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Crystal Orientation Analysis of Pure Aluminum Damaged by Cavitation Impact
キャビテーションにより損傷を受けた純アルミニウムの結晶方位解析

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1. Introduction

One of actions caused by collasped bubbles generating when cavitation arises in fluid is such strong impact on materials that are made damaged by this impact, so that plastic deformation and fatigue occur in the materials. This damage is generally called ‘erosion’. The author investigated the state of eroded pure metal and alloys from microstructural point of view using EBSD (electron back scattering diffraction) method,[1)] and found under a damaged surface that the orientation of a grain changes from that of no erosion, a grain is refined and so on.[2)] The effect of grain refining was remarkable for copper whose crystal system is face center cubic. It seems that grain refining is characteristic to f.c.c. crystal. One of the purpose of our research is to make clear this supposition. Though our previous study treated alluminum that is also f.c.c., the test time of cavitation erosion test was not enough to show grain refining of the alluminum.

In this paper, we show that grain refining occurs in alluminum by cavitation impact and observe the state of grains of alluminu using EBSD method.

2. Experimental Methods

The specimen used in our experiment was a plate of the size 20 x 20 x t2 mm^3 and made of pure alluminum (Al > 99.999 mass%, Nilaco Coop.). The surface of the specimen exposed to cavitation was polished until the surface became mirror planed. The cavitation experiment was carried out using vibratory instrument based on ASTM G32 standards where the frequency and amplitude of the vibration was 20 kHz and 50 μm p-p, respectively. **Figure 1** shows the schematic diagram of the experiment; the specimen was placed in water parallely to the vibrating surface of the ultrasonic horn of the instrument that generated cavitation bubbles; 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 cavitation imact was imposed on the specimen for 10 min. After the experiment, the cross section of the damaged surface of the specimen was observed by a FE-SEM and the crystallographic analysis of the cross section was done using a EBSD device attached to the FE-SEM.

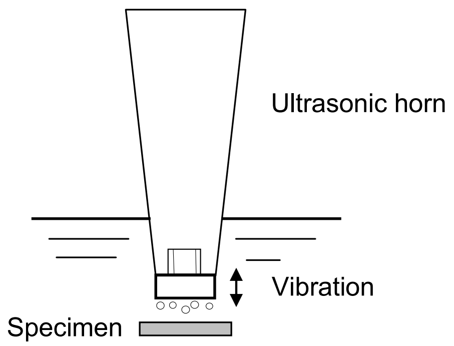

Fig.1 Schematic diagram of experiment

3. Results and Discussions

In the first place, grain boundaries were not observed in the area distant from the damaged surface the specimen and the crystal directions were almost constant, so that the specimen before damaged by cavitation was considered as nearly a single crystal.

The COMPO image of the cross section of the specimen after experiment and the analyzing area of EBSD are shown in **Fig. 2** where the damaged surface is upper side. Grain boundaries are not found in COMPO image. The result of EBSD analysis of the rectangle area in **Fig. 2** is shown in **Fig. 3**. It is seen that since the dark lines of the image quality (IQ) map almost correspond to the grain boundaries of the inverse pole figure map (IPF), grain refining occurs in the grains. In addition to this, **Fig. 4** shows the analysis done in other area that is not contained in **Fig. 2**, but similar grain refining effect is observed. Therefore, it follows that grain refining that was also observed in copper[2)] occurs in pure aluminum by cavitation impact. It is thought that the origin of this phenomenon is to have the same f.c.c. crystal system between copper and aluminum.

On the other hand, although darker lines are

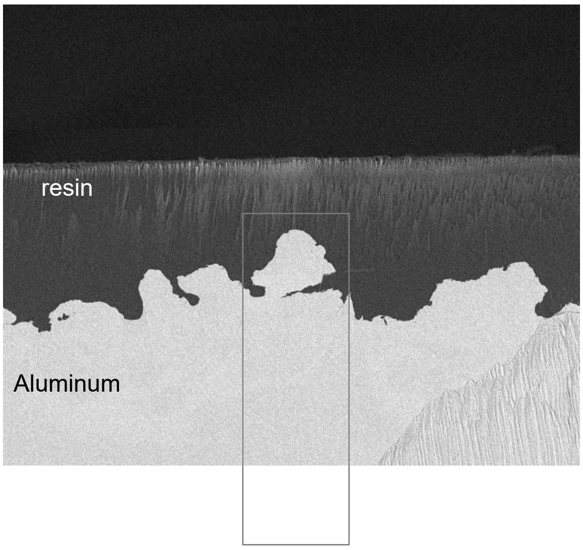

Fig.2 COMPO image of cross section of damaged surface that is protected by resin and rectangle area where EBSD analysis is applied.

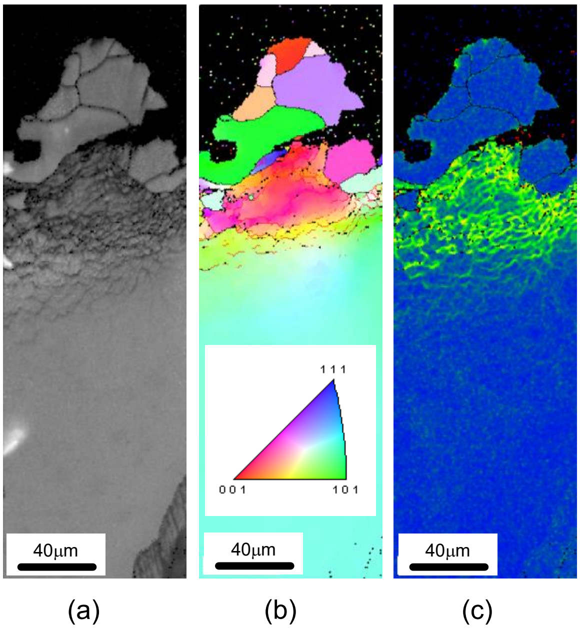

Fig.3 EBSD analysis of rectangle area in Fig.2: (a) image quality, (b) inverse pole figure, and (c) kernel average misorientation.

observed in IQ map, there exists an area in which these lines do not correspond to grain boundaries in IPF map. It is observed from **Figs. 3(c) and 4(c)** that in the area nesting these lines in IQ map, kernel average misorientation (KAM) value is larger than that of the area surrounding this area. It is thought that plastic deformation occurs in this area.[3)]

Moreover, although there does not exist grain boundaries in the area having larger KAM values, it is observed that the crystal orientation in this area changes continuously. However, the change of crystal direction in such grains that have already refined is not remarkable.

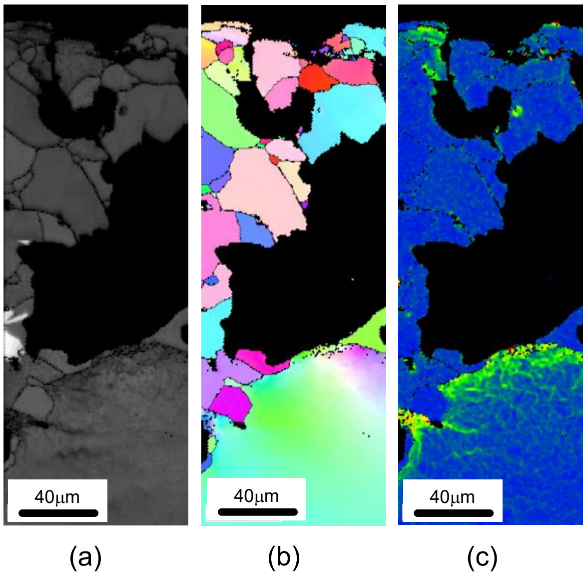

Fig.4 EBSD analysis in different area from that in Fig.2: (a) image quality, (b) inverse pole figure, and (c) kernel average misorientation.

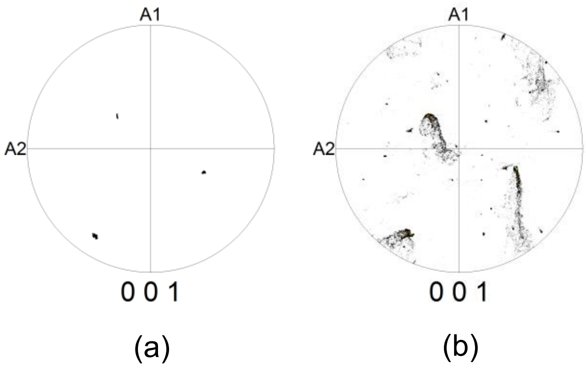

Fig.5 Comparison of pole figures: (a) undamaged region, (b) damaged region of the rectangle in **Fig. 2**.

Finally, the pole figure of the rectangle area in **Fig. 2** that is damaged is compared with that of an undamaged region, and the result is shown in **Fig. 5**. The distribution of the crystal directions of undamaged region indicates a fixed direction. On the other, the crystal directions of damaged region does not distribute randomly, but changes gradually and regularly from the fixed direction of undamaged region.

References

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