INERTIAL FUSION TARGET DEVELOPMENT*

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The next series of inertial fusion experiments will approach and then achieve the conditions for ignition. These planned experiments include the OMEGA Upgrade experiment at the University of Rochester, and the National Ignition Facility to be built at Lawrence Livermore National Laboratory. To achieve sufficient density to approach ignition conditions with reasonable laser power, these experiments call for cryogenic targets.

In this paper, we review the specifications for these targets, describe the next steps in target technology from ignition to fusion energy application, and describe the coordinated R&D program of the ICF Labs (Lawrence Livermore, Los Alamos and University of Rochester) and General Atomics to develop this technology.

Targets are required that are larger than those currently used, with fabrication accuracy requirements that are comparable to or even more stringent than those for current experiments. The requirement for a precise cryogenic fuel layer of uniform thickness with very smooth inner surface finish poses difficult challenges for target fabrication, handling and characterization.

Several approaches are being pursued for fabrication of cryogenic targets. These include tritium self-heating ("beta layering") to achieve a uniform solid layer, and thermal gradient techniques and use of a porous foam shell "wick" to achieve a uniform liquid layer. We describe the status of the R&D programs now underway to demonstrate these techniques and to characterize these cryogenic targets with sufficient accuracy. Beta layering for cryogenic DT targets has been demonstrated in cylindrical geometry with thickness and uniformity that meet ignition target needs, but the surface finish requires further refinement. Thermal gradient techniques have been used to levitate thick layers of cryogenic fuel; heat profile shaping to achieve adequate uniformity must now be developed. Foam target shells with a uniform low density polymer foam wall up to 100 µm thick and a ~5 µm full density polymer outer coating have been produced. Characterization techniques to determine the liquid layer uniformity and inner surface finish must be developed. An overfilled foam shell with a few microns of excess liquid fuel that could be symmetrized in free fall is a possible approach, and should extrapolate to power plant applications. Recent studies at Lawrence Livermore National Laboratory, W. J. Schafer Associates and General Atomics indicate promising directions for cost-effective target manufacturing and for inertial fusion power plant target injection techniques.

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