Proton Beam-on-Liquid Lithium Stripper Film Experiment

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A ~10 μm thick liquid lithium film, flowing at ~50 m/s bombarded by a 65 keV, 300 W proton beam was successfully tested at Argonne Liquid metal Experiment (ALEX) facility, Argonne National Laboratory (ANL) for the Facility for Rare Isotope Beams (FRIB) at Michigan State University (MSU). FRIB will accelerate a variety of ions, up to uranium, to an energy of 200 MeV/u with beam power up to 400 kW. To increase the charge state of the ions for efficient acceleration and thereby reduce the size of the driver linac, a charge stripper is needed that can strip uranium ions from charge state 33+ to 78+. Developing the charge stripper for such an intense uranium beam is a severe technological challenge; the leading design choice for this stripper is a thin, high speed, liquid lithium film of thickness ~10 μm. The uranium beam will deposit about 700 W in the film while passing through and losing about 2% of its kinetic energy. Previous R&D at ANL has demonstrated the stable formation of such a film, but prior to the work reported here, the film has not been bombarded with an ion beam.

This paper reports the details of the proton beam-on-liquid lithium film experiment for a thermal testing, the results, and its potential applications.

To provide a suitable proton beam for the thermal testing of ANL's liquid lithium stripper film, an ion source for the Low Energy Demonstration Accelerator (LEDA) was borrowed from Los Alamos National Laboratory (LANL) and moved to MSU where it was re-commissioned after a new beam transport system was built and installed. The ion source was then transferred to ANL and mated with Argonne's lithium stripper system, where the proton beam deposited in the lithium film a power density comparable to 30 % of the maximum power density expected at FRIB when accelerating 400 kW of U beam at 200 MeV/u. Video of the beam-on-film test will be discussed. Because the 65 keV protons only penetrate the first 1.5 μm of the lithium film's ~10 μm thickness, the net thermal effect, in that first 1.5 μm of the film, is a power density higher than FRIB by a factor of 2. Hence, a stripper based on this liquid lithium technology is now the base-line design choice for FRIB. This technology may also be applicable to other high power target areas, such as the lithium target neutron source.

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