EXAFS study on local structure of Fe in nano-structured Al alloy

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Introduction

Nano-structured Al-based alloys prepared by electron beam evaporation with small amount of additives can achieve excellent mechanical properties [1]. For the case of Fe additive, grain size decreases and hardness increase with increasing of the amount of Fe up to 5at%. These alloys show x-ray diffraction patterns of super-saturated sold solution of Al. Mechanical properties of these alloys strongly depends on the preparation process of the alloys even the x-ray diffraction patterns do not show clear difference. Hence, it is expected that there is a difference of the local structure around the additive depending on the amount of additives and the sample preparation process. In present work, we study the local structure around Fe atoms in Al-Fe alloy (1.0at% and 2.5at% Fe).

Experimental

Al-Fe alloys were prepared by electron beam deposition with Al and Fe target in a high vacuum chamber. Two types of alloys, Al-1.0at%Fe and Al-2.5at%Fe, were prepared on the substrate of two different temperatures of 100°C and 250°C.

The Fe K-edge XAFS spectra were measured using fluorescence mode at the BL12C station with a double Si(111) monochromator at 20K.

Results and discussion

Fig. 1 shows Fourier transform (F(r)) of the Fe K-edge EXAFS, $k^3 \cdot \chi(k)$, of Al-2.5at%Fe and Al-1.0at%Fe alloys prepared with different substrate temperatures together with those of the simulated results for Fe in fcc Al, Al_2Fe and Al_3Fe intermetallic compounds using FEFF program. Both samples of Al-1.0 and 2.5%Fe samples deposited on the 250°C substrate exhibit similar F(r); one nearest neighbour correlation observed at 2.0Å. On the other hand, the 1.0-at%Fe(100°C) sample exhibit nearest neighbour peak at 2.4Å. While for the 2.5at%Fe(100°C), the F(r) shows two peaks at 2.0 and 2.5Å .

As seen in Fig.1(e), Fe-Al correlation in fcc Al calculated using FEFF locates at 2.5Å. Therefore, it can be concluded that the peak at 2.5Å for the 1.0-at%Fe(100°C) can be attributed to the Fe atoms substituted to fcc Al. On the other hand, the peaks at 2.0Å of the sample for 250°C substrate are very close to nearest Fe-Al correlation in Al_2Fe or Al_3Fe intermetallic compounds. However, long-range correlations are vanished, as seen in Fig.1 (b)-(d). These features indicate that very small (nano-meter size) or distorted intermetallic compound is formed in 250°C substrate alloys.

Mechanical properties of the 1.0-at%Fe(100°C) sample is relatively inferior to other samples. Consequently, these results suggest that the formation of the nano-sized and/or distorted intermetallic compounds in this Al-Fe alloy improves mechanical properties.

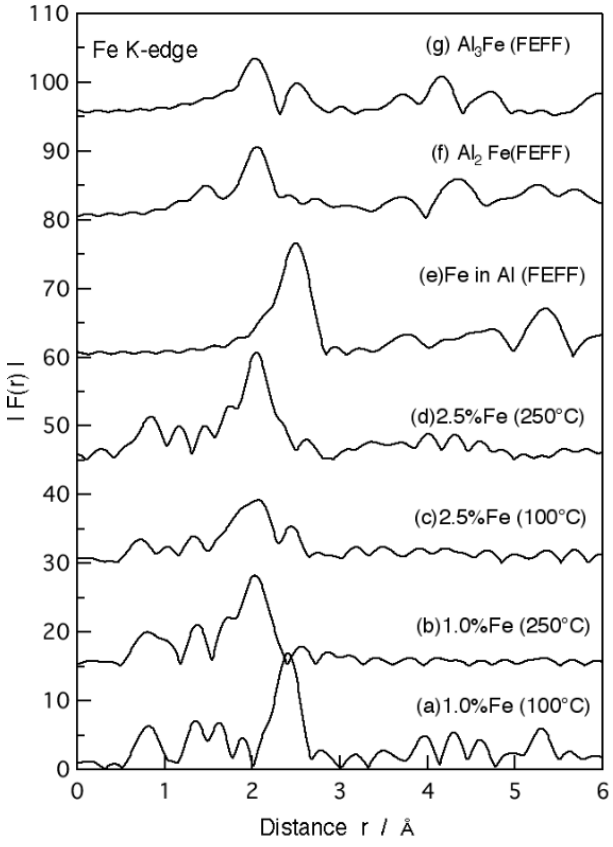

Fig.1 Fourier transform of k^3 weighted Fe K-edge EXAFS of Al-Fe alloys and Fe in fcc-Al, Al_2Fe and Al_3Fe intermetallic compounds calculated from FEFF program.

References

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