Thin-target preparation for heavy element experiments

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The heavy element research program at the Cyclotron Institute will utilize low-energy (~5 MeV/u) beams and requires thin targets (~300 μg/cm^2), because the products of complete fusion-evaporation reactions have large masses and low velocities that can be stopped in thick targets. Thin targets also cause less angular straggling. The ability to make thin targets on site would be very beneficial to the future of the heavy element research program.

Physical vapor deposition is often used in the field to make these thin targets; in this method vapors of the target material are deposited on a substrate. The deposition occurs in a vacuum (< 10^{-4} torr) allowing for even deposition and greatly reducing the chance of contamination. The Cyclotron Institute Target Laboratory has a thermal and electron gun evaporator shown in Fig. 1, which could be used to make the needed holmium targets. The reaction ^{165}Ho(^{40}Ar, 6n)^{199}At was chosen due its similar kinematics to ^{208}Pb(^{50}Ti, n)^{257}Rf reaction, which is of future interest. Due to the high melting point of Ho the electron gun evaporator was more suitable. Ho pieces purchased from Alfa Aesar were used and the deposition occurred on an Al foil (~0.8 μm) sandwiched in a Cyclotron Institute standard target frame, covered with a mask. After numerous attempts to make targets it was determined that the cooling system for the gun could not handle the high temperature of the Ho evaporation. Also, the thickness of the deposition could not be monitored in the chamber with the current setup.

FIG. 1. Close-up of thermal and electron gun evaporator at target lab (bell jar retracted).

The Materials Characterization Facility (MCF) has a newer thermal evaporator, a BOC Edwards Auto 306 Metal Evaporation Chamber shown in Fig. 2, which could be used to make the Ho targets. This instrument could monitor the thickness of the deposition by using a quartz crystal thickness monitor which works by monitoring the change in frequency of a quartz crystal oscillator while the deposition occurs. Typically, the deposition rate fluctuated between 0.1-0.4 nm/s during the deposition. Evaporation of Ho required higher voltages than normal because Ho goes through sublimation instead of melting like most metals used in the thermal evaporator. Though difficult, the necessary targets were successfully prepared. Metals with lower melting temperatures than Ho can be used in the future. The thermal evaporator at the MCF is a suitable instrument for making thin targets in the future for the heavy element research program here at the Cyclotron Institute.

FIG. 2. Thermal evaporator at MCF.