Improved-flatness beryllium disk stripper for uranium acceleration at RIKEN RIBF

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We have successfully provided a stable uranium beam during long-term operation in November 2012 (totally 1.18 × 10^{18} particles in 37 days) using a rotating beryllium disk stripper with a thickness of 0.1 mm as the second stripper. The number of irradiating particles and disk conditions are summarized in Table 1 along with those of other disks described below. This first used Be disk is denoted as Disk 1 in the Table. However, emittance growth due to the nonflatness of the disk exceeded the accepted levels for subsequent cyclotrons (IRC, SRC)1.

To realize flatter disks, we prepared a Be disk subjected to diamond polishing (Disk 2) in March 20132). Also, disk thickness was reduced from 0.1 mm to 0.085 mm, which was suited for the IRC injection energy. Therefore, transmission efficiencies of the IRC and SRC were improved. The Be disk was still usable even after the totally 9.29 × 10^{17} U-particle irradiation during the 30-day beam time operation.

Disk 2 was used again for the U beam time in March 2014. The lifetime of this disk ended and was determined to be additional 21 days (Fig. 1: Right). The total number of U beam particles was 1.68 × 10^{18} during 51 days (including 30 days in 2013) as written in Table 1. Many cracks were observed along the beam irradiation traces.

The Be disk was replaced with a new one (Disk 3), which was identical to Disk 2 (0.085-mm-thick, diamond polished), for the remaining beam time. Irradiation with an additional 8.83 × 10^{17} U particles was carried out in 17 days. Beam transmission efficiency was improved, but since the thermal load to the disk was increased from 90 W to 230 W because of the increased beam intensity, the disk was greatly deformed. The difference in the deformation is shown in Fig. 1 (Right: Disk 2, Left: Disk 3).

In October 2014, we introduced the Be disk with a special design3) (Disk 4) to reduce the thermal deformation. Due to this improvement, this Be disk survived after the U beam time with approximately 9 × 10^{17} U-particle irradiation in 20 days. Main changes were as follows: 1) The outer diameter of the disk was 110 mm (from 120 mm), 2) 12 areas with cuts existed around the disk circumference, 3) the disk holder was made of copper (from aluminum) with an outer diameter of 65 mm, and 4) 12 holes with 2-mm diameter existed around the holder. Beam availability was further improved by the suppression of the beam fluctuation. The conditions of U beam irradiation are listed in Table 1 (Disk 4). This Be disk is still usable and exhibits no problem. Figure 2 shows the special-design Be disk: (left) new and (right) after usage.

Table 1. Summary of four Be disk used.

<table>
<thead>
<tr>
<th>Disk</th>
<th>Irradiation current</th>
<th>Total beam particle</th>
<th>Days</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk 1</td>
<td>4 - 5 epA</td>
<td>1.18×10^{18}</td>
<td>37</td>
<td>Many cracks</td>
</tr>
<tr>
<td></td>
<td>Not polish</td>
<td></td>
<td></td>
<td>Still usable</td>
</tr>
<tr>
<td>Disk 2</td>
<td>4 - 12 epA</td>
<td>1.68×10^{18}</td>
<td>51</td>
<td>Distortion and Many cracks</td>
</tr>
<tr>
<td></td>
<td>Diamond polish</td>
<td></td>
<td></td>
<td>Not usable</td>
</tr>
<tr>
<td>Disk 3</td>
<td>12 epA</td>
<td>8.83×10^{17}</td>
<td>17</td>
<td>Distortion, Slightly cracked</td>
</tr>
<tr>
<td></td>
<td>Diamond polish</td>
<td></td>
<td></td>
<td>Still usable</td>
</tr>
<tr>
<td>Disk 4</td>
<td>8 epA</td>
<td>9×10^{17}</td>
<td>20</td>
<td>Slightly: Distorted</td>
</tr>
<tr>
<td></td>
<td>Diamond polish</td>
<td></td>
<td></td>
<td>No crack</td>
</tr>
<tr>
<td></td>
<td>0.085-mm thick</td>
<td></td>
<td></td>
<td>Still usable</td>
</tr>
<tr>
<td></td>
<td>61 mm</td>
<td></td>
<td></td>
<td>No beam fluctuation</td>
</tr>
<tr>
<td></td>
<td>Special processing</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 2. (a) New specially designed Be disk and (b) after irradiation. Deformation was moderated.

References
2) PASCAL CO., LTD.
   URL: http://www.pascal-co-ltd.co.jp/home.html