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OBSERVATION OF SPHEROIDAL GRAPHITE IN DUCTILE CAST IRON BY TEM

CHARAKTERYSTYKA GRAFITU W ŻELIWIE SFEROIDALNYM TECHNIKĄ TRANSMISYJNEJ MIKROSKOPII ELEKTRONOWEJ

The microstructure of spheroidal graphites in ductile cast iron (FCD450) was investigated by TEM using cross sectional TEM samples prepared by FIB method. The spheroidal graphite consisted of many small areas, and all of these areas were indexed as the graphite structure and just carbon peak was detected from there.

Keywords: ductile cast iron, spheroidal graphite, TEM, FIB methodGRAPHITE

Mikrostruktura sferoidalnych wydzieleń grafitu w żeliwie sferoidalnym (FCD450) badana była przy użyciu transmisyjnej mikroskopii elektronowej i cienkich folii przygotowanych techniką FIB. Grafit sferoidalny składał się z wielu małych obszarów i stwierdzono, że wszystkie te obszary mają strukturę grafitu i wykryto tylko pik od węgla.

1. Introduction

The ductile cast iron has good mechanical properties, and is widely used for parts of automobiles, construction machinery, machine structure and so on [1,2]. After development of the ductile cast iron, many researchers have worked on nucleation and growth mechanism of spheroidal graphite until now, but the nucleation mechanism of spheroidal graphite particles is not clear yet [3-7]. In this study, as a part of the research which clarifies the nucleation and the growth process of spheroidal graphite of FCD450, spheroidal graphite was investigated directly. The sample which passes along the diameter of spheroidal graphite was prepared, and its direct observation was performed using the TEM.

2. Experimental procedures

Steel scrap and pig iron were melted in high frequency induction furnace, then spheroidizing treatment and inoculation were carried out. The melt were cast to obtain samples of 25 mm thick. Chemical composition of the cast material is shown in Table 1, it is almost the same as a FCD450 in the Japan Industrial Standards (JIS).

Specimens were polished mechanically and a cross-sectional TEM specimen of the spheroidal graphite was prepared by FIB method (Hitachi FB2100) and observed by 400kV-TEM (Jeol 4010T).

TABLE 1

Chemical composition of the ductile cast iron (mass%)

	C	Si	Mn	P	S	Cu	Mg	Fe
FCD450	3.43	2.37	0.40	0.02	0.01	0.17	0.03	bal

3. Results and discussion

Fig. 1 shows an optical microscopic image of spheroidal graphites in a typical FCD450 sample after polishing mechanically. Many spheroidal graphites were confirmed in the α-ferrite of white contrast in this sample. A few spheroidal graphites which included some segregated elements, such as Mg or S in their core were just detected among 210 spheroidal graphites by SEM-EDS method. The cross-sectional TEM thin sample for these spheroidal graphites was prepared by FIB method and its TEM bright field image was shown in Fig. 2. This is a part of cross section of spheroidal graphite, and it consisted of many small areas like as mosaic. The width of these small areas close to the center is narrower than those of outwards.

A series of SAED patterns presented in Fig. 3 were obtained from each area of spheroidal graphite marked by (1) - (12) in Fig. 2, and all of them were indexed as the graphite structure. It shows that the c-axis of each area of spheroidal

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graphite is parallel to radius for outwards from the center. Also, the incident electron beam direction is nearly parallel to the <1120>direction of graphite, but it is rotating slightly.

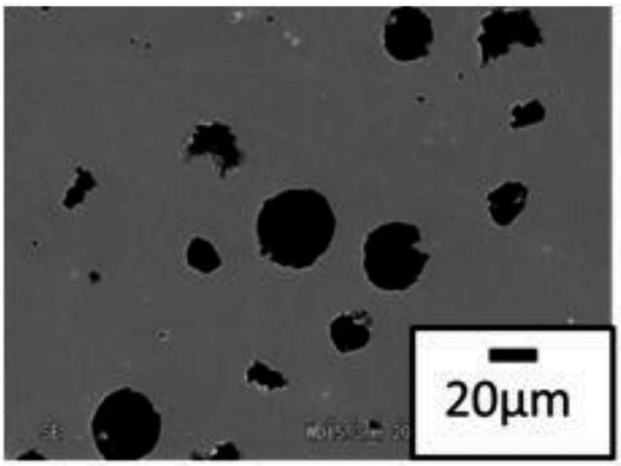

Fig. 1. Optical micrograph of a typical FCD450 sample

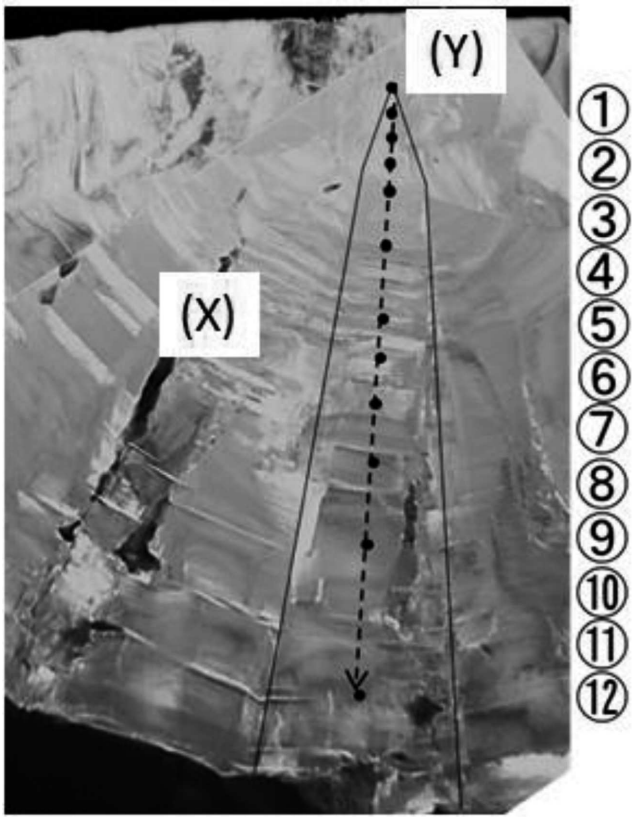

Fig. 2. TEM bright field image of a part of cross section of spheroidal graphite

Fig. 4 shows the results of EDS analysis for areas X and Y marked in Fig. 2. Fe peak was detected from the dark contrast of X, and Y shows just C. It seems that this spheroidal graphite includes γ-austenite during its growth process.

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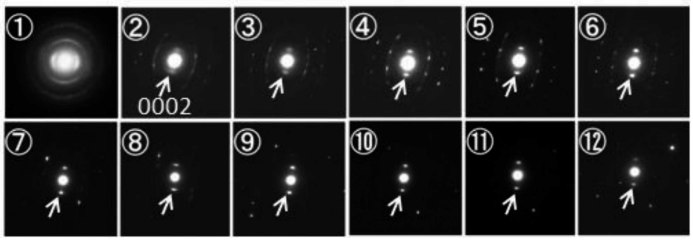

Fig. 3. A series of SAED patterns obtained from each area of spheroidal graphite marked by (1) - (12) in Fig. 2

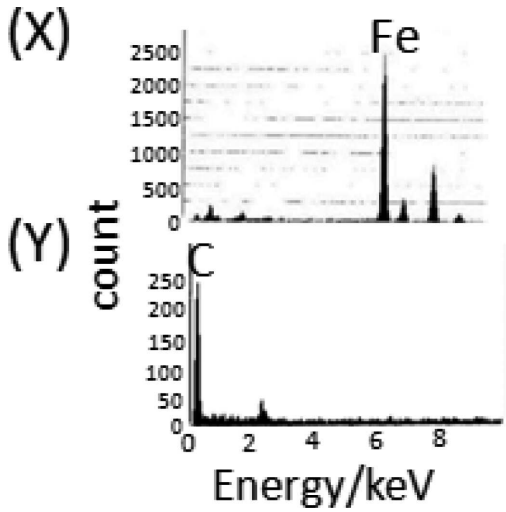

Fig. 4. EDS profiles obtained for areas marked by X and Y in Fig. 2

4. Conclusions

The cross sectional TEM samples of spheroidal graphites in FCD450 were prepared by FIB method and investigated by TEM to understand its structure. The spheroidal graphite consists of many small areas like as mosaic, and the width of these small areas close to the center is narrower than those of outwards. According to a series of SAED patterns obtained from each area of spheroidal graphite and EDS analysis, all of them were indexed as the graphite structure. The γ-austenite was included inside spheroidal graphite.

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