DEVELOPMENT OF SECOND GENERATION LIQUID METAL TARGET SYSTEMS

R. F. Welton, B. S. Morgan,[1] R. L. Auble, P. E. Mueller, D. W. Stracener, and C. L. Williams[1]

The next generation of liquid metal target systems has been designed and constructed for the production of Radioactive Ion Beams (RIBs) such as ^{69}As and ^{67}Ga, which are best produced from targets in the liquid state. These species are produced by proton bombardment of enriched liquid Ge through the ^{70}Ge(p,2n)^{69}As and ^{70}Ge(p,α)^{67}Ga reactions. The first design is based on the concept of suspending liquid target material on a metallic or carbide substrate in the form of a low density foam or "birds nest" of thin metallic wire creating a highly pervious structure. By utilizing a substrate which exhibits a high degree of adhesion with the liquid target material, μm scale coatings with vast surface areas can be achieved thereby reducing the mean diffusion length several orders of magnitude compared to traditional volume-type liquid targets. Wetting experiments performed in a bell jar have shown that fairly uniform coatings (10-100 μm) of Ge can be drawn onto fine Mo wire of similar dimensions provided the target reservoir enclosure exhibits a comparatively low degree of adhesion with Ge. Here, graphite was employed as the target enclosure. Materials must be chosen to insure that the heat of adhesion between the liquid/substrate (Ge/Mo) exceeds the corresponding values between the liquid/reservoir enclosure (Ge/C) and also exceed the corresponding values of cohesion for the liquid/liquid (Ge/Ge) system at the operating temperatures of the target. Coatings of a given thickness are achieved by introducing a calculated amount of Ge directly into the target material reservoir and heating the target and substrate to operational temperatures. Typically, a Ge-Mo system can be formed which is 90% porous, contains a mole fraction of less than 10% Mo and has a target surface area 10^2-10^3 fold greater than traditional volume-type liquid metal targets of comparable thickness. This configuration is illustrated in Fig. 1.

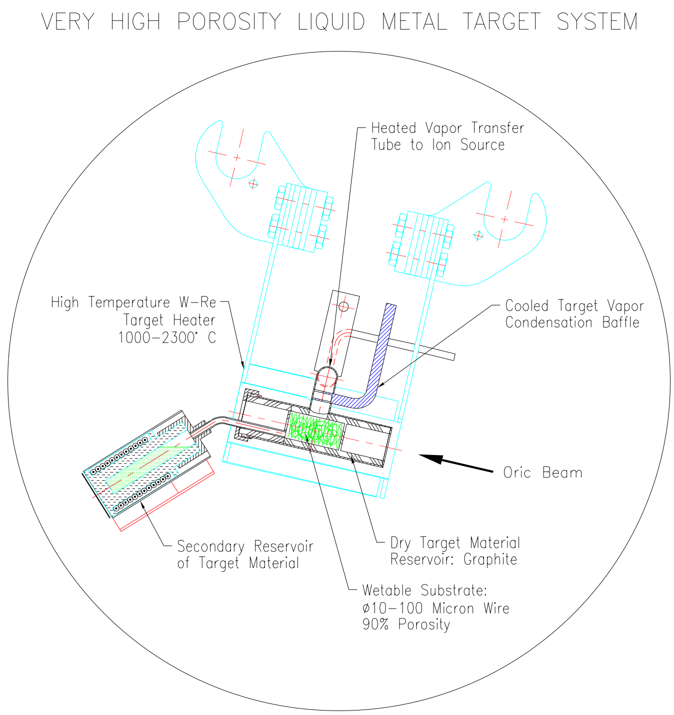

Fig. 1. Liquid metal target coated on thin wire substrate.

The second liquid target design, shown in Fig. 2, allows the application of higher production beam intensities by distributing the beam over a larger, more efficient radiating structure. Here a thin Ge coating is drawn over a W or Mo foil which is inclined with respect to the beam axis thereby distributing the beam intensity over a larger area, effectively lowering the volumetric beam heat generation rate (W/m^3) by a factor of ~5. Typically, a coating thickness of ~0.8 mm is required for maximum production from 40 MeV protons and a 13^o angle of beam incidence. The inclined system also decreases the mean diffusion length of the target by approximately a factor of 10 when compared with traditional volume-type liquid targets of comparable thickness.

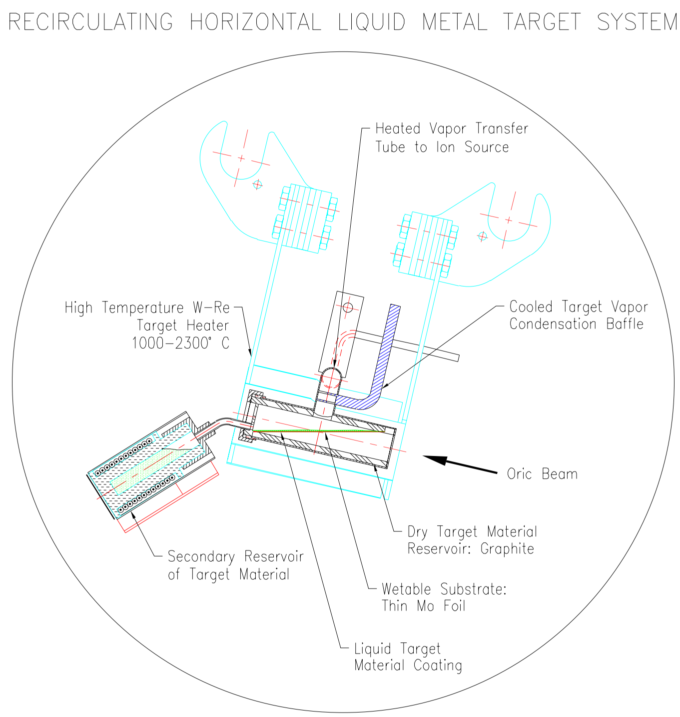

Fig. 2. Liquid metal target supported by a wetable substrate and beam incident at shallow angle.

Two additional design features which are common to both of the above target systems include a re-circulating baffle and secondary target material reservoir. The baffle, located in the vapor passage between the target and ion source is cooled conductively by a heat sink and functions to reduce the flux of Ge vapor entering the ion source. This is accomplished by directly cooling the heat sink to insure the baffle operates at lower temperatures than the target material reservoir which is heated both by the production beam and the heater shown in the figures. Ge vapors then condense on the surfaces of the baffle which are inclined 13^{o} downward to facilitate return of the condensate to the target reservoir achieving a re-circulation effect. A secondary reservoir of target material is located outside of the production beam path and functions to supply Ge as needed to the active target area thereby considerably increasing the operational lifetime of the target system.

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1. Oak Ridge Institute for Science and Education, Oak Ridge, TN.