TURN-KEY SOLID TARGETS IRRADIATION SYSTEM

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Abstract

A complete system for the irradiation of solid target materials including a target station, a transfer system, a receive station and a dedicated programmable logic controller is described. The target station allows solid targets, which are capable of intercepting up to 25 KW beam energy, to be placed at a variable angle of three to seven degrees during irradiation. Pneumatic target transfer to the hot cells uses compressed air and incorporates a hot cell receive terminal.

1 INTRODUCTION

A large percentage of medical and industrial radioisotopes is accelerator produced by bombardment of metallic target material. In its simplest form, a metallic foil is placed in the beam and retrieved manually with long tweezers. Most applications, however, require a more sophisticated approach.

Modern isotope production cyclotrons are capable of producing beam currents in excess of one milliampere and extracting the beams into multiple beam lines. External targets have almost completely replaced the antiquated practice of internal (placed inside the cyclotron) targetry. This approach allows the complete separation of the accelerator and targets, usually in separate vaults, permitting individual access and service.

The remote manipulation in placing the target in the beam path at the required position and angle, the connection of the coolant, and finally the retrieval to a hot cell for processing is the topic of this paper. The system described is the result of twenty years production experience and represents the latest generation of solid radioisotope production targetry.

2 TARGET

Metallic target material is deposited on a solid substrate by sputtering , electroplating or another method. For many materials the limiting factor is the target temperature during irradiation; it must obviously be kept below the melting point, but sublimation and delamination should be considered as well; 100ºC to 300ºC is the usual range.

To disperse the beam over a larger area and decrease the target material thickness, the target is designed to intercept the beam at a small angle. The angle can be pre-adjusted to 7º, 5º or 3º depending on the target design. The target is shown figure 1, together with the results of finite element analysis, which has been experimentally verified. The pure silver substrate features integral coolant channels optimized for coolant flow and power distribution. In this example the 200 microampere, 30MeV Gaussian beam, oval in shape, is truncated to a rectangle representing 80% of beam power.

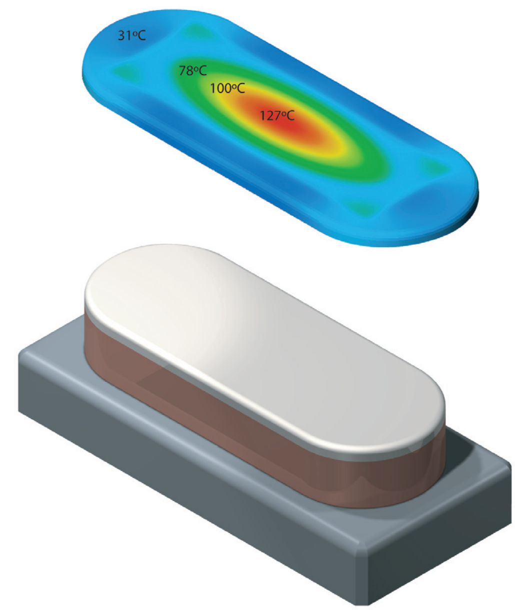

Figure 1. Target and FEA

3 HOT-CELL TERMINAL AND TRANSFER SYSTEM

The prepared target, once ready for irradiation, is placed inside a carrier (rabbit) for transfer to the irradiation station. Since the irradiated target on its return is radioactive, the sending terminal is usually located inside, or adjacent to the processing hot cell.

The sending terminal consists of two parts. A solid tube extending into the hot cell is connected to a pneumatic transfer line surrounded by a sliding sleeve that facilitates the placement of the target by the hot cell manipulator.
The transfer uses the plant's compressed air and does not require a dedicated blower. Distances of 30m and more can be accomplished with travel times of a few seconds. Travel progress is monitored en route by magnetic sensors placed around the transfer tube.

CP600, *Cyclotrons and Their Applications 2001, Sixteenth International Conference,* edited by F. Marti

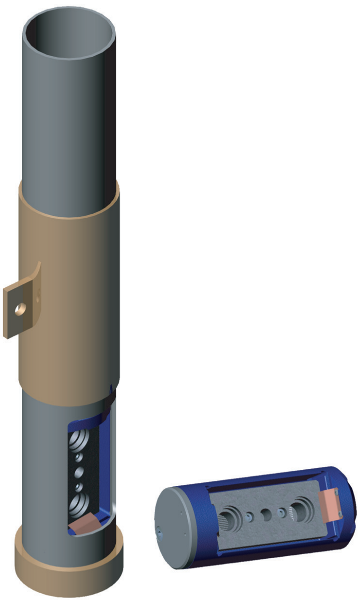

Figure 2. Sending terminal; extra target in carrier

4 TARGET STATION

The main objectives of the present design were increased reliability, minimized maintenance and reduction of the target station footprint. Special attention was given to the accurate collimation of the beam on target. Micrometric collimators are placed on all four sides of the target allowing very precise beam trimming. The collimators are water cooled and each is designed to withstand the full beam power for a limited time. This is important in case of a sudden beam shift during irradiation.

The three main modules of the station are the irradiation/vacuum chamber that supports the diffusion pump, the target flange and collimators, the landing terminal that receives the target in its carrier as it arrives from the hot cell, and the manipulator that removes the target from the carrier and places it in the irradiation chamber, connecting the coolant to the target at same time. Modular design simplifies the access and maintenance since the modules can easily be detached for replacement or service.

To minimize radiation damage and activation, only ceramic and metal, mostly aluminum, are used in the construction of the station. With the exception of the diffusion pump, all vacuum components including mechanical pumps, are placed outside the vault. The same is true for other devices, such as water flow controllers, valves, etc.

The overall view of the station is shown on the right and details of the chamber appear above.

The top port can be fi tted with a window allowing target observation with a CCTV camera during irradiation. This feature is useful for alignment, troubleshooting or development.

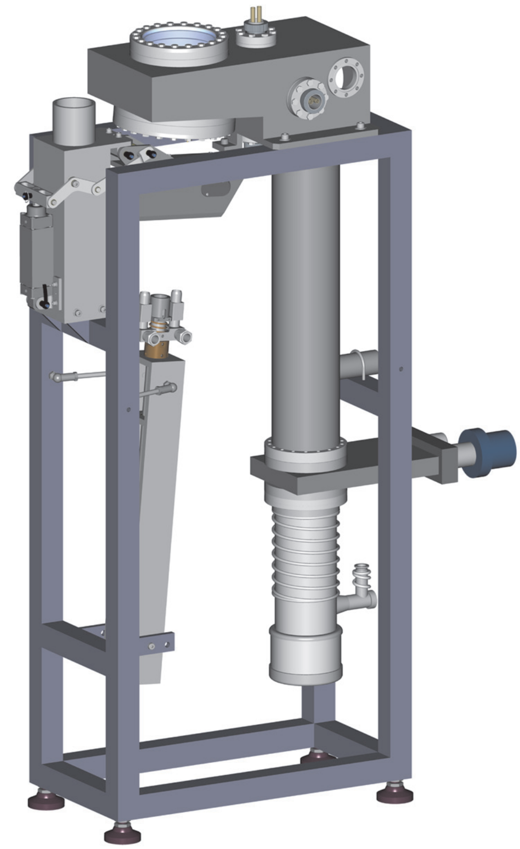

Figure 3. Target station

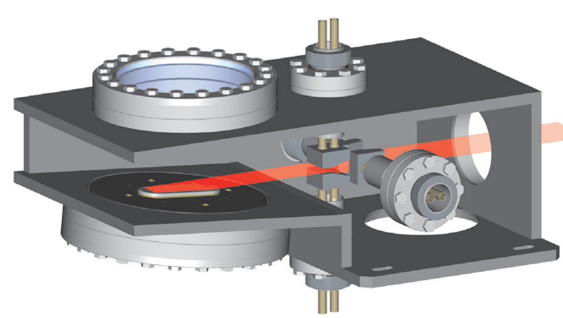

Figure 4. Vacuum chamber

5 CONTROLS

The entire operation of the system is controlled and monitored by a Programmable Logic Controller. Model T100MD1616 by "Trilogi" was chosen for its small size (20x120x300 mm approximately), low cost and fast response. It is supplied with an editor, compiler and simulator software for programming using simple ladder logic. The progress and status can be displayed on a PC. An additional expansion 16/16 I/O unit is easily added when required.

Each irradiation system, including its transfer line, is individually controlled by a dedicated PLC, thus avoiding complicated programming and minimizing the response time.

6 CONCLUSION

It is expected that this new system will exhibit improvements in both performance and reliability upon its installation. Both required maintenance and radiation exposure to personnel during maintenance should be reduced dramatically when compared to existing solid target systems. Two stations are planned for assembly and testing in 2001 on existing TR-30 beamlines, with four additional stations planned for the TR-30 expansion in 2002-2003.

7 REFERENCES

1. Gelbart, W. Z., Stevenson, N. R., Ho, W., Bakhtiari, S., "High Current Encapsulated Target and Target System for Radioisotope Production," Proceedings of 7th Workshop on Targetery and Target Chemistry, 1997, Heidelgerg, Germany

2. Bakhtiari S., Ho, W., Gelbart, W. Z., Stevenson N. R., "Encapsulated Target for Isotope Production Cyclotrons," Proceedings of 1997 Particle Accelerator Conference, 1997, Vancouver, Canada, pp. 3842-3844

3. Nortier, F. M., Stevenson, N. R., Gelbart, W. Z., "Investigation of the thermal performance of solid targets for radioisotope production," Nuclear Instruments & Methods in Physics Research Section A, 1994, pp. 236-241

4. Nortier, F. M., Stevenson, N. R., "Thermal Analysis of the TRIUMF Solid Targets", Symposium on Isotope Production and Applications in Medicine, Science and the Environment, Vancouver, Canada, 1993

5. Gelbart, W. Z., Stevenson, N. R., "High Current Targetry for Radioisotope Production," Targetry '91, Paul Scherrer Institut, pp. 52-3

6. J. J. Burgerjon et al., "A High-Power Target System for Radioisotope Production," Proc. 11th Int. conf. on Cyclotrons and their Applications, 1986, Tokyo

7. Pinto G. et al., "Target Systems for Radioisotope Production," Proceedings of 7th Conf. on the Applications of Accelerators in Research and Industry, 1982, Denton, Texas

8. Wong R., Gelbart W.Z., Stevenson N.R., Wong A., "Investigation of Thermal-Mechanical Properties of Solid Targets for Isotope Production" 3ICI, Third International Conference on Isotopes, Vancouver, Canada, 1999

9. Gelbart, W. Z. et al, "High Current Radioisotope Production with Solid Target System," Proceedings of the 1993 Particle Accelerator Conference, P. 3099-3101

10. Gelbart, W. Z., W. Ho, "The Design of the High Current Encapsulated Target System" TRIUMF Design Note TRI-DN-95-30