LA-UR-99-932

Title: RELATIONSHIP BETWEEN HIGH-STRAIN-RATE SUPERPLASTICITY AND INTERFACE MICROSTRUCTURE IN ALUMINUM ALLOY COMPOSITES

Author(s): J. Koike, Dept. of Mat. Sci. ,Tohoku Univ., Sendai 980-8579, Japan

K.E. Sickafus, MST Div., LANL

T.E. Mitchell, CMS, LANL

RECEIVED

MAY 03 1999

OSTI

Submitted to: Conference Proceeding "Microscopy - Microanalysis Portland, Oregan, August 1st - 5th, 1999

Los Alamos

NATIONAL LABORATORY

DISCLAIMER

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

RELATIONSHIP BETWEEN HIGH-STRAIN-RATE SUPERPLASTICITY AND INTERFACE MICROSTRUCTURE IN ALUMINUM ALLOY COMPOSITES

J. Koike, K. E. Sickafus*, and T. E. Mitchell**

Dept. of Materials Science, Tohoku University, Sendai 980-8579, Japan
* Materials Science and Technology Division, Los Alamos National Laboratory
** Center for Materials Science, Los Alamos National Laboratory,
Los Alamos, NM 87535

The Al alloy composites reinforced with Si_3N_4 or SiC have been reported to exhibit superplasticity at high strain rate of faster than $1x10^{-2}$ s^{-1}. It has been shown in many aluminum alloy composites that the optimum superplastic temperature coincides with an incipient melting temperature. The coincidence suggests a contribution of the liquid phase to the superplasticity mechanism. This paper shows a direct evidence of partial melting along matrix grain boundaries and matrix-reinforcement interfaces. Based on the obtained results, the role of the liquid phase in the high-strain-rate superplasticity is discussed.

The sample was Al-Mg (5052) alloy reinforced with 20vol% Si_3N_4 particles, fabricated by a powder metallurgy process. The sample showed an excellent superplasticity under the conditions given in Table 1. Partial melting was confirmed to occur at 821 K by differentail scanning calorimetry. The microstructural changes during heating were observed in situ by TEM using a heating stage. The structure of interfaces and grain boundaries was observed by HREM. Chemical analysis was performed with EDS attached to VG-STEM.

A bright-field image of the composite is shown in Fig. 1. Notice that the edge of the Si3N4 particles are fragmented. Fig. 2 (a) shows a selected-area diffraction pattern taken at 821 K . A halo ring appears at this temperature, indicating partial melting. Fig. 2 (b) shows a dark-field image with an inverted contrast, taken from a part of the halo ring. The location of partial melting can be identified by a dark contrast along the matrix grain boundaries and the matrix-reinforcement interfaces. Above this temperature, grain-boundary corners become a rounded shape caused by the formation of the liquid phase at triple grain junctions. Figure 3 shows a concetration profile across a matrix-reinforcement interface. The left side is the aluminum matrix and the right is a Si_3N_4 particle. In the middle in between two dotted lines, there is a region where the Al and Si concentrations take intermediate flat values, indicating the formation of an interface phase. Mg segregation at the location of the left dotted line is also observed. This solute segregation is considered to be a cause for partial melting. The crystal structure of the interface phase was investigated by HREM and shown in Fig. 4. The figure shows the Al matrix and the interface phase. The interface is severely serrated and may become a stress concetration site during deformation. FFT of various regions reveals that the interface phase is composed of MgO, Al_2MgO_4, andMg_2Si.

In the present work, partial melting was observed along interfaces and grain boundaries. Solute segregation is suggested to be the cause for partial melting. The liquid phase is considered to act as a stress accommodation site that can prevent cavitation failure at the serrated interfaces and triple grain junctions.

This research was supported by the US DOE, OBES and by Japanese Ministry of Education.

Table. 1 Optimum conditions for high-strain-rate superplasicity.

elongation	temperature	strain rate	flow stress	strain rate sensitivity
700%	818±10 K	1 s^{-1}	6 MPa	0.3

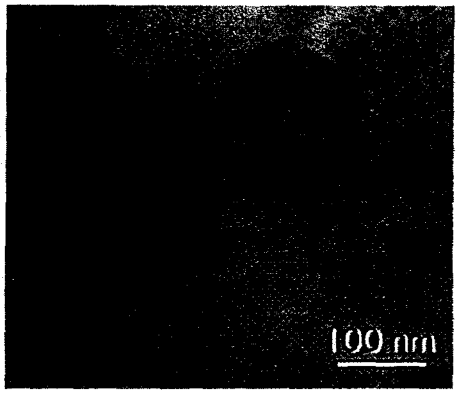

Fig. 1 BFI of the composite.

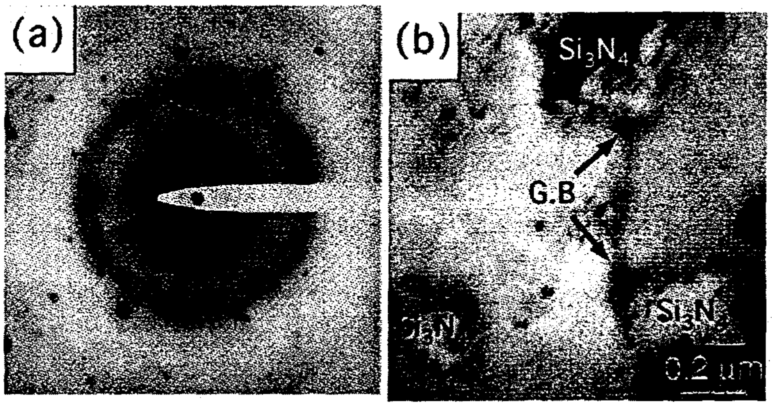

Fig. 2 (a) SAD and (b) DFI from the halo ring at 821 K with an inverted contrast.

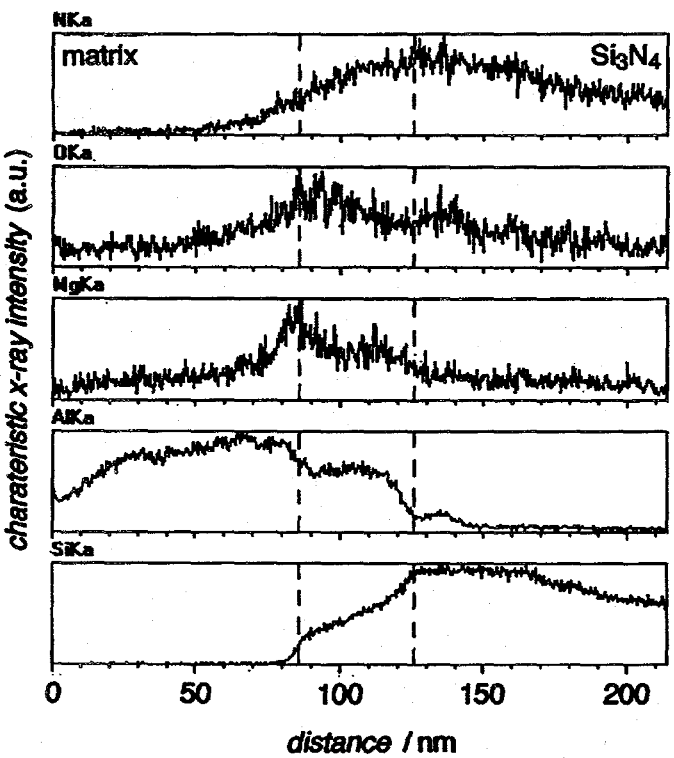

Fig. 3 Concentration profile across the interface.

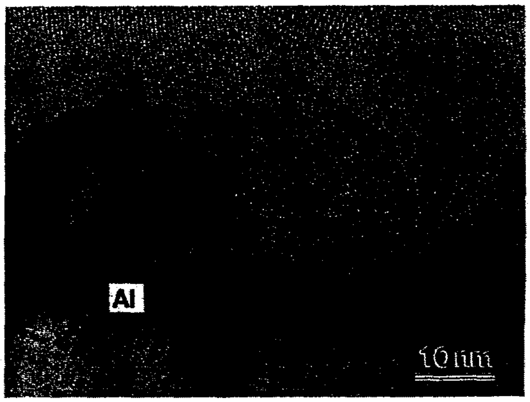

Fig. 4 HREM of the interface between the Al alloy matrix and the interface layer.