Phase equilibria in the Al–C–Fe–W quaternary system

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1. Introduction

(1) Background

Traditional WC / Co cemented carbide:
+ Poor corrosion and oxidation resistance
+ High cost
+ Environmental toxicity

WC–FeAl composites
+ Good mechanical properties at high temperatures
+ Good oxidation and corrosion resistant performance
+ Low costs

(2) The purpose of the present work
+ To measure the phase equilibria of the Al–Fe–W system at 900 and 1100 °C
+ To investigate the phase constitution of WC–FeAl (Fe–40 at.%Al) composites with 5, 10 and 15 wt.% FeAl
+ To establish the thermodynamic database of the Al–C–Fe–W system

2. The Al–Fe–W system

(1) 900 °C

Fig. 1. (a) BSE image and (b) XRD pattern of alloy $\text{Al}_6\text{Fe}_{13}\text{W}_4$ annealed at 900 °C for 60 days, respectively, indicating the three phase equilibria of $\text{Al}_2\text{Fe} + \text{B}_2 + (\text{W})$; (c) BSE image and (d) XRD pattern of alloy $\text{Al}_2\text{Fe}_{13}, \text{W}_4$ annealed at 900 °C for 60 days, respectively. The two phase equilibria of $\text{Al}_2\text{Fe}_5$ (W) are confirmed; (e) Calculated isothermal section of the Al–Fe–W system at 900 °C along with the experimental data obtained in the present work.

(2) 1100 °C

Fig. 2. (a) BSE image and (b) XRD pattern of alloy $\text{Al}_6\text{Fe}_{13}\text{W}_4$ annealed at 1100 °C for 40 days, respectively, indicating the three phase equilibria of $\text{Al}_2\text{Fe} + \text{B}_2 + (\text{W})$; (c) BSE image and (d) XRD pattern of alloy $\text{Al}_2\text{Fe}_{13}, \text{W}_4$ annealed at 1100 °C for 40 days, respectively. The two phase equilibria of $\text{Al}_2\text{Fe}_5$ (W) are confirmed; (e) Calculated isothermal section of the Al–Fe–W system at 1100 °C along with the experimental data obtained in the present work.

3. The Al–C–Fe–W system

Fig. 3. (a) BSE images of WC–FeAl (Fe–40 at.%Al) composites vacuum sintered at 1450 °C with 5, 10 and 15 wt.% FeAl, respectively; (d) The corresponding XRD patterns of the composites. The composites compose of WC and FeAl phase are confirmed.

Fig. 4. (a) DSC heating curve of the WC–10 wt% FeAl composite. (b) Calculated vertical section for the WC–10 wt% FeAl composite.

4. Conclusion

Phase equilibria of the Al–Fe–W system at 900 and 1100 °C were investigated by means of XRD and EPMA analysis.
Based on the experimental data obtained in the present work and the thermodynamic parameters for the sub-binary systems from the literature, thermodynamic assessment of the Al–Fe–W system were performed by CALPHAD approach. The calculated results can reasonably reproduce the experimental data.
WC–FeAl composites with 5, 10 and 15 wt.% FeAl were prepared through vacuum sintering technique. Phase constitution of the composites were investigated by XRD and EPMA analysis. DSC measurements were performed to determine the phase transition temperatures.
The thermodynamic database for the Al–C–Fe–W system was established by extrapolating the sub-binary systems and the calculated results are compared with the experimental data. More experimental data are needed to verify the reliability of the database.

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