STATUS OF LARGE-AREA DISK TARGET DEVELOPMENT FOR ISOL FACILITY OF RAON

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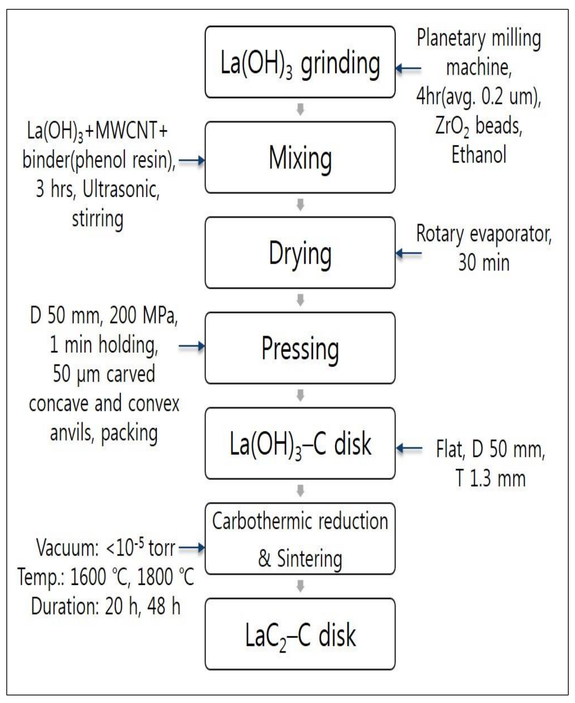
Abstract

The compound of uranium carbide (UCx-C) disk will be used as an Isotope Separator On-Line (ISOL) target for ISOL facility of Rare isotope Accelerator complex for ON-line experiments (RAON). Since uranium material has a radiation issue and lanthanum carbide has a similar chemical properties to uranium carbide, lanthanum di-carbide (LaC_2) was used to carry out a precedent research for optimal condition of fabrication process for UCx-C. Disks of LaC_2-C (Multi-Wall Carbon Nano-Tube, MWCNT) of 50 mm in diameter were fabricated and tested. The long-term high temperature test was carried out at 1600℃, 1800℃, and 2000℃. Test duration were 20 hrs and 48 hrs in each temperature condition. The disks of LaC_2-C were inspected and analyzed in regard of weight, diameter, micro-structure, composition and porosity. UCx-C disk of 50 mm in diameter have been successfully fabricated based on the LaC_2-C experiment. Microstructure of UCx-C has been examined, but more analysis is needed to confirm properties and to optimize the fabrication process.

Introduction

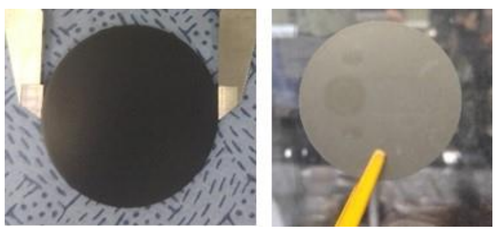
ISOL facility for RAON in Rare Isotope Science Project (RISP) is being developed. The UCx-C compound is investigated as the ISOL target. The specifications of UCx-C disk for RAON were designed as 70% in porosity (2.5 g/cm^3 in density), 1.3 mm in thickness, 50 mm in diameter and 0.5 μm (and less) in particle size of UCx. This specification is established to use the UCx-C disk in 10 kW proton beam power condition. The fabrication process of UCx-C is investigated because the disk is very thin with large surface area. Three widely features are needed for ISOL target; high porosity, high thermal conductivity, and good mechanical solidity in high temperature. In order to fulfill the required features, the disks should be fabricated by optimal process considering selection of auxiliary materials, dispersion time with specific frequency, compacting pressure, and sintering temperature with time. However, uranium material has lots of limitation for handling and doing research. Therefore, LaC_2-C compound was investigated as a precedent research of UCx-C target. The result of research for LaC_2-C and the status of UCx-C development is presented.

Precedent Research (LaC_2-C)



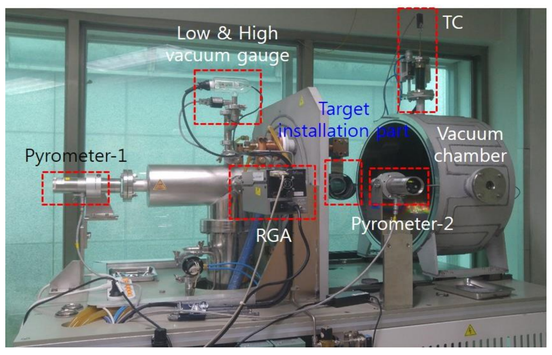
[Fig.1] Fabrication process of LaC_2-C.

LaC_2-C disks were fabricated according to the fabrication process in Fig.1. This process was established based on the ISOLDE (CERN) Nano-UCx fabrication process. High Temperature Integrity Test (HTIT) was carried out at 1600 ℃, 1800 ℃, and 2000 ℃. (for 20 hrs and 48 hrs at each temperature).



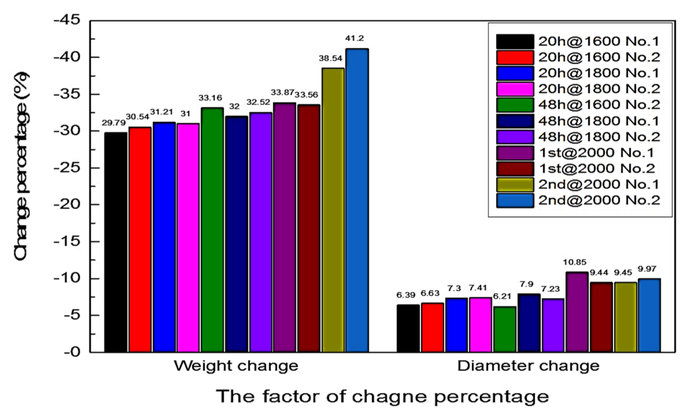
[Fig.2] Picture of the disk before (left, black) and after (right, gold) sintering.

The tests were carried out with sample disk in Fig.2. Color of the disk was changed from black to gold after sintering.



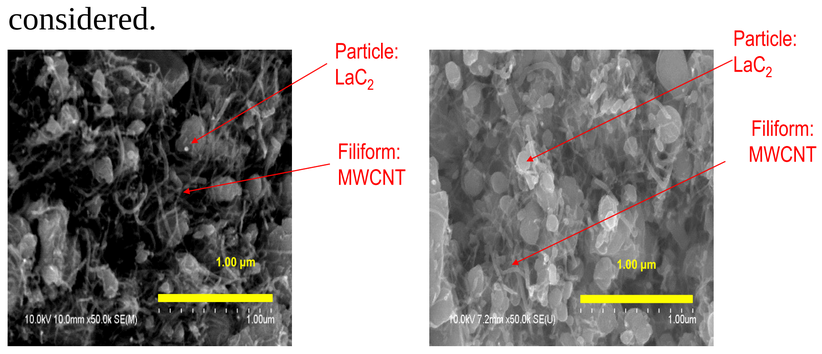
[Fig.3] Experimental set-up with vacuum furnace.

The vacuum furnace in Fig.3 and cylindrical type graphite container were used for the HTIT.



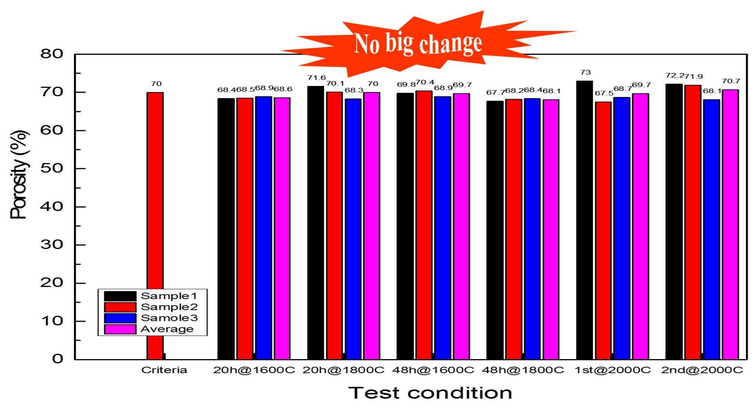
[Fig.4] Change of weight and diameter after sintering.

Weight and diameter of disks after sintering were decreased avg. 30% and avg. 7%, respectively [Fig.4]. In order to fabricate appropriate thickness and diameter of disk after sintering, the reduction effect should be considered.



[Fig.5] SEM image of the test at 1600 ℃ for 20 hrs (left) ,and at 2000 ℃ for 48 hrs (right)

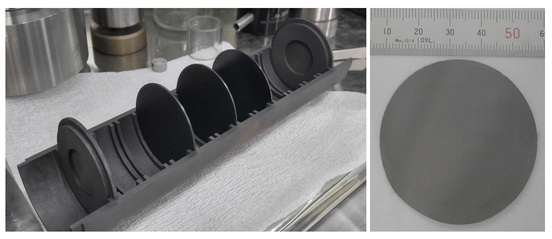
Microstructure of the disk is examined after sintering. As shown in Fig. 5, the LaC_2 particles were uniformly dispersed and they didn't grow even for the test at 2000 ℃.



[Fig.6] Porosity result of the test.

Fig.6 shows the porosity results of the HTIT. However, there is no big change of porosity regardless of temperature and exposure time to high temperature.

50 mm in dia. UCx-C target

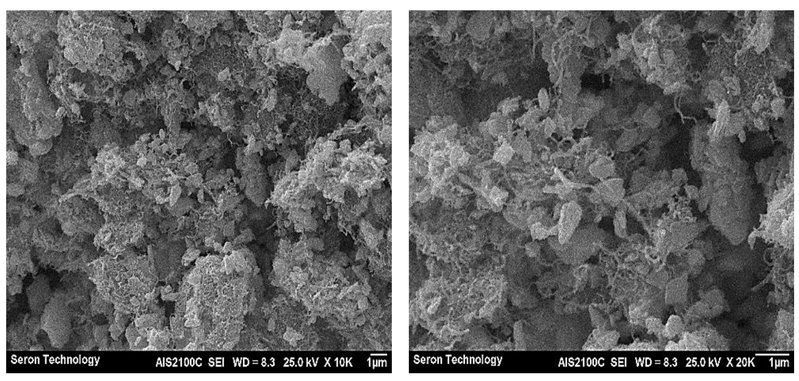


[Fig.7] UCx-C samples.

UCx-C disks of 50 mm in diameter have been successfully fabricated (sintered at 1650 ℃) by the similar fabrication process of the LaC_2-C disk, which is based on the fabrication process of Nano-UCx at ISOLDE (CERN).[Fig.7]

[Fig.8] UCx-C disks in glove box.

U_3O_8 (Depleted, KEPCO NF.), MWCNT (NC3100, Nanocyl), Phenolic resin as a binder, and ethanol as a solvent were used to make green disk of UCx-C at a compacting pressure of 200 MPa. The sintered UCx-C disk is highly inflammable when it is exposed to the air with high humidity. Therefore, the disks were handled in glove box with Ar gas [Fig.8]. The way of transportation of UCx-C disks after sintering has to be devised to avoid moisture atmosphere in operation stage.



[Fig.9] SEM image of UCx-C disk after sintering.

Fig.9 shows the result of SEM analysis. UCx particles seem to be well spread in MWCNT but not as much as LaC_2-C case. UCx-C disk of 50 mm in diameter has been successfully fabricated but further study and analysis is needed to confirm properties and to optimize the fabrication process.

Summary

- Large-area disk target of LaC_2-C has been investigated as a precedent research for UCx-C ISOL target in IBS/RISP.
- LaC_2-C disk was fabricated and long-term high temperature integrity was tested.
- The properties of LaC_2-C disk was inspected by XRD and SEM. The LaC_2 particles are spread uniformly in most area of MWCNT. The weight loss and the diametral shrinkage of the samples after sintering were calculated to be about 30% and 7%, respectively.
- The UCx-C disks of 50 mm in diameter were successfully fabricated (sintered at 1650 ℃). Intact UCx-C disks after sintering was acquired. However more analysis is needed to investigate the properties and to optimize the fabrication process.
- On-line test for performance validation of UCx-C target will be conduct after development of the fabrication process.