INVESTIGATION OF THE EARLY STAGES OF DECOMPOSITION IN A QUENCHED Al-BASE Ag ALLOY BY THE SAXS METHOD

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Although many papers published to date have dealt with decomposition in quenched Al-base Ag alloys, only a few of them have considered the early stages of decomposition[1]. This paper presents the experimental data of an investigation of the isothermal kinetics in the early stages of decomposition in quenched Al-16 wt.(or 4.5 at.)pct. Ag alloy which could be successfully interpreted on the basis of the spinodal decomposition model.

To this end small-angle x-ray scattering (SAXS) spectra were measured on quenched and annealed specimens. Two types of quenched specimens were used: quenched from the solid state at 550°C (in the following denoted as KK specimens); and quenched from the liquid state at 900°C (UBK specimens). After quenching to room temperature, specimens were annealed in an oil bath at a given temperature. Temperature range was chosen within the metastable miscibility gap established by Baur and Gerold[2], and according to our previous study[3]. The annealing temperatures were: 140, 120, 100 and 80°C; the times of annealing were up to: 5, 10, 20 and 40 hours, respectively. For each specimen the annealing process was repeatedly interrupted in order to measure SAXS curves at room temperature. Two types of SAXS evacuated cameras were used: the Kratky camera, using Ni-filtered Cu radiation; and the Guinier-Levelut camera using Cu K_α radiation monochromatized by a LiF doubly bent single crystal. Scattered radiation was detected by means of a scintillation counter connected with a pulse height analyser.

The scattering intensity curves obtained by the described cameras on the as-quenched KK (about 60 μm thick) and UBK (from 15 up to 40 μm thick) specimens can be compared in Fig. 1. The curves were corrected for parasitic scattering only. In the same figure one can see the maxima in scattering intensities caused by the fluctuation of concentration of silver atoms; and also that fluctuation had hardly occurred during the quenching of UBK specimens because of the high cooling rate. The SAXS data obtained were analysed on the basis of the linear spinodal theory (LST) according to the method proposed by Rundman and Hilliard[4] and it was found that only the curves obtained in the initial stage of aging obeyed the linear logarithm of intensity (log I) on time (t) dependence which is essential for the LST. The times (in hours) after which deviation from this relationship became observable were about: 0,5 at 140, 1 at 120, 2 at 100 and 20 at 80°C. According to the LST, the data mentioned above were used to calculate the amplification factor (R(k)). The values of R(k) were derived by the least squares method for each value of k, where k is proportional to the scattering angle ε ($k=2\pi\varepsilon/\lambda$). Fig. 2 (a) shows one of several curves R(k) obtained using the Guinier-Levelut camera for UBK specimens aged at 100°C, while Fig. 2 (b) shows the same data in $R(k)/k^2$ against k^2 plot. Some of the R(k) curves obtained with the Kratky camera for both types of specimens annealed at 120 and at 80°C are shown in Fig. 3.

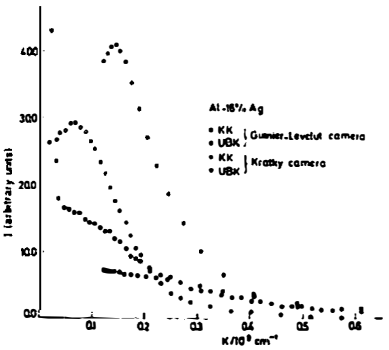

FIG.1. Comparison of SAXS curves for the as-quenched specimens studied and the cameras used.

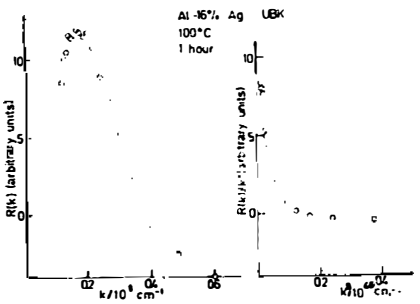

FIG.2. (a)The R(k) against k, (b) the $R(k)/k^2$ against k^2 plots, both derived from the same SAXS data obtained with the Guinier-Levelut camera for the UBK specimen annealed up to 1 hour at 100°C.

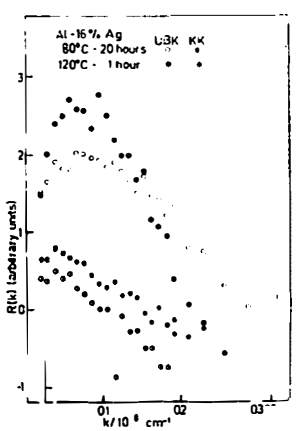

FIG.3. Influence of the quenching rate and annealing temperature on the R(k) curves derived from SAXS data obtained with the Kratky camera and measured during denoted aging times.

The results obtained from the evaluation of all scattering curves allow the following conclusions:

- the comparison of the results obtained using two completely different SAXS cameras gives a satisfactory agreement;
- the crossover point for the scattering curves on I against k plot with t as a parametar is not well defined;
- each of several R(k) derived curves shows one maximum only;
- the $R(k)/k^2$ curves deviate smoothly from linear relationship, and this relationship is observed only at small k^2 values;
- the values of k_c, which belong to the crossover points and for which R(k) is equal to zero, depend greatly on the annealing temperature and quenching rate. For the same annealing temperature k_c values are higher for UBK specimens than for KK specimens, while with increasing annealing temperature they move to smaller values for both types of specimens;
- the estimated values for the interdiffusion coefficient ($\tilde{D}$) may be equal, or slightly higher, for UBK specimens in comparison with KK specimens;

- the activation energy for the decomposition processes investigated, the values for the spinodal temperature and the values for the gradient-energy coefficient were estimated from the experimental data to be about: 23 kcal/mol, 200°C and $3 \cdot 10^{-5}$ erg/cm, respectively. The values are approximately equal for both types of specimens. In order to determine these values more accurately one should use specimens obtained with the same quenching rate which is difficult to achive in experiments.

Finally, the main features of the kinetics of the early stages of decomposition can be fitted quite well to the LST, but the observed details of kinetics or deviations from the predictions of the LST can be better described by the non-linear spinodal theory which has been proposed[5].

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