Development of thin graphite carbon (GC) disks†

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Graphite carbon sheet (GCS) disks have been used as the final charge stripper for U-beam acceleration since 2015 and have successfully provided stable U beams. Whereas the thickness of the GCS disk was 14 mg/cm^2 (two layers of 7.0-mg/cm^2-thick sheets)[1)], disks with a thickness less than 4.45 mg/cm^2 are also required for other ion beams. A graphite carbon (GC) disk with a thickness of 2.2 mg/cm^2 was fabricated for trial by Kaneka Corporation[2)]. The dimensions of the GC disk were identical to those of the GCS disk; the outer diameter was 110 mm with a hole at the center for mounting. The GC disk has sufficient flexibility and high mechanical strength considering its thickness. This GC disk was used for a Ca beam time in November 2015. The Ca^{16+} ions were stripped into Ca^{20+} with a fraction of 87% at an incident energy of 45 MeV/nucleon. A total of 3.31×10^{18} Ca particles were irradiated on one disk at 10-electric-μA intensity, which corresponded to a thermal load of 6.4 W. Fig. 1 shows the GC disk before (left) and after (right) Ca beam irradiation. There was no deterioration in appearance except for a slight color change and deformation. This deformation did not affect the beam intensity at the downstream. Therefore, the GC disk was still usable.

A thinner GC disk with a thickness of 0.91 mg/cm^2 has also been fabricated for trial use. Although its thickness was less than half that of the 2.2-mg/cm^2-thick GC disk, the mechanical strength was almost the same. This GC disk was tested for U-beam stripping at 50 MeV/nucleon in November 2015. In order to evaluate the thickness uniformity of the GC disk, the disk was rotated at a high speed, and the beam fluctuations were monitored at the downstream. The rotation speed was 300 rpm for the first 2 h, and it was increased up to 1000 rpm for five more minutes. No intensity fluctuation was observed during the measurement. In addition, charge distributions of U after passing through the GC disk was measured with the incident U^{64+} beam. The beam intensity was 10 electric μA, which corresponded to a thermal load of 8.5 W. Fig. 2 shows the GC disk after the test. No damage was observed, and it was in pristine condition. Fig. 3 shows the charge distributions of U after passing through GC disks with thicknesses of 0.91 (blue) and 2.2 mg/cm^2 (green), and a GCS disk with a thickness of 14 mg/cm^2 (red). The mean charge states of U behind the disks with thicknesses of 0.91, 2.2, and 14 mg/cm^2 were 78+, 82+, and 87+, respectively.

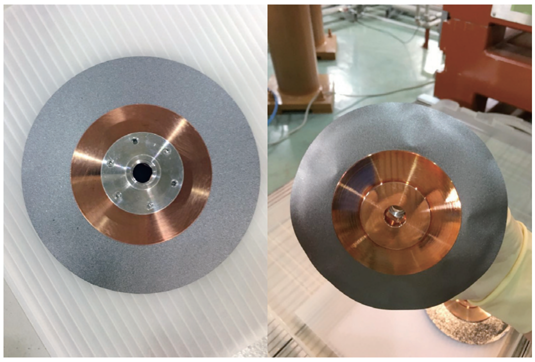

Fig. 1. GC disk with a thickness of 2.2 mg/cm^2 before (left) and after (right) usage in Ca beam irradiation.

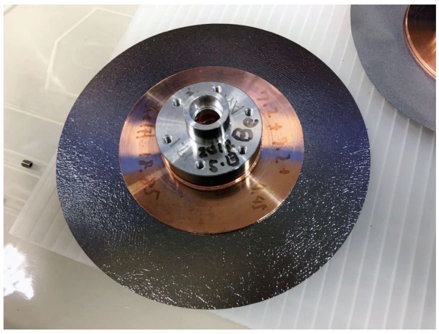

Fig. 2. GC disk with a thickness of 0.91 mg/cm^2 after the U beam irradiation test.

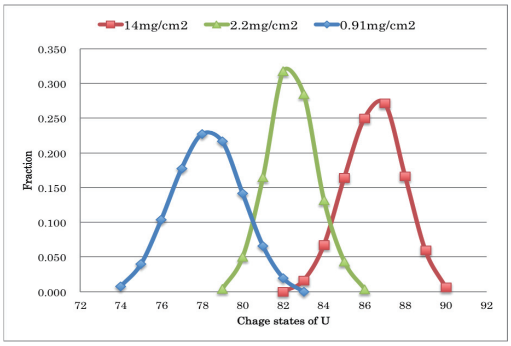

Fig. 3. Charge distributions of U behind GC disks with thicknesses of 0.91 (blue) and 2.2 mg/cm^2 (green), and a GCS disk with a thickness of 14 mg/cm^2 (red).

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References

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