Optical Properties of Materials at High Pressure Using “Sandwich” Targets

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High pressure optical properties provide information regarding transport and relaxation phenomena

- Reflectivity of materials changes as pressure increases
  - broadening of the band gap
  - reduction in relaxation time due to increase in density

- Increase in temperature causes the reflectivity to decrease
  - phonon generation reducing the relaxation time

- The reflectivity of aluminum, gold, iron, and titanium exhibit similar behavior.

- Initial aluminum reflectivity data may be compromised.

- Absorption due to LiF window is minimal.
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Thin material layers make it possible to study the optical properties at high pressure.

LiF remains transparent at pressures less than 6 Mbar.
Multiple pressures are produced by stacked 3-ns laser pulse.
VISAR image contains both pressure and reflectivity data

Al ($R = 93\%$)

Au ($R = 77\%$)

Diamond

LiF

VISAR-2 shot 50552

Time (ns)

Pressure (Mbar)

0 2 4 6 8 10 12 14

0 1 2 3 4 5

-2 0 2 4 6 8 10

0 500

0 500

$\mu m$
Temperature increases gradually until the shock coalesces.
The reflectivity of gold, aluminum, titanium, and iron exhibit similar behavior.
Changes in temperature and pressure affect material reflectivity and conductivity

<table>
<thead>
<tr>
<th>Reflectivity</th>
<th>Index of refraction</th>
<th>Conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ R = \left</td>
<td>\frac{n - n_0}{n + n_0} \right</td>
<td>^2 ]</td>
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</tbody>
</table>

Increase in conductivity

- Band broadening

Decrease in conductivity

- Increase in phonon density

\[ n_s \approx \frac{k_B T}{\hbar \omega_s} \text{ for } T \gg T_D \]

\[ \tau \downarrow \text{ for } T \uparrow \]

- Increase in density reduces mean-free path and \( \tau \)

- \( k_B T \) increases current carrying electrons

\( a_0 = \text{interatomic spacing} \)
Observed reflectivity of warm dense aluminum differs from current models

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Model: conductivity of aluminium at 532 nm

Experiments show little absorption due to LiF window

Radiation balance

\[ 1 = T + \alpha + R \]

\( R < 2\% \) for shock pressures below 6 Mbar*

![Graph showing normalized reflectivity over time for shock pressures]

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Gold layer prevents preheat from affecting optical properties