ELSEVIER

Physica B 276–278 (2000) 921–922

PHYSICA B

www.elsevier.com/locate/physb

SANS investigation of precipitation in heat-treated AA6082 alloy

G. Albertini[a,b,*], G. Caglioti[c,d], F. Fiori[b,e], R. Pastorelli[c,d]

[a]Dipartimento di Scienze dei Materiali e della Terra, Università di Ancona, Via Brecce Bianche, I-60129 Ancona, Italy
[b]INFM - Istituto Nazionale per la Fisica della Materia, Research Unit of Ancona, I-60129 Ancona, Italy
[c]Politecnico di Milano, Dip. Ingegneria Nucleare - CESNEF, Via Ponzio 34/3, I-20133 Milano, Italy
[d]INFM - Istituto Nazionale per la Fisica della Materia, Research Unit of Milano-Politecnico, Milano, Italy
[e]Universit di Ancona, Istituto di Scienze Fisiche, Via Ranieri 65, I-60131 Ancona, Italy

Abstract

The small-angle neutron scattering technique is used in order to detect the microstructure changes induced by two different quench rates and two different ageing treatment in the Al–Mg–Si alloy AA6082. In particular, small size and large size precipitate particles of Mg_2Si are deduced to vary differently for different thermal history. The two kinds of precipitates are known to be related to the mechanical properties of the alloy. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Small-angle neutron scattering; Metals; Alloys

1. Introduction

AA6082, a well known and widely used Al–Mg–Si alloy, exhibits mechanical properties which are highly sensitive to thermal treatments. In fact, starting from the solubilised state, too slow cooling rates can lead to the reduction of several important properties (strength, formability, toughness, etc.), while too rapid cooling can generate undesired macroscopic deformations. From a microscopic point of view, the alloy elements are usually solubilised by high-temperature (520°C) annealing. In the subsequent cooling procedure, rapid quenching is needed to create the Guinier–Preston zones whose size will increase as a consequence of the subsequent ageing, leading to an improvement of the mechanical behaviour. However, a too rapid quench can enhance residual stresses. On the other hand, too slow quenching generates coarse incoherent precipitates leading to a reduction of the mechanical performances.

In order to optimise the quenching rate and the subsequent thermal treatment, research projects aiming to determine the correlation between residual stress field and microstructure changes induced by different quenching rates were undertaken. The preliminary SANS results are reported in the present paper.

2. Material and samples

The composition of the AA6082 alloy is the following (%wt): Si 0.7–1.3, Fe 0.5, Cu 0.1, Mn 0.4–1, Cr 0.25, Zn 0.2, Ti 0.1, Al bal.

The samples (thickness 1 cm, radius 5 cm) were cut from cylindrical samples of the same radius but 10 cm high which were first annealed at 520°C and then quenched at different rates: 1°C/s, by quenching in boiling water and 30°C/s, by quenching in water at 20°C. After quenching two different ageing treatments were considered: natural ageing for 72 h at 40°C and “T6” ageing for 16 h at 165°C. Four different specimens are thus generated, from which our samples were obtained.

* Corresponding author. Tel.: + 39-071-2204735; fax: + 39-071-2204605.

E-mail address: gialbe@popcsi.unian.it (G. Albertini)

PII: S0921-4526(99)01296-X

3. SANS measurements and results

SANS principles can be easily found in many books and papers (e.g. [1]). The SANS measurements were carried out at the D11 instrument of the Insitute Laue Langevin (ILL) in Grenoble (France). A neutron wavelength $\lambda = 1$ nm was used. Three sample-to-detector distances were used (1.1, 4 and 20 m), for a total Q range running from 0.018 to 2 nm^{-1}.

Fig. 1 reports the SANS curves obtained from the different samples. The curves are reproducible, as it was checked by considering three different gauge points in each sample.

Each curve can be approximately divided into two parts: one in the lower Q region (up to 0.1 nm^{-1}) and one in the higher Q region. The former mainly depends on the number and on the neutron contrast of heterogeneities, having size approximately in the range 30–200 nm. The latter corresponds to sizes approximately in the range 2–30 nm.

The smaller sizes family was assumed to correspond to fine Mg_2Si precipitates, while the larger one was assumed to correspond to the coarse incoherent Mg_2Si precipitates leading to a reduction of the mechanical performances.

The quenching rate mainly affects the relative abundance of coarse precipitates, while the nature of the ageing treatments mainly affects the relative abundance and the size distribution of the smaller precipitates. In fact, irrespective of the nature of the ageing treatments the coarse precipitates are favoured by low quenching rate (LN and LT samples), as it can be deduced from the higher intensity of the corresponding curves in the low Q region. The number and the size distribution of smaller precipitates, on the other hand, strongly depend on the ageing treatment in rapidly quenched samples (HN and HT curves). At lower rate of quench (LN and LT curves) the difference is smaller but well detectable.

In conclusion, the SANS technique puts in evidence the occurrence of different heterogeneities in samples with different thermal history. The experimental data are used to put in evidence that both the chosen quench rates and the chosen treatments of ageing induce precipitate particles different in size and number. The observed changes are in agreement with the starting hypothesis of the projects. A more detailed analysis of the data (in particular the study of the size distribution function and the corresponding volume distribution function) will be undertaken as soon as TEM pictures are available.

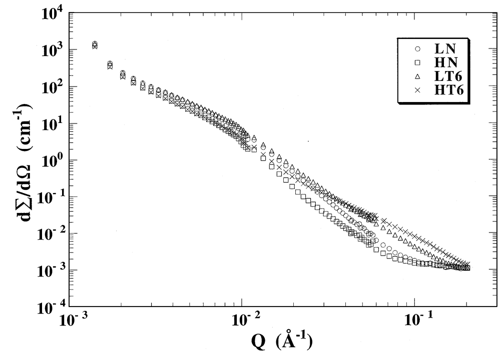

Fig. 1. SANS curves obtained from sample quenched at 30°C/s (HN, HT6) or 1°C/s (LN, LT6), after ageing 72 h at 40°C (HN, LN) or 16 h at 165°C (HT6, LT6).

Acknowledgements

This work was partially supported by the Centro Nazionale delle Ricerche (CNR) – Italy: projects no. 96.01776.CT11 and no. 97.00378.CT11 concern a combined study of residual stresses by neutron diffraction and microstructure evolution by small angle neutron scattering (SANS), together with the use of mechanical tests and electron microscopy observations. Thanks are also due to Dr. P.Fiorini for sample preparation.

References

[1] G. Kostorz, in: R.W. Cahn, P. Haasen (Eds.), Physical Metallurgy, 3rd Edition, Pergamon Press, New York, 1983, p. 853.