Measurement of the Si Mass Ablation Rate in Direct-Drive Implosions on the OMEGA Laser System

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CH targets coated with Si were used to measure the mass ablation rate in direct-drive implosions on OMEGA

Summary

- Time-resolved x-ray self-emission images provide a tool to measure the time to burn through the Si outer layer
- The mass ablation rate of Si was measured by varying the thickness of the Si layer

One-dimensional simulations that include models for cross-beam energy transfer (CBET) and nonlocal thermal transport agree well with measurements.
Collaborators


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Direct-drive inertial confinement fusion implosions are driven by laser energy absorbed near the critical density and transported by electrons to the ablation surface.

Measurements of the shell trajectory \( V_{\text{shell}} \) and mass ablation rate \( \frac{dM}{dt} \) constrain the coupling physics.

Rocket effect:

\[
-M \left[ \frac{d(V_{\text{shell}})}{dt} \right] = -V_{\text{ex}} \frac{dM}{dt}
\]
X-ray self-emission imaging provides a tool to study implosion velocity and mass ablation rate in Si/CH targets.

The inner peak corresponds to the ablation front* and the outer peak corresponds to the position of the Si/CH interface.

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The positions of the ablation front and Si/CH interface were measured in a series of time-resolved x-ray framing camera (XRFC) images.

- **Ablation of Si**
  - $t \sim 870$ ps

- **Si burnthrough**
  - $t \sim 1360$ ps

- **Ablation of CH**
  - $t \sim 1570$ ps

- **Ablation of Si**
  - $t \sim 1910$ ps

Intensity (normalized)

<table>
<thead>
<tr>
<th>Radius (μm)</th>
<th>250</th>
<th>450</th>
</tr>
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<tbody>
<tr>
<td>Ablation front</td>
<td>0.0</td>
<td>0.8</td>
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</table>

<table>
<thead>
<tr>
<th>Radius (μm)</th>
<th>200</th>
<th>400</th>
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<tbody>
<tr>
<td>Si/CH interface</td>
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<td>0.8</td>
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</table>

<table>
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<tr>
<th>Radius (μm)</th>
<th>200</th>
<th>400</th>
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<tbody>
<tr>
<td>$t \sim 74080$</td>
<td>0.0</td>
<td>0.8</td>
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<table>
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<th>Radius (μm)</th>
<th>100</th>
<th>300</th>
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<tr>
<td>$t \sim 74079$</td>
<td>0.0</td>
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The Si burnthrough time corresponds to the divergence of the ablation front and Si/CH interface trajectories.

The average mass ablation rate was determined from the burnthrough times for four Si thicknesses.

A rate of $73 \pm 15 \mu g/\text{ns}$ was calculated.
Simulations including models for CBET and nonlocal thermal transport are in good agreement with measured values.

Simulations with a time-dependent flux limiter adapted to match the shell trajectory overpredict the mass and kinetic energy of the shell.
CH targets coated with Si were used to measure the mass ablation rate in direct-drive implosions on OMEGA.

- Time-resolved x-ray self-emission images provide a tool to measure the time to burn through the Si outer layer.
- The mass ablation rate of Si was measured by varying the thickness of the Si layer.

One-dimensional simulations that include models for cross-beam energy transfer (CBET) and nonlocal thermal transport agree well with measurements.
DRACO simulations of cryogenic implosions show that perturbations have a minimal impact on the measurement of the burnthrough time.*

*DRACO simulations were performed with and without perturbations seeded by target offset, DT ice roughness, and laser imprint up to mode 150.