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Spherical Particles in $Al_{65}Cu_{20}Fe_{15}$ Alloy Prepared by Arc Melting

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$Al_{65}Cu_{20}Fe_{15}$ alloy draws researchers' attention because of the report of stable icosahedral quasicrystalline (IQC) phase. Alloy with this composition prepared by arc melting consists of particles with different morphologies [1]. Among these, a type of particles of spherical shapes seems to be complicated and is closely involved in the precipitation of IQC. This type of particles have been considered as pure β phase in previous studies. Present study provides new insight regarding this spherical particle.

Alloy was prepared by arc melting pure Al, Cu, and Fe. The as-prepared alloy is porous. The alloy was fractured and the exposed surface of voids is examined by using a TESCAN Vega-3 XMU Scanning Electron Microscope (SEM). Transmission Electron Microscope (TEM) observation was carried out by using JEOL JEM-2100. Some TEM specimens were prepared by using Focused Ion Beam (FIB) of JEOL JIB-4500 multi beam system.

Fig. 1(a) shows a SEM image of a spherical particle. A TEM specimen was prepared from this particle and the corresponding TEM image in Fig. 1(b) shows a grain with different contrast from the rest of the matrix. Typical electron diffraction patterns (EDP) from the matrix and the internal grains are shown in Figs. 1(c) and (d), respectively. EDP of Fig. 1(c) was indexed by considering the τ crystal structure [2]. Diffraction spots on EDP of Fig. 1(d) lack of periodicity and the ratio of spacing between spots, such as OB/OA=1.64, corresponds to the golden ratio, demonstrating the IQC structure for the internal grain.

A TEM image of a different specimen prepared in a similar way is shown in Fig. 2(a), the right edge corresponds to the surface of the spherical particle. A layer in the order of one hundred nanometers on the surface is marked with an arrow. High resolution imaging revealed similar lattice fringes for the lower and out-most layers, shown in Figs. 2(b) and (c), respectively, implying same crystalline structure for the two layers. However, compositional difference is observed, as shown in the energy dispersive X-ray spectroscopy (EDS) of Figs. 2(d) and (e), from the lower and out-most layers, respectively.

In summary, the spherical particle is found to be of two phases, consisting IQC grains inside as core and single crystal τ phase as matrix. There are places the single crystal τ phase has more than one layer. The out-most τ layer has higher Cu concentration. Further, the surface of the particle is found to be faceted, the details of which will be explained. Models for the formation of spherical particles, the out-most layer, and the facets have been suggested.

References

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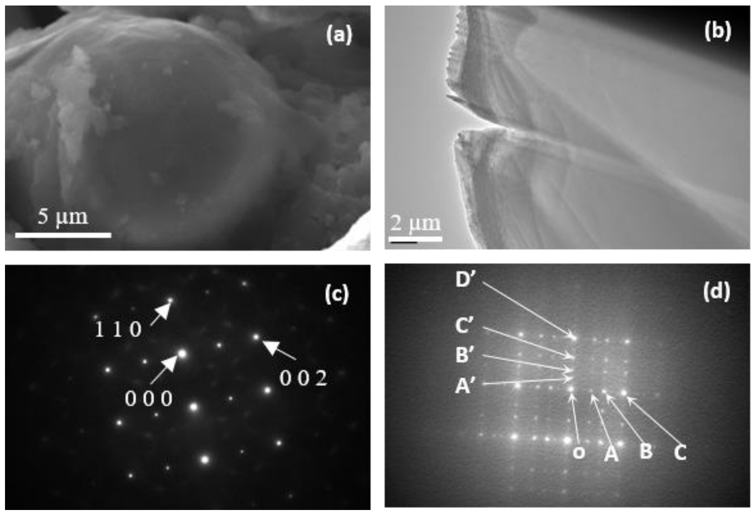

Fig. 1 TEM image (b) of a specimen prepared from a spherical particle shown in (a). (c) and (d) are EDPs from the matrix and internal grain, respectively.

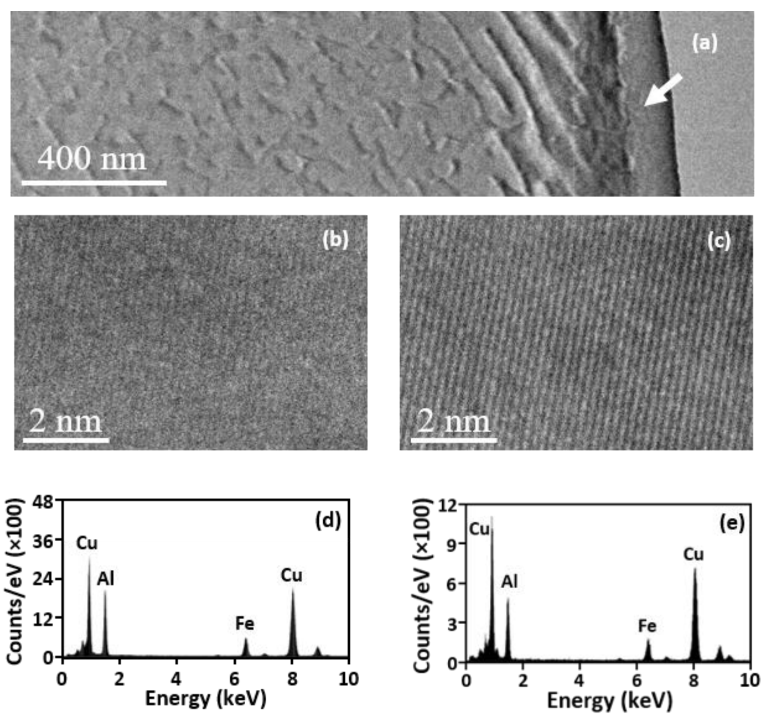

Fig. 2 TEM image (a) of a different specimen shows the existence of out-most layer marked with arrow. (b) and (c) are high resolution images from lower and out-most layers, respectively. (d) and (e) are EDS spectra from lower and out-most layers, respectively.