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Target Fabrication for Inertial Fusion Energy*

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Inertial fusion energy (IFE) power plants will require precision targets to be fabricated at high production rates. A single power plant will require of order 90,000 to 900,00 targets/day, depending on power plant design. This far exceeds current day production. The development status and strategies of some high production rate methods for fabrication of targets for IFE will be reported on. The emphasis will be on low density (≤50 mg/cm^3) polymer foam shells, several millimeters in diameter, which are useful for wetted foam target designs[1]

Production of wetted foam capsules for inertial fusion energy (IFE) is priority research opportunity listed in the DOE Basic Research Needs for IFE workshop report[2]. A wetted foam target typically consists of or includes a spherical polymer shell with a layer of low-density polymer foam just inside the shell. The foam layer would be used to wick in and create a layer of liquid DT filling the foam. Lower density foams are wanted in this application since the carbon and other high atomic number elements in the foam are mixed with the DT increasing radiative losses in DT fuel during the implosion of the target making ignition of the target more difficult. Polymer with just carbon and hydrogen (or deuterium) are preferred over those that also contain some oxygen or nitrogen for this same reason. Faster filling of liquid DT via wicking into a foam shell (10's of seconds expected) would greatly lower tritium inventory of the IFE DT target fill system compared to kilogram tritium quantities that would be required for permeation gas filling targets[3].

We are developing spherical foam shells with density ≤50mg/cm3. Two different approaches to the manufacture of these shells are being pursued: microencapsulation and additive manufacturing via two photon polymerization (2PP). We report on our progress towards making the low-density foam shells by these two approaches. We outline the design of micro-projection-2PP printer for IFE (STARFIRE). We have microencapsulated dicyclopentadiene/norbornene (DCPD/NB) foam shells at 25mg/cm^3 (RISE). This is a pure CH chemistry. We have taken some of these foam shells through solvent exchange, critical point drying, and overcoating steps (see Figure 1) and continue to work to improve quality and fabrication yield. We have developed techniques to microencapsulate our GACH pure CH or CD foam. In the previously available cast or cast and machine techniques, GACH foam has been made in billets with density from 5 to 200 mg/cm^3 and submicron pore size[4]. We have made microencapsulated GACH foam shells with a nominal density of 15 and 25mg/cm^3, diameters of 3 to 4 mm and wall thicknesses of ~100 to 200 µm. We continue to improve wall uniformity and drying processes for these foam shells. Methods for deterministic symmetry control in micro-encapsulated capsules/foam shells will also be outlined.

Figure 1. (LEFT) DCPD/NB foam shells, dry, with nominal foam density of 25gm/cm3, diameters 3-4 mm. (Right) DCPD/NB foam shell overcoated with ~6 µm of GDP (glow discharge polymer).

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