PROGRESS OF THE RIST PROJECT

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Abstract

The status and progress of the Radioactive Ion Source Test (RIST) Project [1] is given. A tantalum target consisting of nearly 6000 foils, 0.0025 cm thick, cut into discs and washers has been diffusion bonded together to form a rigid structure and tested at temperatures up to 2300 K. Fins on the surface allow the target to dissipate over 23 kW of beam power. Progress of the separator and the target tests is given.

1. INTRODUCTION

Future advanced radioactive ion beam facilities will require more intense beams than currently available. At the world leading ISOLDE facility [2], the radioactive beams are produced by the impact of high energy, 1 GeV, protons of up to ~2 µA on various targets. The RIST Project is aimed at the development of a high power tantalum foil target and ion source to produce higher intensity radioactive ion beams than are presently available at ISOLDE by bombardment with proton currents of up to 100 µA. The test is to be performed in the target station of the ISIS Facility [3]. The specific aims are:-

a) To produce a tantalum target which will withstand up to 100 µA of proton beam. At this high power, ~23 kW, the target must be capable of maintaining a uniform temperature of 2000 to 2700 K.

b) To show that the radioactive beam currents are comparable with that from ISOLDE at the same proton current and scale with proton current.

c) To examine fluctuations of the high voltage on the target when the target is bombarded by intense pulsed proton beams.

This report gives the progress made towards achieving these goals.

2. TARGET CONSTRUCTION

The target is made from a stack of 0.0025 cm thick tantalum foil discs, spaced apart by washers. The thickness of the washers is adjusted to maintain uniform power dissipation along the length of the target. To dissipate the power by thermal radiation the thermal emissivity is increased by enlarging the

Figure 1. The diffusion bonded target assembly, with domed end caps and the central hole for the ioniser.

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diameter of some of the discs to create fins, 0.1 cm high spaced at 0.03 cm intervals along the length of the target. The whole assembly, with dished end caps, is diffusion bonded together by pressing at 800°C in a vacuum to form a rigid gas tight structure, 18 cm long. Figure 1 shows a photograph of the completed target and Figure 2 shows a schematic cross section of the target construction.

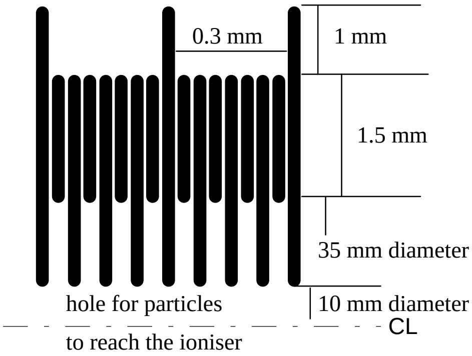

Figure 2. Schematic section of the target construction.

Five tungsten wire filaments surround the target and provide electron beams to heat the target to the required temperature.

The target and the filament assembly are enclosed within a water-cooled copper jacket to remove the heat. Figure 3 shows the assembly schematically.

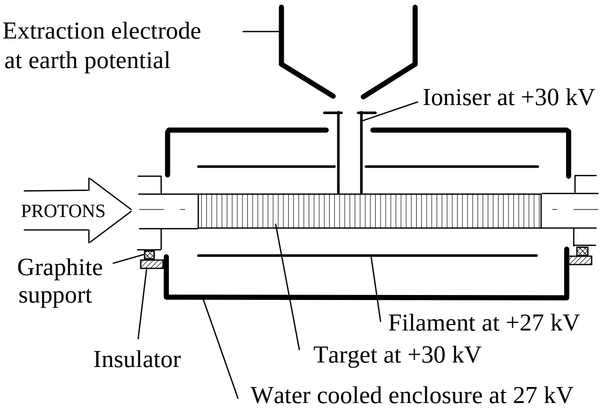

Figure 3. Schematic assembly diagram of target, ion source, filaments and extraction electrode.

3. THERMAL PERFORMANCE

The target has been heated by electron bombardment to temperatures of 2300 K at a power of 24 kW. This corresponds to a hemispherical total thermal emissivity of 0.72, the fins increasing the value by a factor of over 2 from that of a plain surface [4].

When the energy of the proton beam is dissipated in the target there will be radial temperature gradients across the foil discs and stresses set up in the target. To mimic this, a test section of target has been heated by an electron beam from a filament placed axially down the central hole. All the heat has to pass through the entire radius of the discs and this produces larger temperature gradients and stresses in the target than it will receive under normal proton beam bombardment. The diffusion bonds withstood this test up to the maximum specified power and temperature.

4. BEAM TESTS AT ISOLDE

Foil discs have been placed inside a standard ISOLDE target tube to simulate the RIST target geometry and the target run on ISOLDE at proton beam currents of up to 3 µA. The target was fitted with a standard tungsten ioniser. The yields of radioactive alkali metal and rare earth beams are comparable to those from the standard ISOLDE target. The release curves [5], which give the variation of the isotope current with time following a single proton pulse, are shown in Figures 4 and 5. The open squares are data from the standard ISOLDE target and the solid squares are from the RIST target. The vertical axis is

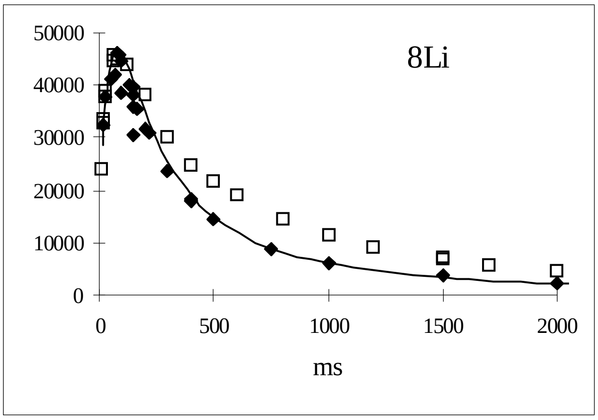

Figure 4. Release curve for ^{8}Li.

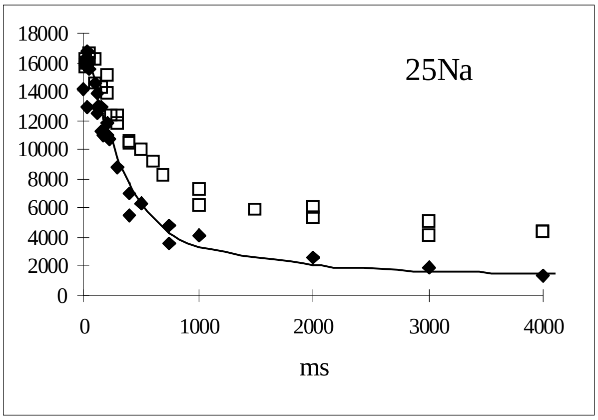

Figure 5. Release curve for ^{25}Na.

proportional to the isotope current: the data from the targets have been normalised at the peaks. In general, the RIST target exhibits faster responses than the ISOLDE target. The ISOLDE target is filled with short rolls of tantalum foils and the faster response of the RIST target is probably due to its more open structure, which increases the effusion rate. This improvement will be important in increasing the yields of rare short lived isotopes.

5. HIGH VOLTAGE TESTS

When the target is bombarded by large pulsed proton currents the high voltage on the target may suffer from current loading problems and the voltage fluctuate. This is not acceptable for a high resolution separator.

To simulate the effects, the proton beam from ISIS has been passed through the walls of concentric tubular electrodes in a vacuum at potentials up to 30 kV. The vacuum is effective in eliminating the problem to negligible proportions. However, the insulation on cables adjacent to the beam gave rise to severe voltage fluctuations during the proton pulses. This is presumed to be due to ionisation of the insulation by the intense radiation. The voltage could be stabilised by the addition of a sufficiently large capacitor.

6. CONCLUSIONS

Thermal tests on the target are continuing, but already it has been demonstrated that the target is dissipating over 23 kW equivalent to a proton beam current of 100 µA. With an emissivity of 0.72 the target could probably dissipate up to 45 kW at 2700 K.

The tests of the target with proton beam at ISOLDE are very encouraging. The very short proton pulses at ISOLDE are similar in intensity to that of ISIS. Therefore, it is to be expected that the yields obtained from the RIST target at ISIS will be similar to those at ISOLDE at the same pulse proton beam current. Furthermore, the yields are expected to increase with the repetition rate. Thus the yield will scale with the proton current.

In addition the ISOLDE tests show that the geometry of the RIST target is likely to favour the production of the short lived isotopes by reason of its faster response times.

The high voltage tests show that loading from the beam hitting the target itself will not be a problem with the target in a vacuum. The ionization of neighbouring insulators can be overcome by the addition of suitable capacitance.

Thus, it can be concluded that the experiments have successfully met the goals of the RIST project even before running the target and separator on ISIS. Indeed, it is arguable whether a test at high beam power in the ISIS target station is now necessary.

7. REFERENCES

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