Summary of Progress reported at 18th HAPL Meeting,
Santa Fe New Mexico, April 8 and 9, 2008

Complied by John Sethian, April 15, 2008

The 18th HAPL meeting was hosted by Los Alamos National Laboratory on April 8 and 9, 2008. 59 attendees from 25 institutions participated. The HAPL program is developing the science and technology for a fusion power plant based on lasers and direct drive targets. An integrated approach is taken to developing fusion energy, in which the needed science and technology are developed simultaneously as a coherent system. The HAPL program builds upon the large physics base in the ICF program and the technology base in the MFE program. This note presents highlights in progress presented at this meeting. For past meetings, go to: http://aries.ucsd.edu/HAPL/

1. DPPSL LASERS (John Caird, LLNL): The Mercury Diode Pumped Solid State Laser project has compiled an aggregate total of 300,000 shots at 10 Hz, with an average power of 55 Watts (55 Joules/shot) at the fundamental wavelength of 1051 nm. The laser has been fully commissioned with an advanced fiber based front end. Advances have been made in crystal growth, but further significant advances may be realized with a new type of diode called VCELs. These have the potential for significant cost reduction (a factor of 4 below the current projected diode cost for a full IFE system). If realized, Nd: phosphate glass can be used as the lasing medium rather than the Yb:S-FAP currently used in Mercury. Nd:Glass is used in the NIF and can be made with larger apertures.

2. KrF LASERS (Frank Hegeler, NRL/CTI): The Electra laser system has an aggregate 250,000 shots at rep-rates ranging from 2.5 to 5 Hz, and energies from 250 to 700 Joules per pulse at the fundamental wavelength of 248 nm. A new solid state pulsed power switch has been developed that is based on a standard commercial component. The main element has run for 90 million shots continuous at 10 Hz, and three switches in a small pulsed power module have run at over 1 M shots at 5 Hz. No failures have occurred. This system has demonstrated the required efficiency and should meet cost requirements. Larger

systems are being built to test scaling. In the areas of hibachi development, three advances have been made that should substantially enhance the foil lifetime: A "Scalloped Hibachi" that significantly reduces the mechanical and cyclic stress on the foil, a more durable cathode material, and a jet cooling technique that can keep the foil under 200 deg C (as opposed to the previous 450 deg C). All have been tested on the bench and all are being implemented on Electra now.

3. KrF HIBACHI FOIL MODELING (Sharham Sharafat, UCLA, Jake Blanchard, Wisconsin). The model includes the experimentally determined thermal stress, mechanical loads, and foil properties. It accurately predicts the observed deformation in the present Electra Hibachi foil. The same model predicts the new "Scalloped Hibachi" will reduce the displacement factor by 100 times, the stress by a factor of 2, and the plastic stress by a factor of 100. These are significant.

4. FINAL OPTICS LASER DAMAGE THRESHOLD (UC, San Diego). The laser damage threshold measurements of the Grazing Incidence Metal Mirror have been extended to over 6 million shots at 4 J/cm^2. This is an order of magnitude increase over previous results. The advance was to use a 0.1% copper solution aluminum alloy and to deploy a beam homogenizer on the laser. The spot size is large enough at 1 mm x 10 mm to diminish statistical variations and edge effects.

5. MAGNETIC INTERVENTION (Dave Rose, Voss Scientific, A.E. Robson. NRL/CTI, Rene Raffray, UCSD). Magnetic Intervention uses a simple cusp magnetic field to divert ions away from the chamber wall and into external dumps. As a background, a major challenge is to mitigate the effects of the energetic ions produced by the target. The ions embed in a shallow depth in the chamber wall, and because they represent a substantial fraction (28%) of the energy released, heat the wall to high temperatures. In addition, the implanted helium ions coalesce into bubbles which cause exfoliation. While an active materials program is underway to solve this problem, Magnetic Intervention may be a more viable approach. The principal was demonstrated in a 1979 experiment at NRL. Recently the experiment was successfully modeled by the HAPL team. At this meeting a new topology was presented that uses an additional coil to divert the ions downward to a pool of flowing lead (or PbLi). The pool is at the end of a long duct which is kept at a lower temperature than the lead. Thus vaporized lead from the pool should be cryo-pumped before entering the main chamber.

6. HELIUM IMPLANTATION EXPERIMENTS (Sam Zenobia, Student, University of Wisconsin). The measured threshold for helium induced exfoliation damage in both poly crystalline and single crystal tungsten were reported. The surface of the exposed samples was measured with an SEM and the retained helium was determined with nuclear depth profiling. The helium ions were produced by the Wisconsin IEC device. The damage threshold was exceeded in less than 10 days of anticipated plant operation. Hence the need for Magnetic Intervention.

7. ELECTRON BEAM BASED MATERIALS TESTER, DIELECTRIC FINAL OPTICS TESTS (Lance Snead, Oak Ridge National Laboratory). A new repetitively pulsed electron beams source, capable of running at 100 Hz for > 1,000,000 shots, has been installed and should be fully operational within three months. The voltage, current, and pulse width of this source has been tailored to exactly mimic the temporal and volumetric ion heat load of the tungsten first wall in an IFE chamber. In another set of experiments by this group, candidate dielectric mirrors and mirror components have been irradiated with prototypical fluxes of neutrons from the ORNL HFIR fission reactor. Final results must wait reflectometry tests, but inspections show no visible damage. Dielectrics offer the promise of higher laser damage thresholds (and hence lower footprints) than the GIMM, but were thought fall apart under neutron radiation. There is reason to believe this is not the case, and hence the reason for the re-visit.

8. UNIFIED MATERIALS RESPONSE CODE (Nasr Ghoniem and Sharham Sharafat, UCLA. Jake Blanchard, Wisconsin). This group is developing a modular code to understand the fundamental physics of the first wall. Four students have participated, with two PhD's awarded. The code includes helium implantation, diffusion and transport, transient stresses, thermo-physical fatigue, etc. More physics packages can be added as needed. The code accurately predicts the helium bubble evolution observed in the Wisconsin experiment.

9. REVIEW OF ICF TARGET DEVLEOPMENT (Bob Cook, Consultant to Schaffer). This was a presentation on the history of the development of shells for the ICF program. The basic theme was "Seemingly insurmountable problems were solved through a combination of hard work and innovation" What is abundantly clear is that while target fabrication is a challenge, direct drive targets are much easier and less expensive to mass produce, than indirect drive or fast ignition targets, for the simple reasons that no assembly is required, and nature prefers a simple sphere.

10. OVERCOATING ON FOAM SHELLS (Jared Hund, General Atomics). In the "hard work' category, meaningful progress has been made in reducing the thickness of the gas tight plastic (CH) overcoat on the foam shells. The target designs call for between 5 and 10 microns. Previous best reported in October 2007, was 25 microns. At this meeting the reported thickness is down to 15 microns.

11. TARGET FABRICATION WORK AT ROCHESTER LLE (David Harding, University of Rochester). This work is not part of the HAPL program, but it is very useful to hear about progress (and challenges) in other areas of target fabrication. The big advance reported here was the achievement of transparent DT ice layers in foam. The layer was grown from a single crystal. Previous attempts were plagued with DT gas bubbles trapped in the foam. A study is being undertaken to understand how the foam morphology affects the DT ice layer smoothness and entrained bubbles.

12. MEASUREMENT OF EFFECT OF XENON GAS ON AN INJECTED CRYO GENIC TARGET (Mariana Bobecia, Student, University of Rochester). This work is under the HAPL program. It was previously reported that only a mono-layer of xenon sticks to the target. At first blush this suggests that the heat load may not be as much as originally thought. However, what is relevant is the energy transfer rate. This will be pinned down with a newly developed wire resistance technique that has shown to be capable of measuring the real time temperature of the phase transition as DT goes from liquid to solid.

13. ELECTROWETTING TECHNIQUE TO MAKE FOAM CAPSULES (Robin Garrel, UCLA). As an example of the “Innovation” approach to solving problems, it was reported that precise, liquid droplets can be accurately manipulated by applying electric fields onto a printed circuit board. Water droplets can be made to encase oil droplets and vice versa. This is the chemistry protocol used to make foam shell, so foam shells could be made by this technique. Currently shells are made in a droplet generator, but this approach could be more precise, have a higher throughput, and in principal faster.

14. SMOOTHING OF DT LAYERS BY TEMPERATURE OSCILLATINS (John Sheliak, General Atomics/LANL). LANL demonstrated that oscillating the temperature of the DT ice by 0.5 deg K resulted in smoother DT ice layers. This is in addition to the enhancement in smoothness that is characteristic of DT ice over foam. The best layer had a reverse cumulative RMS surface roughness of 0.8 um. (NIF spec over the same spectrum is 1.2 um). One issue that needs to be resolved with this or any other ice smoothing technique is the several hour time scales needed to achieve a smooth layer. It must be faster for an IFE plant.

15. MODELING OF A FLUIDIZED BED (Kurt Boehm, Student, UCSD). The DT ice smoothing time could be reduced by placing the targets in a fluidized bed. The concept has been demonstrated at room temperature, and the cryogenic bed is nearing completion. The modeling here will help determine optimum conditions (gas flow, temperature, bed dimensions, target filling, etc).

16. IMPROVING ACCURACY OF GLINT BASED TARGET ENGAGEMNT TECHNIQUE (Lane Carlson, UCSD). Under development is a target tracking and laser beam pointing system that records the reflection or “glint” of a precursor laser off the target, and uses that information to steer the laser beams. An accuracy of about 20 microns is required, based on pellet physics calculations. Last October it was reported that a surrogate target could engaged with an accuracy of 150 microns. At this meeting it was reported the accuracy had improved to 80 microns.

17. ELECTROSTATIC INJECTION AND STEERING OF A TARGET (Ron Petzold, General Atomics). The target is electrically charged, and then electric fields are used to both accelerate and steer the target to a precise position. This

saves the complexity of steering the laser beams. At this meeting, placement accuracy a dropped target of better than 13 microns over a distance of 50 cm was demonstrated on the bench. While not currently envisioned for a power plant (owing to the required length and standoff distance), this technique would be appropriate for start up experiments on the FTF as well next generation ICF experiments.

The next meeting will be held at the University of Wisconsin in late October 2008