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Crystal Orientation Analysis of Pure Tin Damaged by Cavitation Impact

キャビテーションにより損傷を受けた純スズの結晶方位解析

Shinobu Sugasawa† (National Maritime Research Institute)
菅澤　忍†（海上技術安全研究所）

1. Introduction

Collapsing bubbles generated in a cavitation phenomenon have large energy and release this energy in short time. As a result, strong impact not only occurs but also various physical and chemical actions are induced. One of the actions makes the surface of solid materials damaged. This damage is called "cavitation erosion" in general, so that plastic deformation and fatigue occur in the materials. The author studied the state of damaged pure metal and alloys from microstructural point of view using EBSD (electron back scattering diffraction) method.[1)] We observed under a damaged surface that the crystal orientations of grains in eroded area changes compared with those in no eroded ones and that grain refining occurs. The effect of grain refining was remarkable for copper[2)] and aluminum[3)] whose crystal system are face center cubic. Grain refining is thought to be characteristic to f.c.c. metals. However, it is unclear whether these effects occur in other crystal system. One of the purpose of our research is to make clear this question.

In this paper, we study the grain refining effect on pure tin, which belongs to tetragonal crystal system, by cavitation impact, observe the state of grains, for example crystal orientation and KAM value, of pure tin using EBSD method, and compare the results with that of pure aluminum.

2. Experimental Methods

The dimensions of a specimen and experimental set up were similar to our previous study. The shape of specimen was a plate of the size 20 x 20 x t2 mm^3 and made of pure tin (Sn > 99.9 mass%, Nilaco Coop.) and the surface of the specimen exposed to cavitation bubbles was polished until the surface became mirror planed; the cavitation experiment was done based on ASTM G32 standards where the frequency and amplitude of the vibration was 20 kHz and 50 μm p-p, respectively; the specimen was fixed by a holder in water in such a way that the vibrating surface was parallel to the specimen; the temperature of water was controlled to 25 ± 1°C and the distance between the specimen and the surface of the horn was 0.5 mm; the test time was 10 min. After the experiment, the mass loss of the specimen was 80.47 mg. The cross section of the damaged surface of the specimen was polished by argon ion etching and observed using FE-SEM and the crystallographic analysis of the cross section was done by the EBSD device attached to the FE-SEM.

3. Results and Discussions

First of all, a specimen before a test was analyzed by EBSD. As a result, it was found that the specimen was polycrystalline where the diameter of grains distributed widely from 10 to 100 micrometers. Next, **Fig. 1** shows the surface of

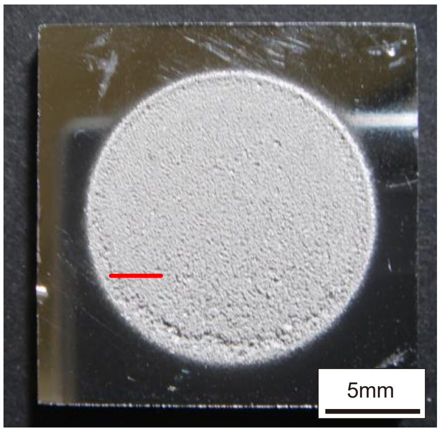


Fig.1 The surface of the specimen after test. The cross-section of the red line was observed.

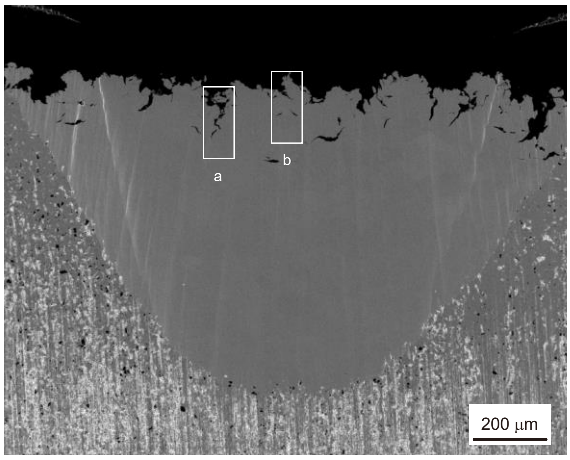
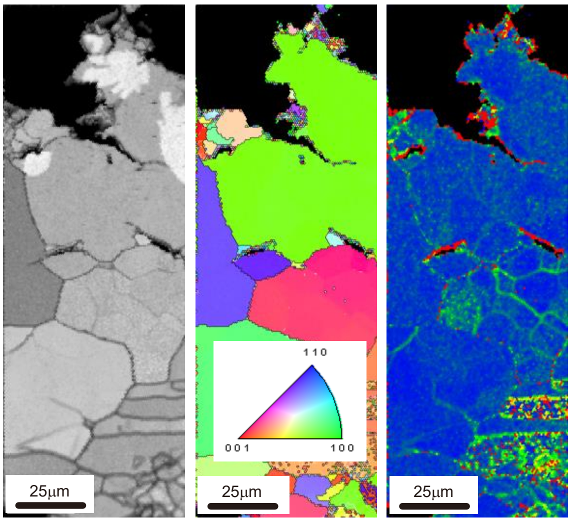


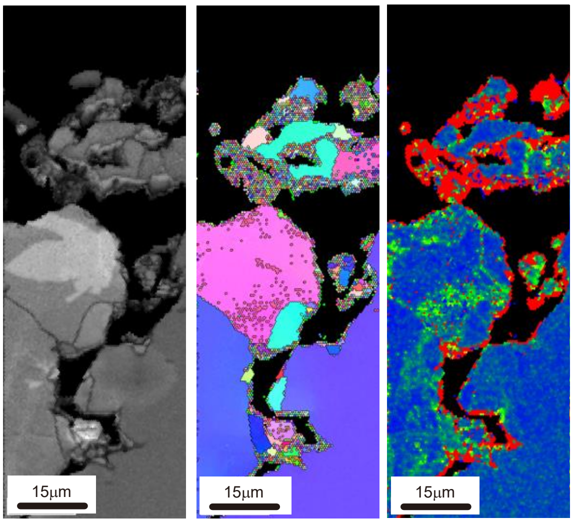
Fig.2 SE image of the cross-section cut along red line in Fig.1. Rectangle areas were analyzed by EBSD method.

the specimen after cavitation erosion test where the cross section along the red line in the figure was observed by EBSD method. The cross section that was observed by FE-SEM is shown in **Fig. 2**. Parabolic area in the figure was polished by argon ion etching, so that the surface of this area became smooth and flat, and distortion that had been introduced by mechanical grinding process was completely removed. Rectangle areas “a” and “b” were analyzed and the results are shown in **Fig. 3**.

Kernel average misorientaion value (KAM)[4] is largest in red area and smallest in blue one. Therefore, it is seen that the KAM on the eroded surface and cracks that are painted red are larger



(a) EBSD analysis of area “a”.



(b) EBSD analysis of area “b”.

Fig.3 The results of EBSD analysis of “a” and “b” areas in Fig. 2 (IQ: image quality map, IPF: inverse pole figure map, KAM: kernel average misorientation map).

than other area. It is thought that the force of destruction of specimen concentrates only on the fracture face. On the other hand, grain refining effect in pure tin is seemed to be ambiguous when compared with pure aluminum. Though the gray lines of IQ maps and the green lines of KAM maps suggest the existence of grain boundaries, there does not exist the corresponding ones in IPFs. Grain refining in pure tin might be thought difficult to occur. On the other hand, it will be worth considering next possibilities. Recrystallization temperature of tin is room temperature. Since heat generates when argon ion beam collides with specimen, the temperature on specimen increased. Therefore, recrystallization is seemed to occur in argon ion etching polishing process. To confirm this hypothesis, we prepared a specimen such that the accelerating voltage of argon ion became lower than that of the specimen discussed now. The result directly under the eroded surface is shown in **Fig. 4**.

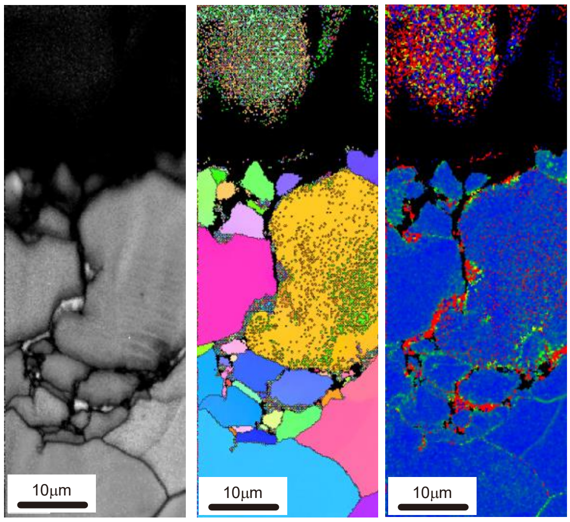


Fig.4 The results of EBSD analysis of specimen polished by lower accelerating voltage of argon ion than ones discussed above.

It is seen that the correspondence between IQ, KAM and IPF improves, so that it is considered that there also exists grain refining effect in pure tin in the same way as copper and aluminum.

References

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