APPENDIX G

TARGET LAYERING

BY

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Infrared heating forms and smoothes HD layers

Liquid HD

After solidification

- plastic shell
- HD vapor
- solid HD 16.69K

1 mm

Direct Drive Target Workshop
9/15/99

Cryogenic fuel layers can be enhanced or formed by absorption of infra-red radiation.

Absorption of IR light generates volumetric heating, $Q_{\text{IR}}$, which adds to or replaces heating from beta layering.

$\Delta T = \frac{Q h^2}{2 K}$

$\delta T(\text{bump}) \approx \Delta T + Q h \delta h / K$

150 $\mu$m thick HD layer formed by uniform infra-red radiation.
The capsule material must be chosen to minimize absorption in the shell.

- Plasma polymer from deuterated p-Xylene
- Using the shift in $T_{TP}$ we have set the maximum baseline absorption at $\alpha < 4 \text{ cm}^{-1}$
- Plastic absorption sets the IR uniformity requirements for NIF
- DT does not affect the relevant transmission spectrum of plasma polymer at room temperature
IR illumination can significantly modulate surface structure.

- Surface with spatially coherent illumination
- 14% coherent illumination
- <3% coherent illumination
The IR now reflects off the bottom of the integrating sphere.

capsule: 870 μm OD
15 μm wall
100 μm HD layer

<table>
<thead>
<tr>
<th>mode amplitude (μm²)</th>
<th>mode number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.72 π analysis</td>
<td></td>
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<tr>
<td>rms (μm)</td>
<td>modes</td>
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<tr>
<td>3.44</td>
<td>1-100</td>
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<tr>
<td>1.33</td>
<td>2-100</td>
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<tr>
<td>0.86</td>
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<tr>
<td>0.59</td>
<td>5-100</td>
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<tr>
<td>0.24</td>
<td>10-100</td>
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</table>
Layers in shells are characterized using the brightband in the shadowgraph image.

The brightband is due to reflections off the gas/solid interface.

Our characterization technique resolution decreases with decreasing layer thickness.
The aspect ratio of the shell impacts the ice layer characterization.

aspect ratio = \( \frac{\text{wall thickness}}{\text{shell diameter}} \)

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low aspect ratio

high aspect ratio
The layer formation process has a significant impact on the final surface finish.

Layer formation from solid.

Apply IR
\[ \sim 5 \, Q_{DT} \]
> 4μm rms

Layer formation from liquid.

Apply IR
\[ \sim 8 \, Q_{DT} \]
3.0μm rms
Turning off the IR causes the surface to roughen.

IR heating rate ~ 1.8 Q_{DT}

- The layer quality is good enough for several minutes.
- The roughening rate is higher for larger Q_{DT}.
Summary

There are several design issues which must be addressed to implement infrared layering.

- capsule material - low absorption
- coating - non-reflective
- illumination - uniform and diffuse
- surface degradation - minimize the time between turning off the illumination and the shot.

- layering time - minutes to hours
- characterization - minimize analysis time (0 to a few seconds)