Development of carbon disk at the final stripping section

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The rotating disk stripper at the final stripping section has played a significant role especially in providing a high-intensity and stable U beam since 2012, owing to the discovery of the Be disk[1,2,3,4]. However, the heat load caused by the increasing beam intensity led to the deformation of the Be disk after a short irradiation period. We needed to look for other candidates to replace the Be disk.

In the autumn of 2014, we attempted to polish a glassy carbon (GC) disk using the polishing technology applied for the Be disk. The GC disk has good properties of high heat resistance, high mechanical strength, and fine-grained structure. This GC disk (model number F-22) had a density of 1.93 $g \cdot cm^{-3}$. The thickness of the disk for operation was 0.085 mm, which was reduced from a 1-mm-thick disk by diamond polishing. Tanken Seal Seiko Co. LTD[5] provided the disk material and machining was carried out by Crystal Optics Inc[6].

Around the same time, a highly oriented graphite sheet (GS) fabricated by Kaneka Corporation[7] was tested as a stripping material. They provided a sample of GS with a thickness of 0.035 mm (7.1 $mg \cdot cm^{-2}$) with a density of 2.0 $g \cdot cm^{-3}$. This GS was made from a polymer sheet under high-temperature and high-pressurized conditions. A prominent feature was the high thermal conductivity of 1500 $W \cdot m^{-1} \cdot K^{-1}$ in the plane direction. In addition, the GS had a high thermal diffusivity of 9.0 $cm^2 \cdot s^{-1}$, which was greater than copper or aluminum. Therefore, the rise in temperature at the beam spot position was suppressed. Besides that, the non uniformity in the thickness was half of the Be disk. The GS was mechanically strong and could be handled easily using scissors or a cutter knife. The GS was stacked as two layers to make a 0.07-mm-thick disk and was cut with an outer diameter of 110 mm.

In October 2014, we tested these two new disks (GC and GS) with the U beam. The charge distributions of the GC and GS disks were almost the same as the Be disk (Fig. 1.). The beam profiles downstream of the stripping section were also the same as the Be disk, which indicated that both disks were applicable for beam operation instead of the Be disk.

We successfully obtained two types of carbon disks, and the GS disk was used for the U beam from March to May[8], and it was used again from October to November in 2015. A total of 2.19×10^{18} U particles with a maximum intensity of 17.5 eμA were irradiated on the GS disk. The heat load maximally became 240 W. This total amount of the irradiated U particles was twice the amount of the Be disk when its lifetime was over. Nevertheless, the GS disk was still usable. Figure 2 shows the photograph of (a) the new GS disk and (b) the disk after usage. No change in the appearance was observed except for a slight color change and deformation. It is evident that the GS disk has high durability.

The GS disk has shown the greatest performance and longest lifetime compared to all disks so far. The GS can be applied for multilayer disks with variable thickness. It is useful for the acceleration of other ion beams. The three-layer GS disk was already used for the krypton beam operation, and it successfully worked. The problem in the final stripping section was solved.

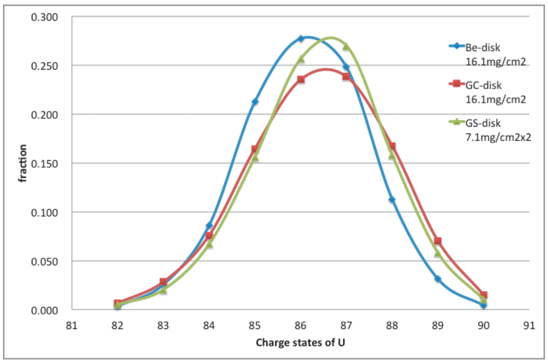
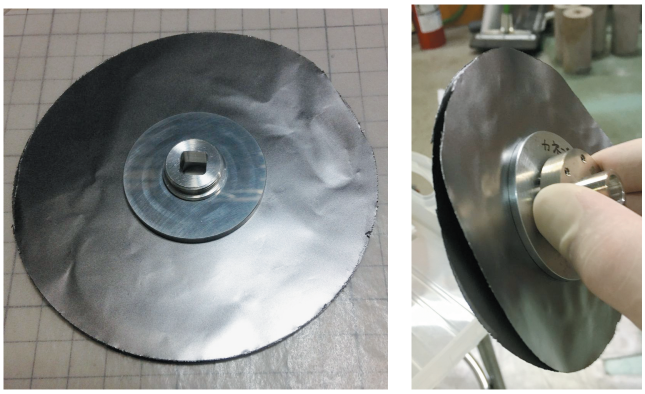


Fig. 1. Charge distributions of Be-, GC-, and GS-disks.



(a) (b)

Fig. 2. (a) New GS disk and (b) the disk after usage (slightly deformed).

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References

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