§35. Development of Radiation-resistant Cu Alloys towards Helical Reactor Divertor

Kasada, R., Konishi, S. (I.A.E., Kyoto Univ.),
Ukai, S., Oono, N. (Hokkaido Univ.),
Noto, H., Hishinuma, Y., Muroga, T.

Copper alloy to be used in the cooling tube of tungsten mono-block type diverter of ITER is believed to be not available in that of DEMO reactors because of the increase of neutron irradiation dose. In the recent helical reactor design study, however, neutron flux of the diverter position is suppressed within a few dpa. Therefore, there is a possibility of using copper alloys by improving the resistance to neutron irradiation. In order to improve irradiation resistance of copper alloys, this study aims to develop a promising oxide dispersion strengthened (ODS) copper alloy by using advanced mechanical alloying (MA) process.

MA of highly ductile copper powders are known to be difficult and will adhere to the MA container or balls at normal planetary ball mill and so on. This study examined a new MA method using a water-cooled high-energy ball milling apparatus introduced into Kyoto University. The new water-cooled high-energy ball mill so-called Emax, Retsch was used with stainless steel pots (capacity 125 ml) where the pot atmosphere was replaced with Ar gas by treating in a glove box. The oxygen concentration was adjusted to 1ppm or less. Outer surface temperature of the pots during MA became steady at about 42 ° C. The raw material powders purchased from Kojundo Chemical Laboratory was pure copper (99.9%) as average particle size 45 μm and yttrium oxide (99.99%) as average particle size 0.4 μm. To investigate the decompositon of Y_2O_3 into copper matrix by MA, X-ray diffraction (XRD) were performed using a strong X-ray diffraction device RINT-TTR-III of Rigaku Corporation.

XRD results before and after MA of Cu-1wt.%Y_2O_3 poweder mixture are shown in Fig. 1. It is observed that Peak height of Y_2O_3 decreased along with the MA time. Significant peak reduction in MA time of 24 hours indicates that Y_2O_3 is mostly decomposed. Further, in this time of MA conditions, it was possible to recover the whole amount of the powder by the water cooling MA process from the mass change before and after MA test shown in Fig. 2. It should be pointed out that the powder is aggregated to the size of the order of mm as shown in Fig.3. In order to produce the ODS-Cu alloy, it is necessary to proceed with the search of further MA conditions for preventing the aggregation using additional methods such as addition of lubricant and usage of hydrogen atmosphere MA. In the next year, the MAed powder will be consolidated by HIP (hot isostatic pressing) facility introduced in NIFS.

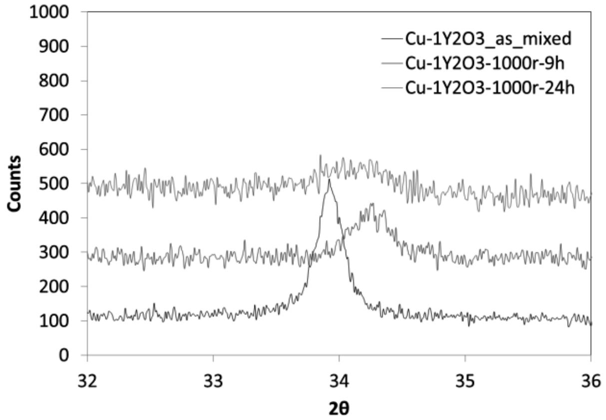

Fig. 1. XRD patterns of Cu-1wt%Y_2O_3 powders before and after mechanical alloying.

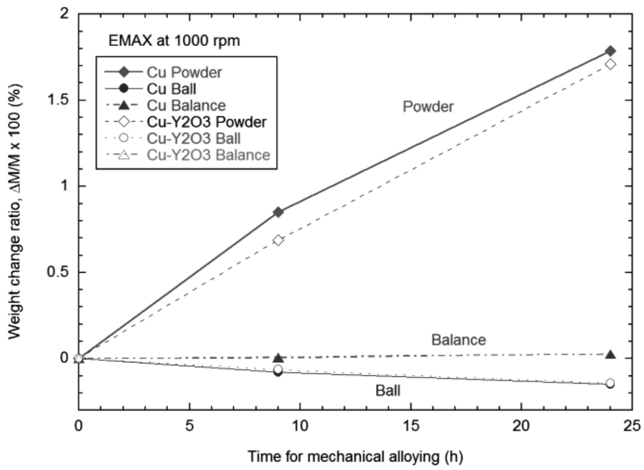

Fig. 2. Weight change ration of Cu-1wt%Y_2O_3 powders after mechanical alloying.

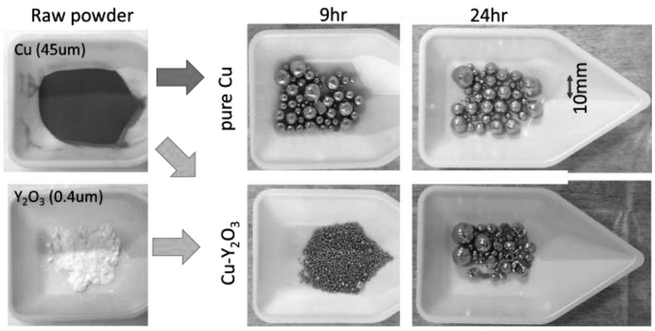

Fig.3. Morphology change of Cu-1wt%Y_2O_3 powders before and after mechanical alloying.