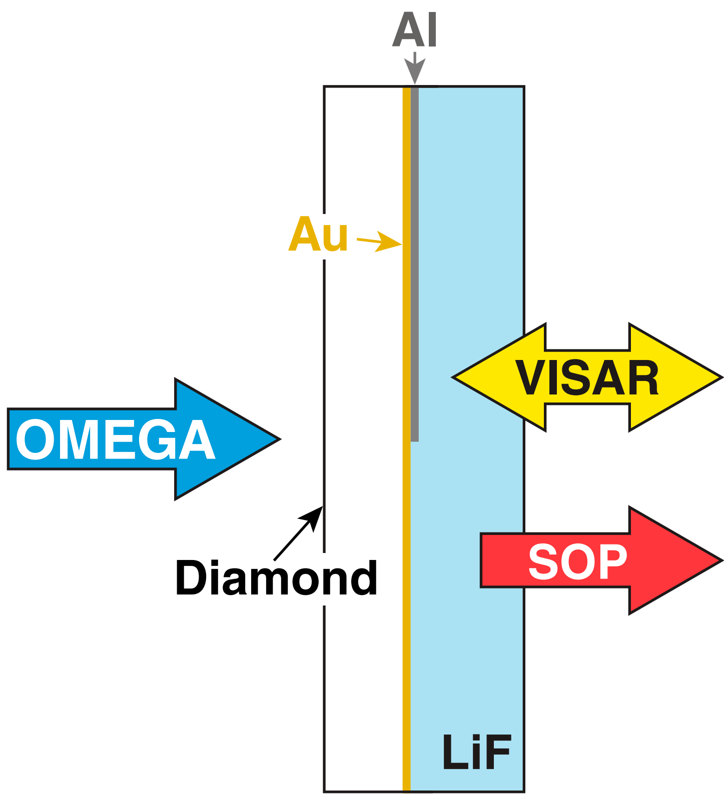
Optical Properties of Materials at High Pressure Using "Sandwich" Targets



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Summary

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.

Collaborators

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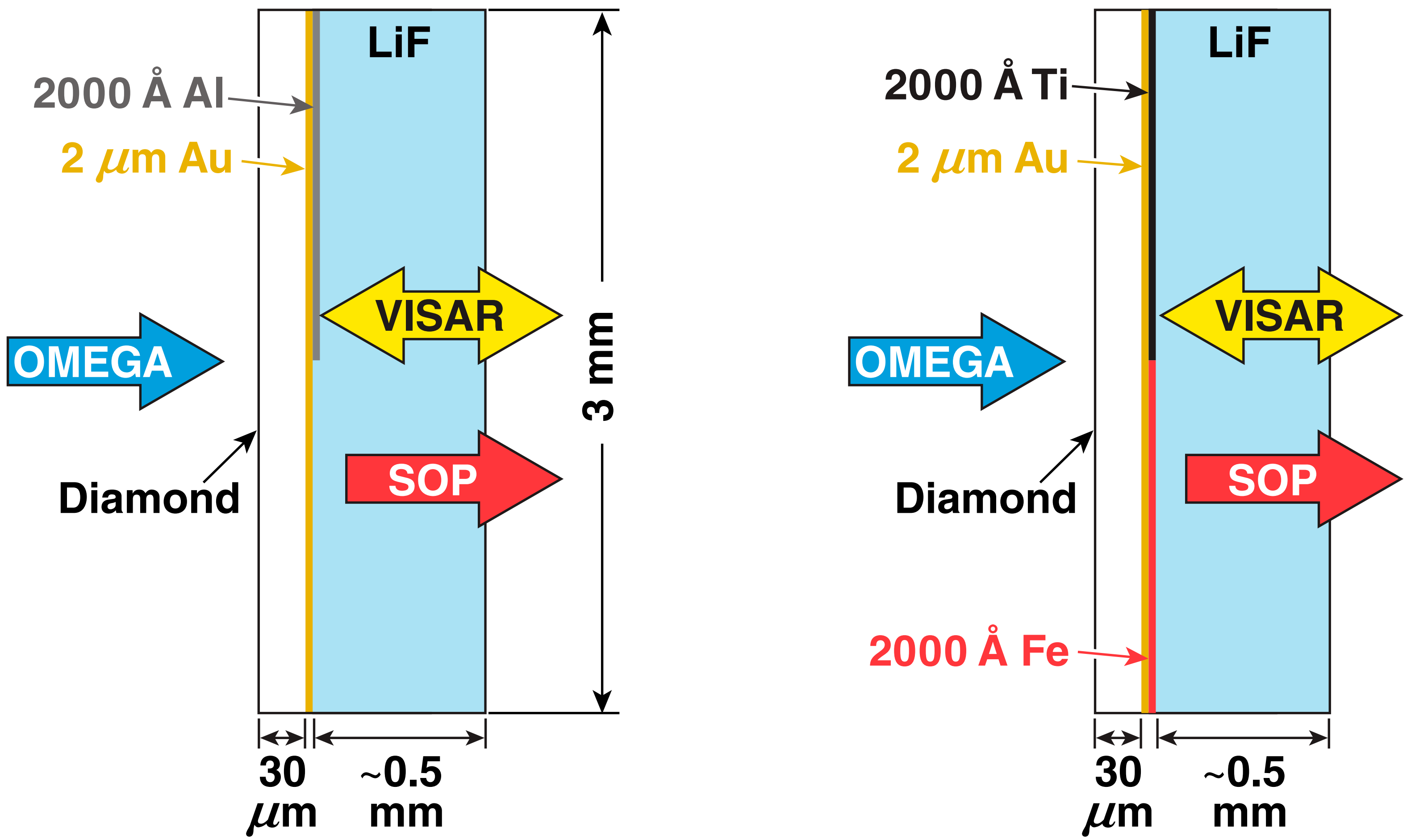
Thin material layers make it possible to study the optical properties at high pressure



LiF remains transparent at pressures less than 6 Mbar.

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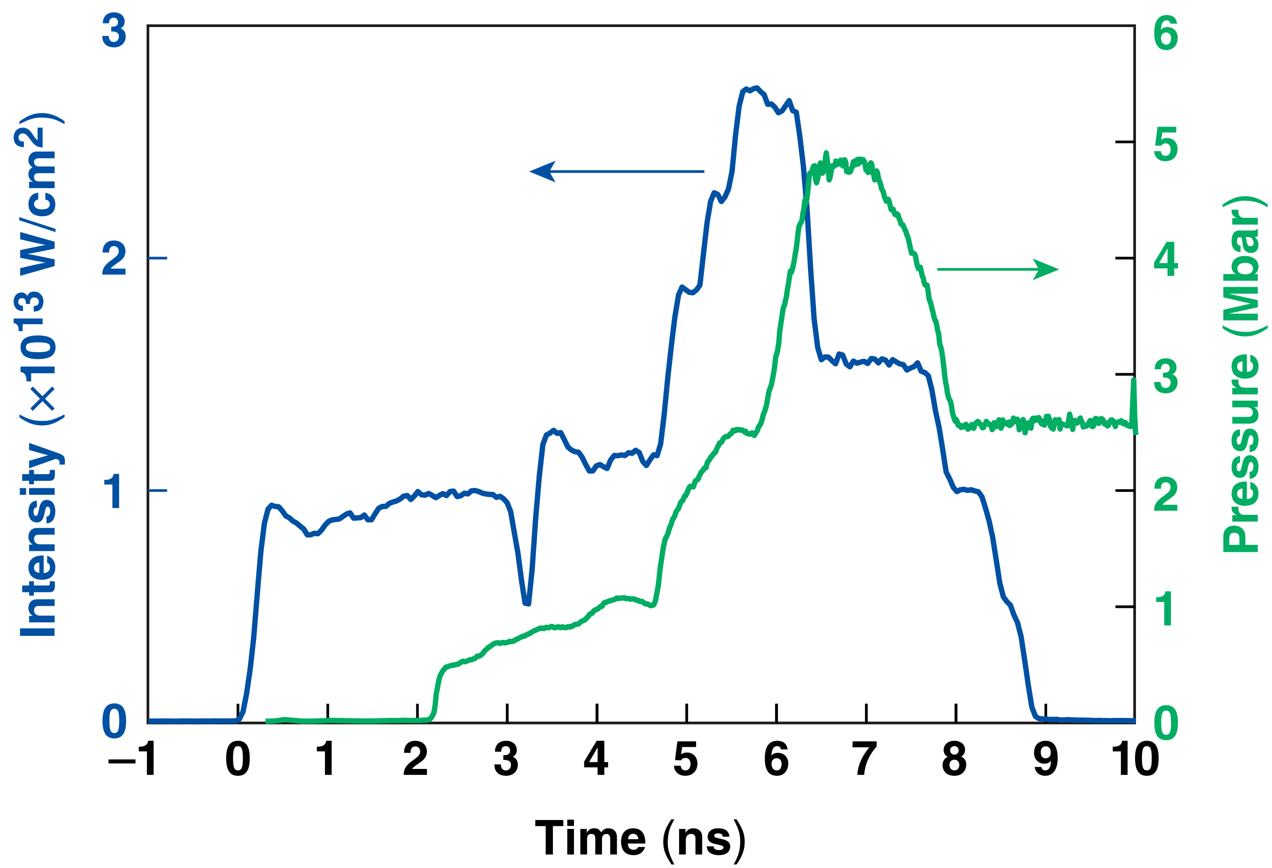
Multiple pressures are produced by stacked 3-ns laser pulse



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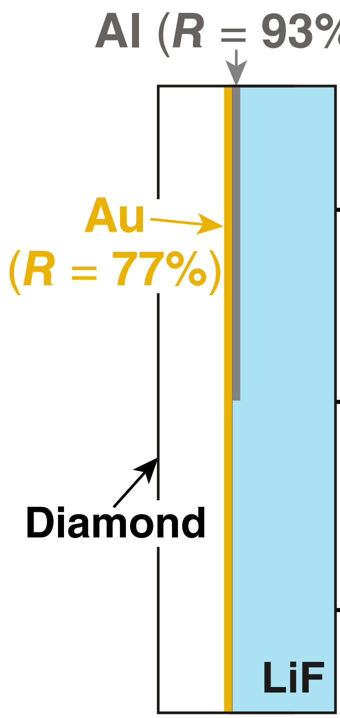
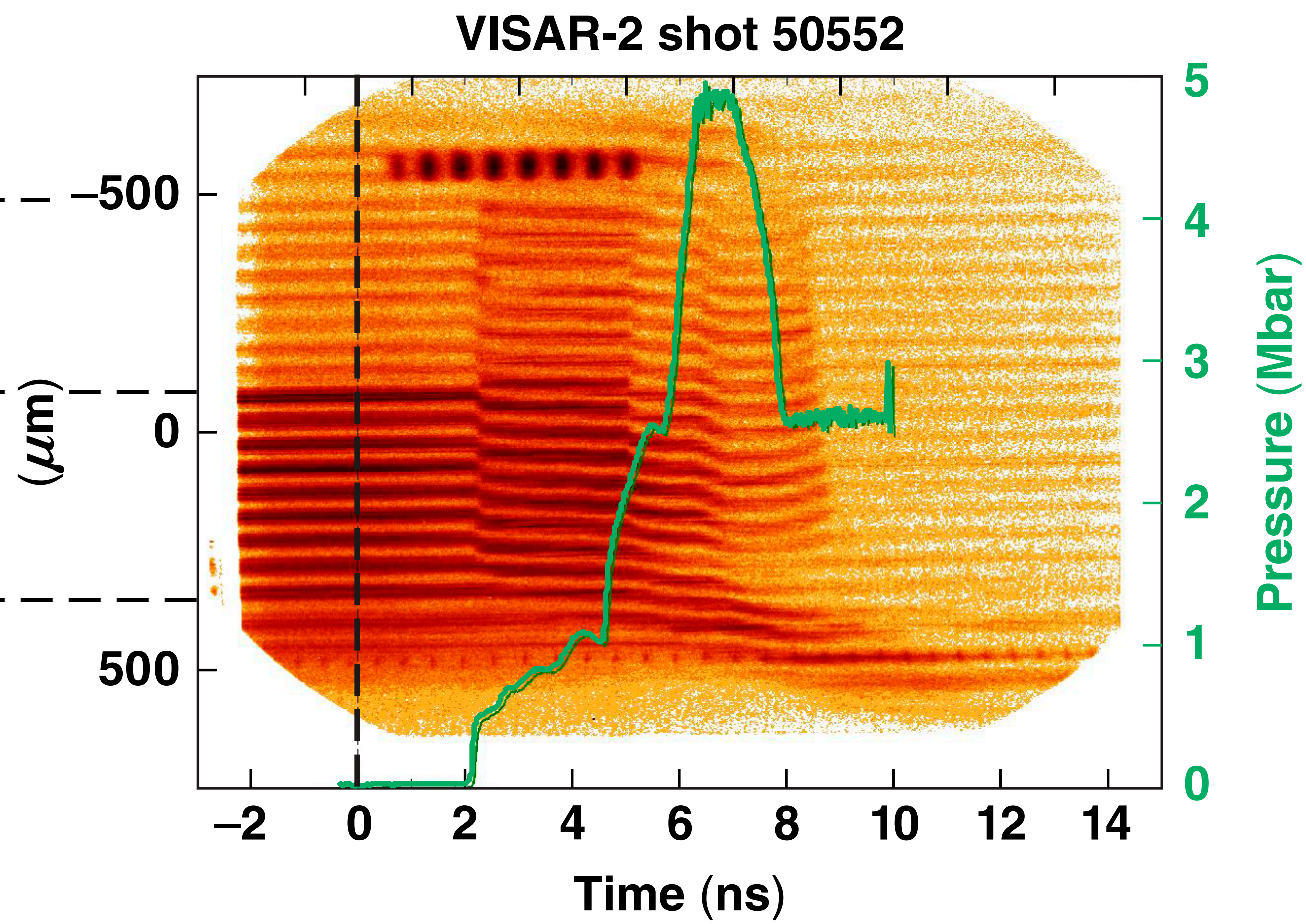
VISAR image contains both pressure and reflectivity data





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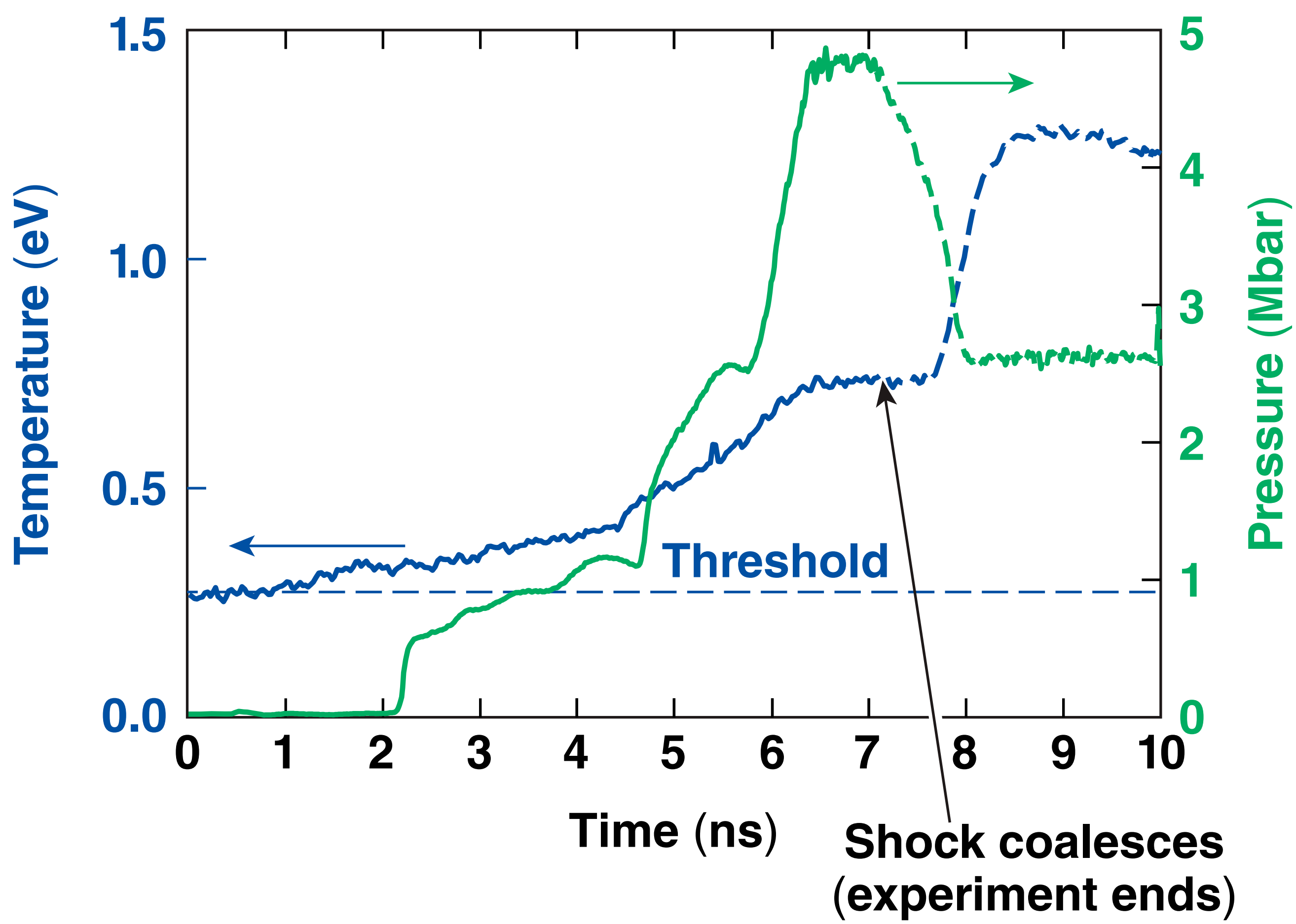
Temperature increases gradually until the shock coalesces



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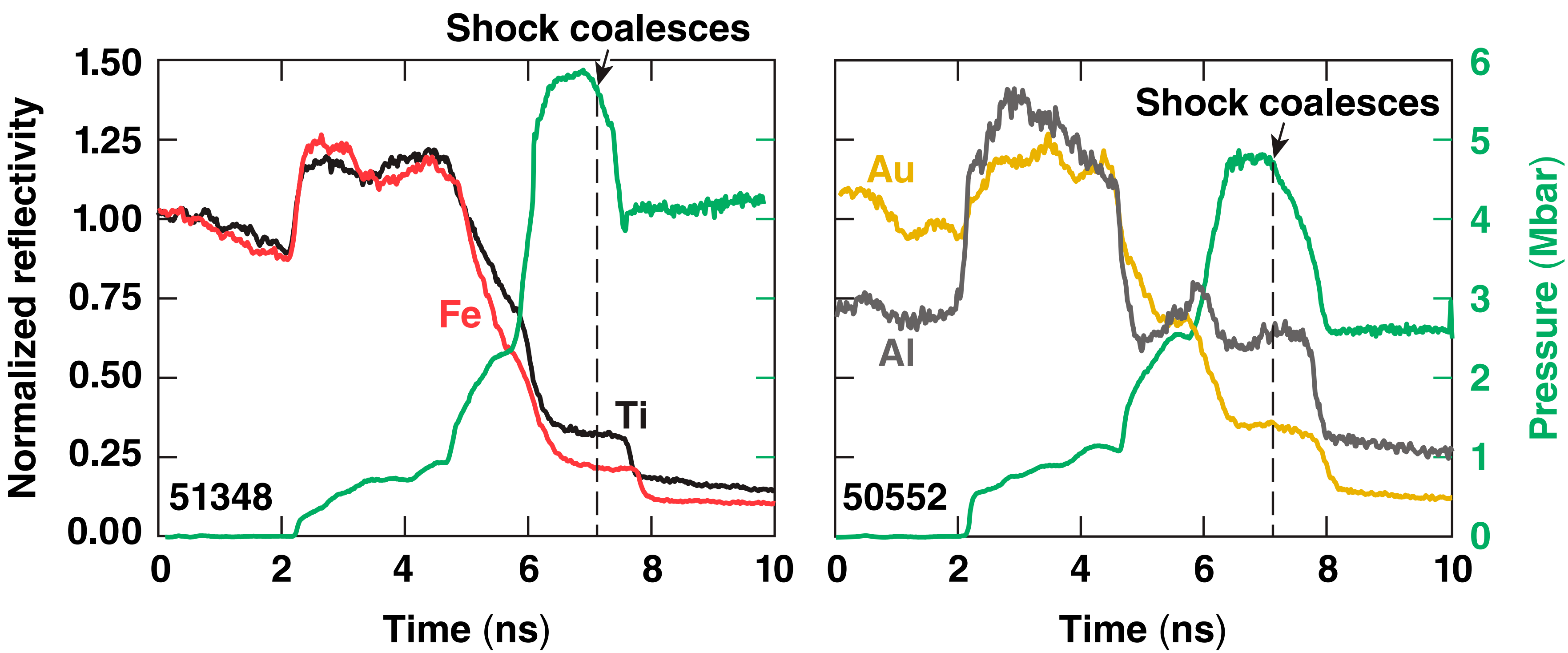
The reflectivity of gold, aluminum, titanium, and iron exhibit similar behavior



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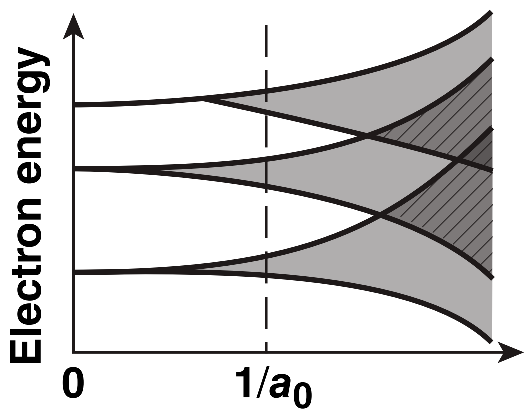
Changes in temperature and pressure affect material reflectivity and conductivity

Reflectivity	Index of refraction	Conductivity
$R = \left\lvert \frac{n - n_0}{n + n_0} \right\rvert^2$	$n = \sqrt{1 + \frac{4\pi i}{\omega}\sigma}$	$\sigma = \frac{ne^2\tau}{m_e}$

Increase in conductivity

- Band broadening



a_0 = interatomic spacing

- k_BT increases current carrying electrons

Decrease in conductivity

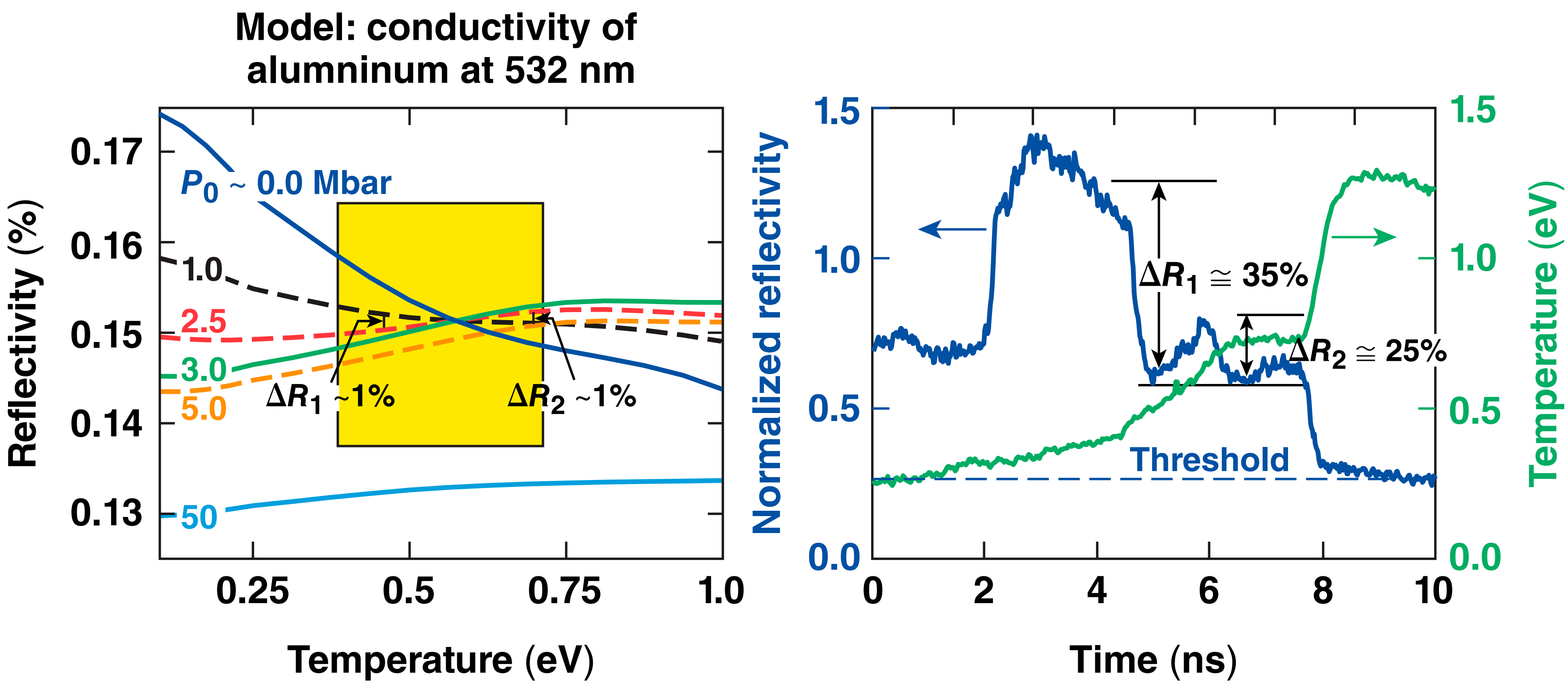
- Increase in phonon density

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

$$\tau\downarrow \text{ for } T\uparrow$$

- Increase in density reduces mean-free path and τ

Observed reflectivity of warm dense aluminum differs from current models



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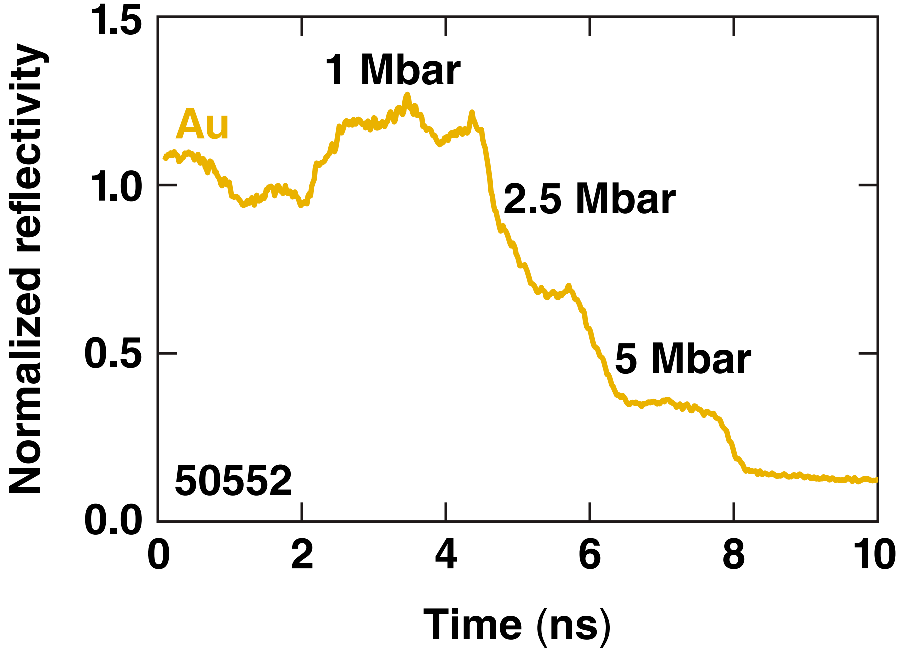
M. W. C. Dharma-Wardana, Phys. Rev. E 73, 036401 (2006).

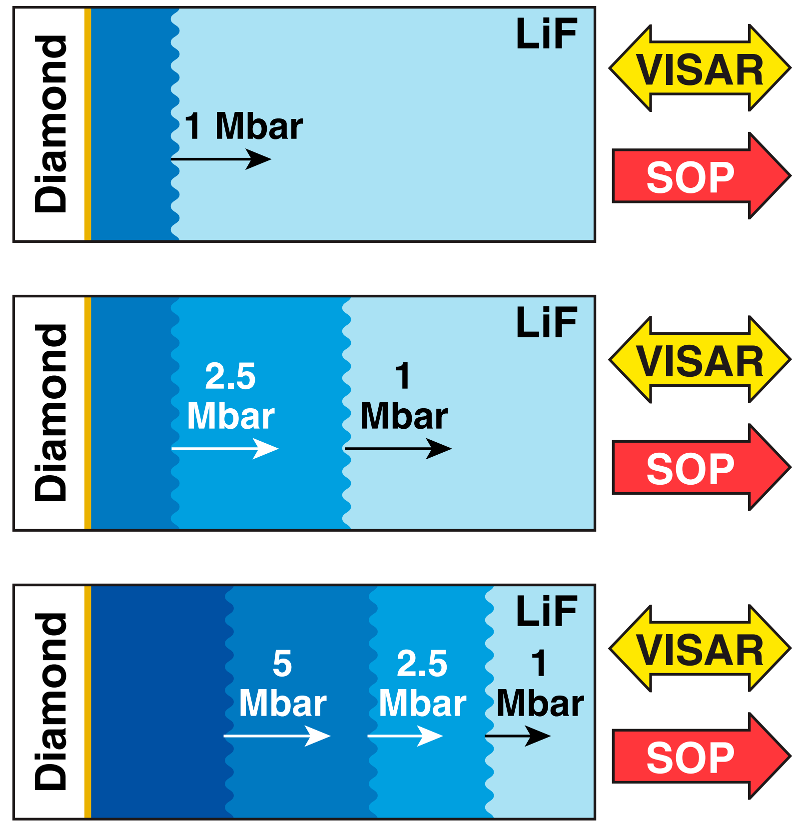
Experiments show little absorption due to LiF window

Radiation balance

$1 = T + \alpha + R$

R < 2% for shock pressures below 6 Mbar*





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*D. G. Hicks *et al.*, Phys. Rev. Lett. 91, 035502 (2003).

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Gold layer prevents preheat from affecting optical properties

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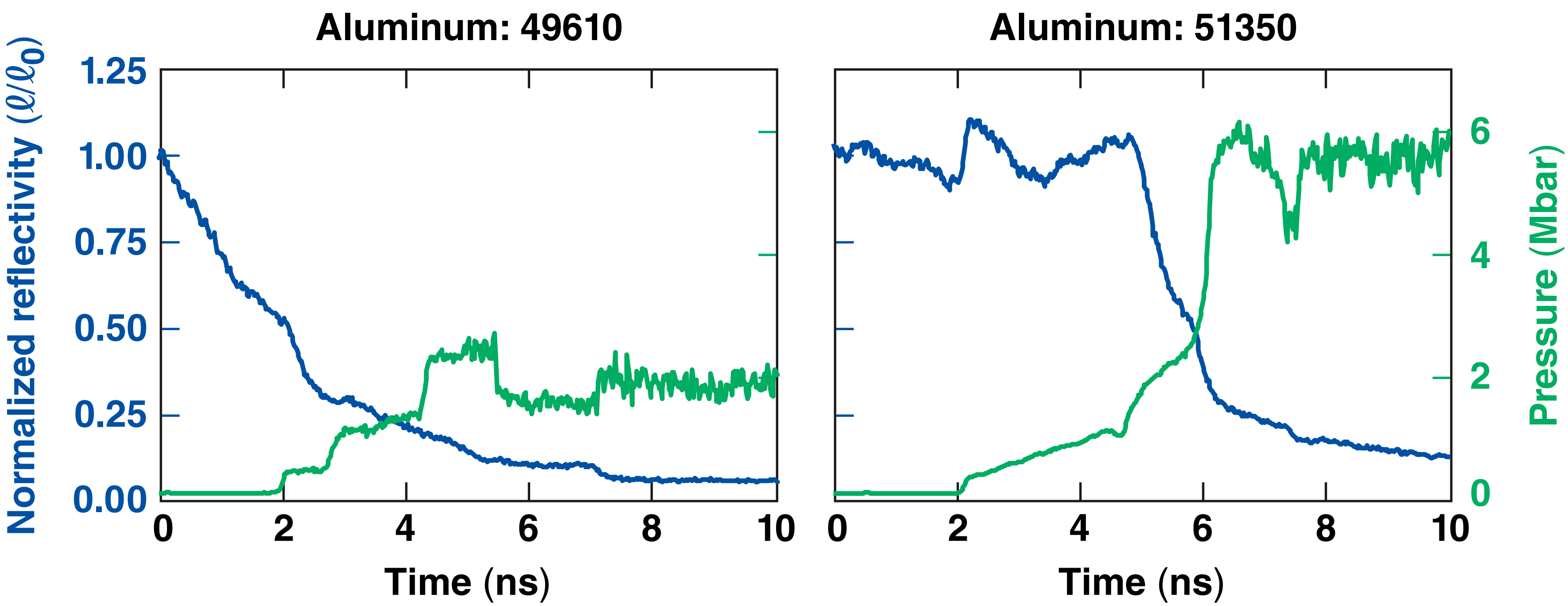

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