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Changes in the structure of alloy on the matrix of FeAl intermetallic phase after primary crystallization and homogenizing treatment

J. Cebulski, S. Lalik

Silesian Technical University, Department of Material Science, Poland
email: cebulski@polsl.katowice.pl

Abstract: In this work results of examinations of the influence of the structure after primary crystallization and after homogenizing treatment. The performed structural examinations of alloy on FeAl intermetallic phase matrix had proved, that after a primary crystallization it has a coarse grain structure. Application of homogenizing treatment at temperature 1050°C during 72 hours leads to decay of growth twins, changes the distribution of dislocation in a manner enabling a hot plastic working.

Keywords: Structure, Intermetallic

1. INTRODUCTION

The intermetallic compounds, being a group of materials with large practical possibilities, both in the past as in present time are a subject of scientific investigations because of their physical-chemical and mechanical properties [1,2] different than those of classic engineering materials. In spite of intensive investigations of this group of materials in the recent years, there remains still a number of unsolved technological questions. This relates in particular to phenomena taking place during the process of primary structure forming. Mechanical properties of alloys having crystalline structure with ordered long range are showing higher sensitiveness on conditions of metallurgical process than the classic metallic materials with unordered crystalline structure. The melting conditions (synthesis and crystallization) for this type of alloys are deciding not only on plasticity at ambient temperature, but also about properties at high temperatures. The technological requirements should protect the cast alloy against exposure to oxygen. This relates especially to alumides and silicides of transition metals [3-5]. The requirements of metallurgical process are deciding, among others, on the width of temperature range of plasticity state and on tendency of alloy to cracking at elevated and high temperatures [3]. The quantities of these properties become especially important in cases, when the ingots of molten alloys constitute blanks intended for further plastic working.

To important practical factors, influencing the quality of alloy on the matrix of iron alumide, belong [4]:

- melting space, furnace type, crucible and smelting environment,
- sort of raw materials used for alloy making: purity, form and a sequence of charging the materials and components into crucible and inoculation,
- temperature and time of smelting,
- parameters of casting process like, casting temperature, method of pouring into moulds, material, size and form of mould.

1. 1. Aim and scope of research

The aim of performed research was determination of the structure after primary crystallization and after homogenizing treatment.

Scope of investigation comprised:

- examinations at the light microscope,
- examinations at scanning electron microscope,
- examinations at transmission electron microscope,
- diffractographic examinations.

1.2. Material for tests

For tests was taken the alloy on FeAl intermetallic phase matrix with chemical composition as presented in Table 1.

For melts were used pure components: ARMCO iron (technical purity), ARO aluminium (purity degree 99.995% mass), aluminothermic chromium obtained by Kroll method and amorphous boron (chemical purity). The melts were performed in vacuum, and aluminium-melting loss did not exceed 2%. Selection of alloy chemical composition was done on experimental way in the scope of previous made research [1].

To homogenize the structure was performed a homogenizing treatment at temperature 1050°C through 72 h.

Table 1.
Chemical composition of tested alloy Fe-40Al-5Cr-0.2Ti-0.2B.

Alloy Fe-40Al-5Cr-0,2Ti-0,2B	Content of elements [%mass.]					
Type of element	Fe	Al.	Cr	Ti	B	C
Adopted	69,50	24,47	5,90	0,11	0,02	-
True	68,21	23,66	5,77	0,15	0,015	0,046

2. TEST RESULTS

In Fig.1 is presented a microstructure of alloy ingot cast at 1500°C. A characteristic feature of this microstructure is a zigzag character of grain boundaries, being probably related with dendritic form of crystallites. Observations of thin films by means of TEM had disclosed a presence of growth twins and small precipitates, which were electronographically identified as carbide particles: TiC and $M_{23}C_6$ (Fig.2).

A dislocation structure of alloy after homogenizing treatment is presented in Fig.2c. It appears, that the homogenizing treatment of alloys performed at 1050°C during 72 hours with air cooling leads to decay of grow twins and alters the dislocation distribution. Presence of grow twins in the matrix along with mentioned microstructure elements is provoking instability of alloy structure. The homogenizing treatment is decreasing a number of dislocations visible at microscopic pictures. Noted is also decay of growth twins present in structure after primary crystallization. The dislocation lines, lying far from particles of precipitated phases are showing a split into two components. This observation allows to assume, that in the time of crystallization are generated conditions for distribution of superdislocation a<111> into two components a/2<111>. This decomposition is probably due to a presence of internal stress in alloy, and their activation is caused by existance of temperature gradients during solidification and a big contraction at the change of state.

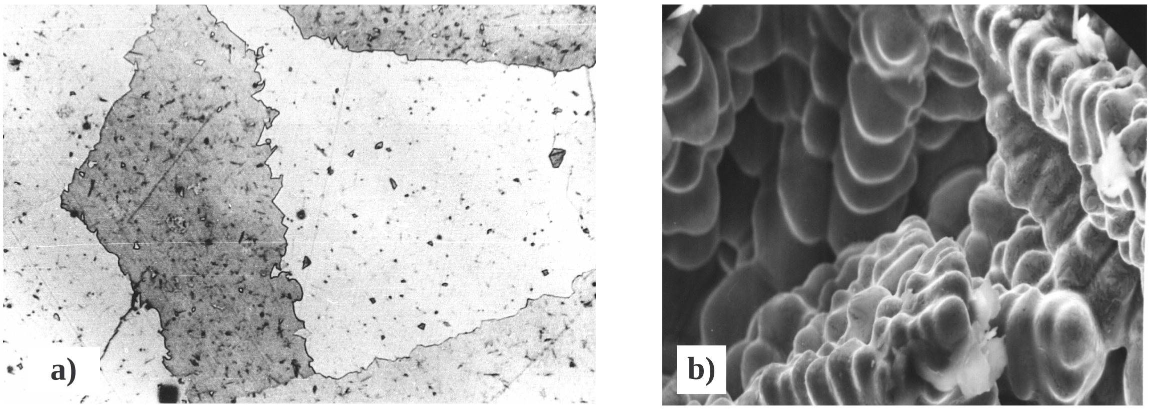
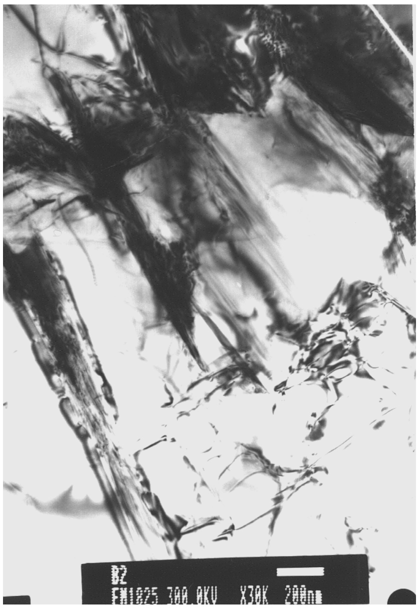


Figure 1. Microstructure of alloy after primary crystallization (a) Magn.80x. Fracture surfaces after plastometric examinations at 1050°C (b) Magn.430x.

a)



b)

c)

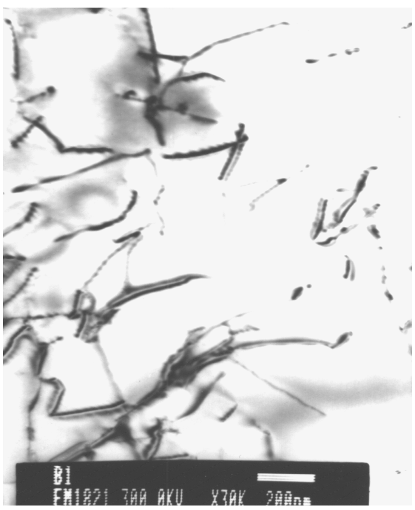


Figure 2.loy structure after primary crystallization observed on thin films by means of TEM:
a and b – growth twins with carbide precipitates;
c – dislocation structure after homogenizing treatment. Magn.30 000x.

A diversified image of dislocation line leads to assumption that in that alloy is appearing dislocations of various sort [1].

Additionally, in purpose of phase identification were executed the diffractographic examinations. A fragment of X-ray diffractogram is showed in Fig.3.

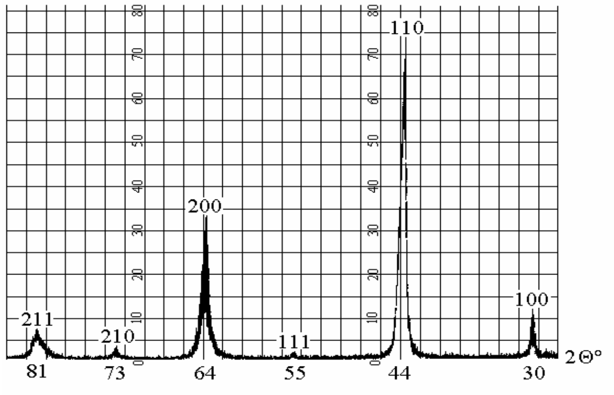


Figure 3. Fragment of X-ray diffractogram of alloy after primary crystallization.

The performed X-ray phase analysis basing on alloy radiograph after primary crystallization had proved, that the tested material has a single-phase structure. In the radiograph, beside of basic lines with a sum of diffraction factors being even number according to the rule of suppression there appear the lines with factors, the sum of which is an odd number. A presence of these lines confirms, that the structure of alloy after primary crystallization is showing a long-range order. From a qualitative comparison of intensity of superstructure line to the basic line results, that the degree of order of alloy after primary crystallization is high.

3. SUMARY

The performed structural examinations of alloy on FeAl intermetallic phase matrix had proved, that after a primary crystallization it has a coarse grain structure. A presence of high-melting structural components is causing the dendritic crystallization and segregation. Such structure has unfavourable influence upon mechanical properties what makes difficult application of further technological processes and especially the plastic working. Such effects are appearing in classic alloys of metals, however in alloys on the matrix of FeAl intermetallic phase this phenomenon is of great importance. Because of that, an appropriate selection of parameters for homogenizing treatment of this group of materials has especially great practical importance. Application of homogenizing treatment at temperature 1050°C during 72 hours leads to decay of growth twins, changes the distribution of dislocation in a manner enabling a hot plastic working. A recognition of phenomena appearing in alloys on the matrix of FeAl intermetallic phase would require continuation of research until their useful aspect will allow for application in industrial processes.

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