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Column-like Structure Observed in Aluminum-Copper-Iron Alloy

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Al_{60} Cu_{25} Fe_{15} is a well-known alloy forming stable quasicrystal structures [1]. It has been reported that, depending on the accurate composition and preparing process, the precipitated phases in the vicinity of this composition are different [2]. Alloys with this composition are typically prepared by arc melting. The microstructure resembles regular alloys with grains of irregular shapes packed densely, though some particles with pentagonal facets have been reported [1]. In the present study, three types of particles with distinct surface morphologies have been observed and the study of one type is reported here.

The alloy with Al_{60} Cu_{25} Fe_{15} nominal composition was prepared by arc melting. The ingot was found to be porous. On the free surface, particles with three distinct surface morphologies have been observed. As shown in the Scanning Electron Microscope (SEM) image in Fig. 1, Column-like and sphere-like particles and particles with distinct pentagonal facets have been observed. Because of the pentagonal facet and the composition of the present alloy, the third type of particles is considered as icosahedral quasicrystalline particle (i-particle). Representative particles of these three types are marked with arrows as c, s, and I, respectively. It should be noticed that Fig. 1 is a combination of SEM images from two fields, the left upper corner and the rest of them, to show three types of particles simultaneously. To our knowledge, the column-like structure has not been reported on and will be the focus of the present study.

The crystal structure of the column could be icosahedral quasicrystal with the 5 fold rotational axis in the length direction of the column based on composition consideration. This is the conjecture of the experiment being conducted. In this case, it is interesting to find out how the supposed pentagonal cross-section of each column tessellate with each other. First, the exact shape need to be examined. Since the image of column in Fig. 1 corresponds to side view, the column-like structure could be just a folded sheet. A cross-section view will not only answer the question of Column vs sheet, but also reveal the shape of the column cross-section if they are indeed column. In a long run, such information will serve as the basis to discuss the formation mechanism of the column-like structure and its potential importance.

This is more complicated than simple cutting through the columns for the following reasons. The column-like structures are very small, most occurrences of them being approximately one hundred micrometers across. Also cutting marks could disrupt or destroy the integrity of the desired cross section. A study was conducted to determine the rate at which material could be safely removed from the sample using sandpaper so that the column-like structures were not sanded away before they could be analyzed. An alloy section sample was chosen which was similar in dimension to the sample with the column structures without any visible column structures of its own. Tests were done with several different grain sandpaper and eventually the right sandpaper was selected for the task. With a complete understanding of the cutting rate of the abrasive, the alloy was sanded down in such a way that we were able to obtain images that showed us a cross section of our alloy. An image was taken of the ends of the column-like structures

revealing a fairly smooth surface achieved using 0.5 μm diamond paper and light pressure as shown in Fig. 2. While further efforts will be made to improve image quality, the areas with dark contrast on Fig. 2 are considered as the cross-section of individual columns, implying that the features observed are column structures.

It has been planned that the relative orientation of the column-like structure to the top and bottom of the alloy ingot prepared by arc melting will be studied. The composition will be studied by using Energy Dispersive X-ray analysis. And the crystal structure will be examined by Electron Back Scattering Diffraction and Transmission Electron Microscopy. Summarizing these results will enable a better understanding for the formation mechanism of this novel structure. [3]

References:

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[3] The authors acknowledge funding from the National Science Foundation (DMR-1229063 AND DMR-1461607).

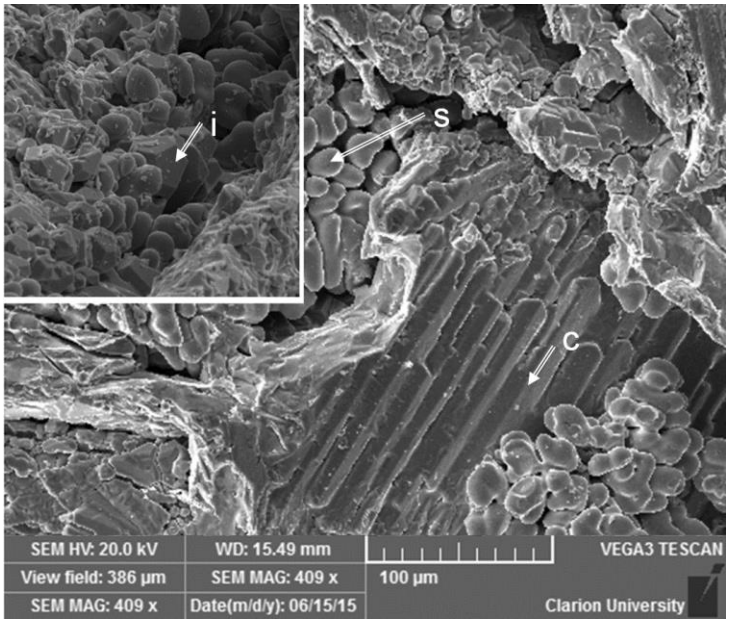

Figure 1. SEM images showing the i-, sphere-like, and column-like structures.

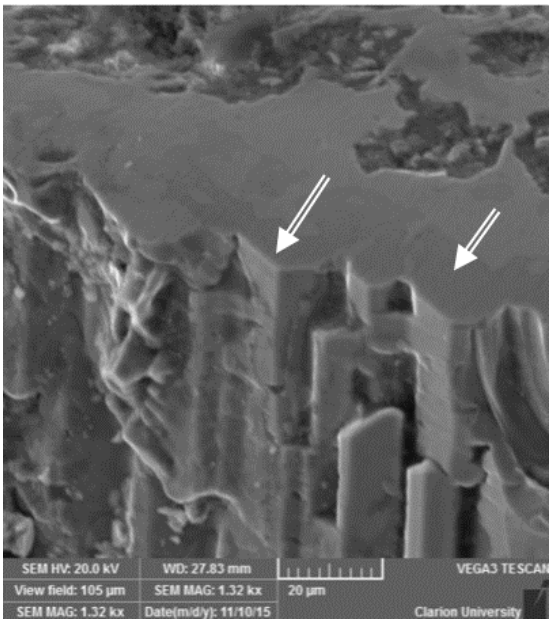

Figure 2. High magnification SEM image showing the cross-section of column-like structure.

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