ SAXS measurements were performed, with respect to time and composition. By using synchrotron radiation, it was possible to collect many data points across the diffusion weld. Due to the small beam size, small spacing between the data points was likewise possible. Good resolution in combination with using a Xpad camera, allowed shorter acquisition times (only a few seconds) in order to achieve reliable results. Figure 1 shows the precipitation kinetics for a diffusion couple, in which the concentration of Mg varies. It is seen that enhanced kinetics are observed for an increasing Mg content, and thanks to the time and space resolved measurement, it becomes possible to assess the effect of the concentration in minor solute on the precipitation kinetics.

A second set of experiment consisted of thickening experiments. In this case the sample contained precipitates from the beginning, and the aim was to observe if there is a strong effect of the minor solute elements on the coarsening resistance of the precipitates. One thickening experiment contained a ramp heating of 2 °C/min starting at 150 °C up to 300 °C. A second set was an isothermal heat treatment at 190 °C, at which it is known that thickening happens. The isothermal thickening period was approximately 2 hours, which unfortunately was too short to identify large differences in the precipitation structure. Again, good resolution allows short acquisition times, so that changes during the experiment can reliably be detected.

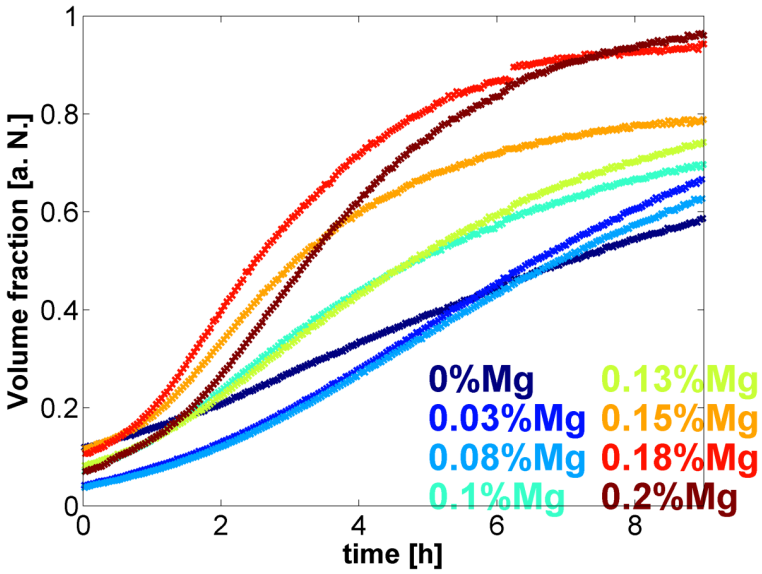

Figure 1: Volume fraction over artificial aging time; Increased precipitation kinetics are observed with increasing Mg content

Overview on the experiments:

Diffusion couples were performed in order to characterise the effect of one diffusing element on the precipitation kinetics. 6 couples were measured, in which 2 were measured twice in order to analyse the reproducibility of the experimental setup.

Couple	Measurements
AlCuLi – AlCuLi **Mg**	1
AlCuLi Mg – AlCuLi Mg**Ag**	2
AlCuLi Ag – AlCuLi Ag**Mg**	2
AlCuLi MgAg – AlCuLi MgAg**Zn**	1

Furthermore, so called thickening experiments were conducted. The initial condition of the alloys was a precipitated condition (so called T8) and two different types of thickening experiments were conducted. One set of experiment included a ramp heating from 150 °C to 300 °C with a heating ramp of 2 °C/min. The other consisted of an isothermal heat treatment at 190 °C in which it is known that for longer aging times, thickening happens. The aging period was 2 hours. Again, for each set of experiments a reliability measurement was performed.

Alloys	Number of samples; Ramp heating	Number of samples; Isothermal thickening at 190 °C
AlCuLi Mg	1	2
AlCuLi Mg0.3Ag	2	1
AlCuLi Mg0.1Ag	1	1
AlCuLi MgZn	1	1
AlCuLi Mg0.1AgZn	1	1

In total 12 thickening experiments were performed. The used energy was 17 keV.