Recent activities of the research unit for exploration of new materials toward innovative electrons devices (Ozaki IDER)

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Acknowledgment


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What is the purpose of the unit?

- Creating novel materials applicable to innovative electronic devices not found in STP condition

<table>
<thead>
<tr>
<th></th>
<th>Gun</th>
<th>Laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial scales</td>
<td>10 mm</td>
<td>1 mm</td>
</tr>
<tr>
<td>Time scales</td>
<td>1 µs</td>
<td>10 ns</td>
</tr>
<tr>
<td>Pressure</td>
<td>0.5 TPa</td>
<td>50 TPa</td>
</tr>
</tbody>
</table>
In order to investigate “Off-Hugoniot” states, new approaches are required.
Some new approaches are under development in Osaka University to access Off-Hugoniot material states

- Static and dynamic “hybrid” compression
- Reflecting shocks
- Isentropic compression
Laser shock experiments on the pre-compressed H$_2$O target have been performed at GEKKO/HIPER facility.
Wide range off-Hugoniot conditions are available for e.g., hydrogen using these techniques.

![Graph showing Shock Hugoniot, ReShock, Hybrid, Hybrid + ReShock, and Isentropic compression.]
Comparison of Hugoniots between cryogenic and pre-compressed H$_2$ targets

<table>
<thead>
<tr>
<th>Density [g/cc]</th>
<th>Pressure [Mbar]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>0.4</td>
<td>1.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature [eV]</th>
<th>Pressure [Mbar]</th>
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<tr>
<td>0</td>
<td>0.7</td>
</tr>
<tr>
<td>1</td>
<td>0.7</td>
</tr>
<tr>
<td>2</td>
<td>0.7</td>
</tr>
<tr>
<td>3</td>
<td>0.7</td>
</tr>
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</table>

- **Standard (Cryo)**: 0.088 g/cc, 20 K (cryogenic liquid H$_2$)
- **0.7 GPa**:
  - 0.122 g/cc, 300 K (0.7 GPa pre-compress)
- **1.2 GPa**:
  - 0.142 g/cc, 300 K (1.2 GPa pre-compress)
Precompression pressures more than 1 GPa have been achieved using even thin flat diamond plates.
Laser shock experiments on the pre-compressed H₂O target have been performed at GEKKO/HIPER facility.
Few eV temperature, which is much lower than principle Hugoniot one, is measured
We have recovered shocklessly compressed silicon

Experimental investigations for Off-Hugoniot with high pressure but low temperature have been started using new techniques:

- Precompression pressures more than 1 GPa have been achieved using diamond anvil cell technique.
  - Laser-shock experiments were also performed at HIPER laser facility.
- Simultaneous measurements with rear VISAR/SOP and monochromatic x-ray diagnostics have been developed.
  - Shock reflection by sapphire anvil has been observed with VISARs.
  - New anvil materials have been investigated up to TPa pressures.
- Ramp wave generations have been confirmed.
  - Al sample is isentropically compressed up to ~ 20 GPa.
  - We are improving the planarity of laser irradiation pattern.

Conclusions