Measures of Strain-Induced Refractive Index Changes in Ramp-Compressed Lithium Fluoride

D. E. FRATANDUONO, M. A. BARRIOS, T. R. BOEHLY, D. D. MEYERHOFER,
J. H. EGGERT*, R. SMITH*, D. G. HICKS*, P. M. CELLIERS*, AND G. W .COLLINS*
University of Rochester, Laboratory for Laser Energetics

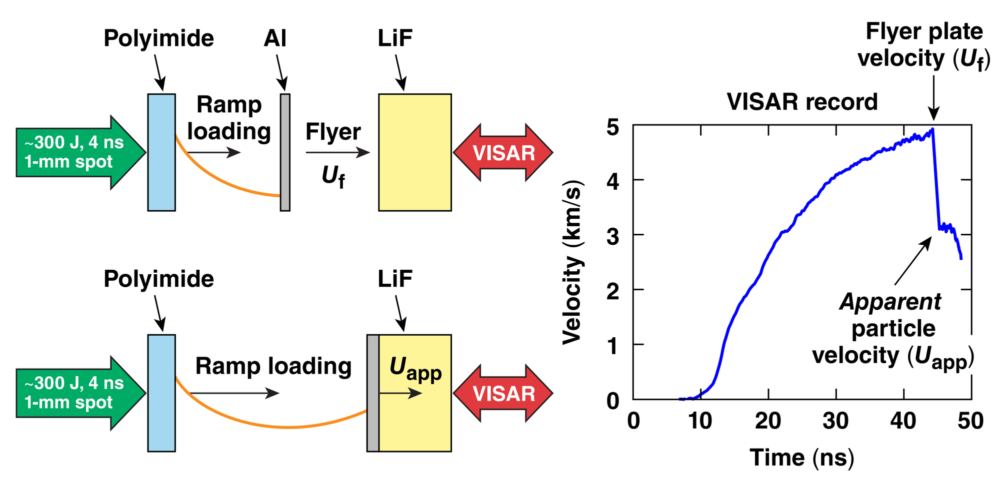
*Lawrence Livermore National Laboratory, Livermore, CA

Abstract

Lithium fluoride (LiF) is frequently used as a window in equation-of-state experiments because it remains transparent for single shocks up to 1.8 Mbar and multishocks up to 5 Mbar. Its refractive index changes when compressed, affecting the sensitivity of velocity interferometry measurements. For shocked LiF, the refractive index has been measured for pressures up to 1.15 Mbar using gas-gun flyer-plate experiments. We report on experiments at the Omega Laser Facility that use laser-driven shocks and ramp compression to compress diamond targets with LiF windows up to 8 Mbar. A specially designed two-section target is used, consisting of a diamond driver with a LiF window attached to half of the rear surface. Diamond free-surface velocity and diamond/LiF interface velocities are measured. The refractive index of compressed LiF is deduced by comparing these velocities.

This work was supported by the U.S. D.O.E Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC52-08NA28302, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

Laser-driven flyer plate experiments demonstrate ability to measure refractive index using lasers as the driving force



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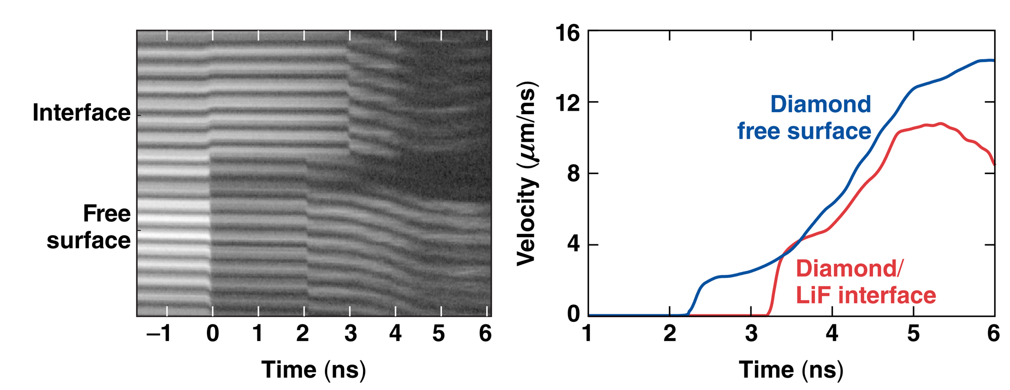

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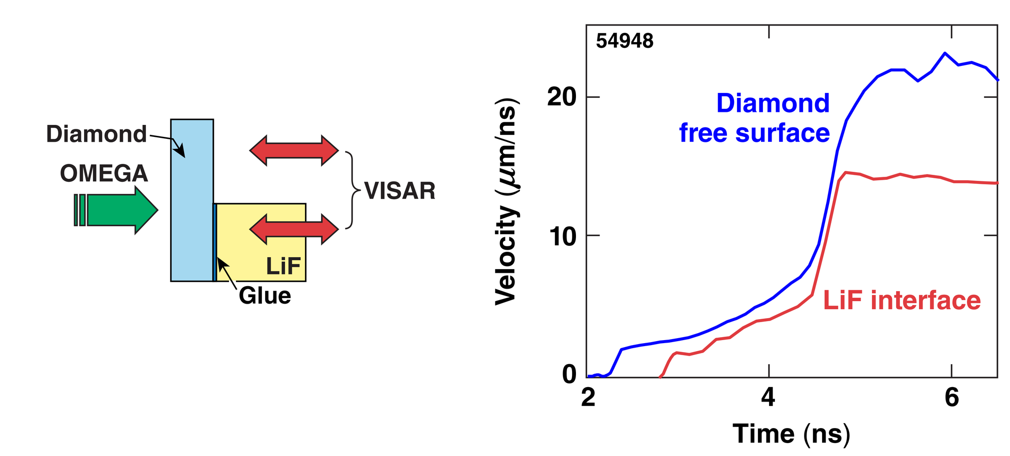
Glue layers compromised ramp measurements, but the final state can be used to obtain correction



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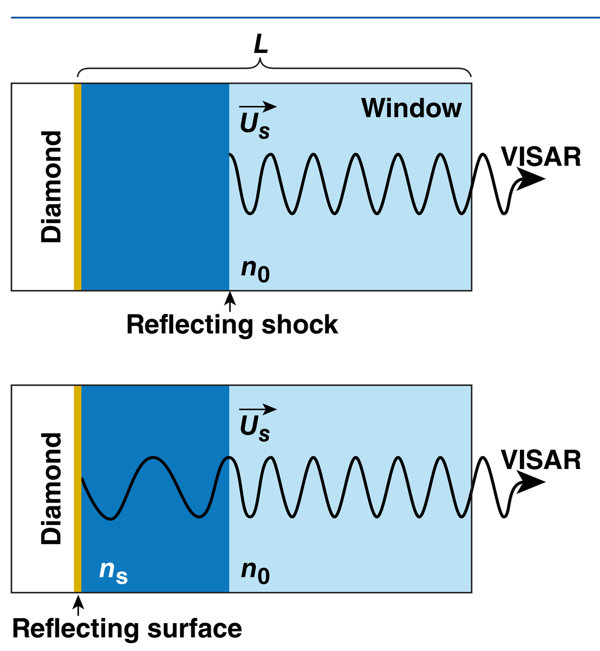
Changes in the refractive index affect VISAR measurements



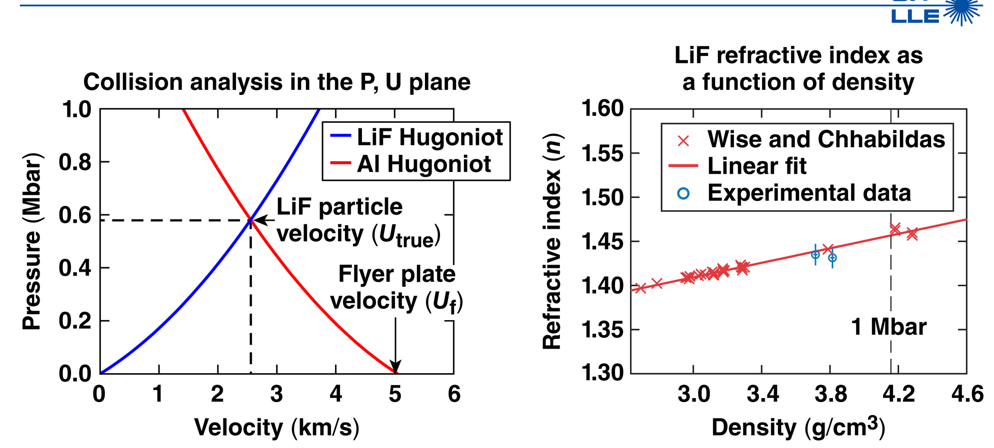
- VISAR measures the rate of change of the optical path length (OPL)
- OPL depends on n_0 and n_s

$$OPL = \int_0^L n(x)\,dx$$

- Corrections must be made for shocked materials (n_s)

E18447a

An LiF collision analysis is used to recover the *true* particle velocity (U_{true})



Correction factor:

$$\frac{U_{app}}{U_{true}} = \frac{\Delta\nu}{\nu_0} + 1$$

Refractive index†:

$$n = n_0 \frac{U_s}{U_s - U_{true}} - \left(1 + \frac{\Delta\nu}{\nu_0}\right)\frac{U_{true}}{U_s - U_{true}}$$

E17788b

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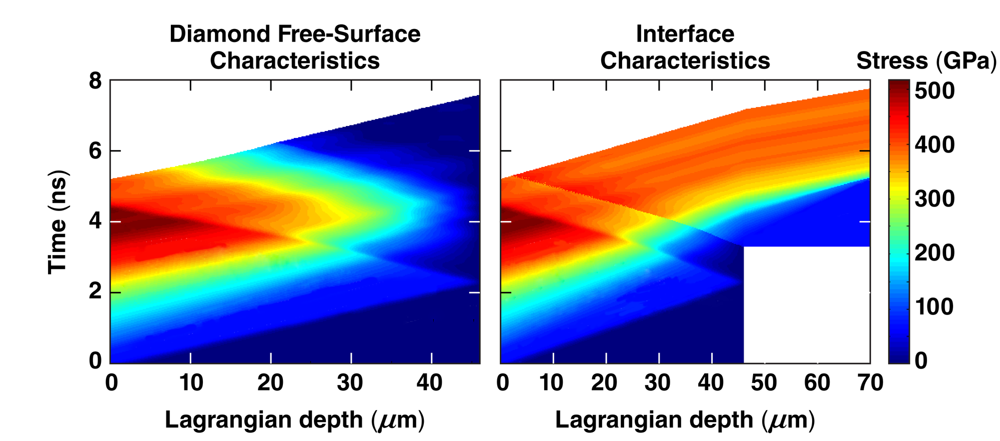
Method of characteristics recovers the *true* interface velocity



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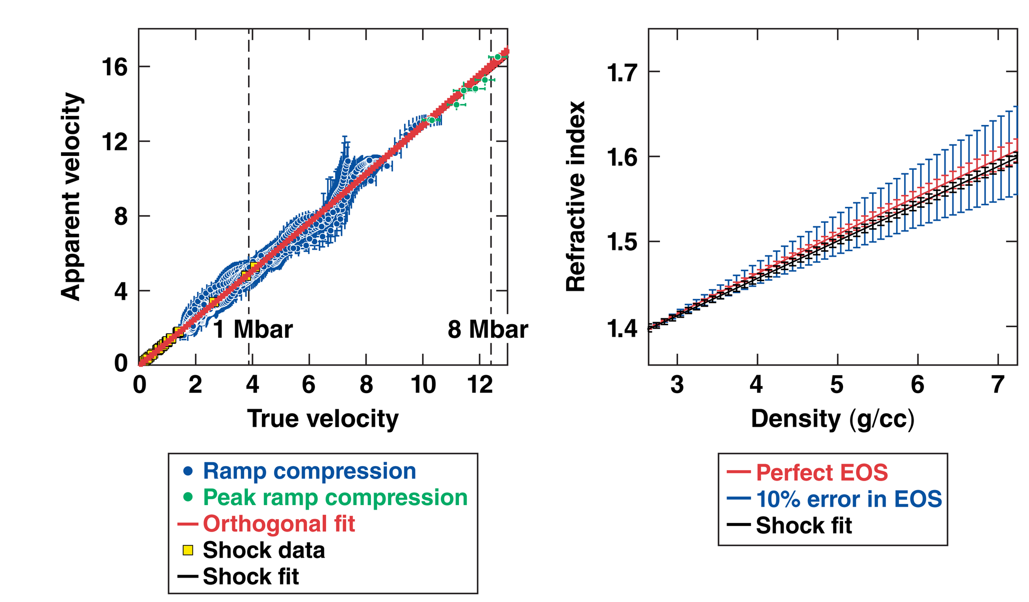
Refractive index is linearly dependent on density up to 8 Mbar



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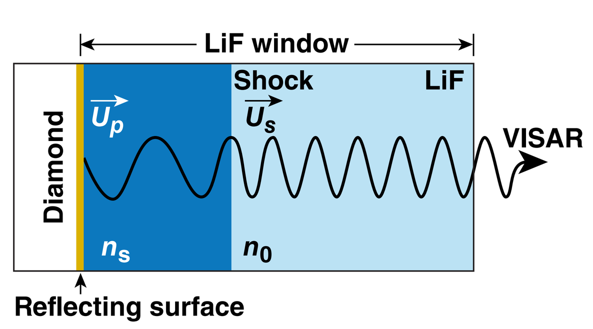
Transparency of shocks in LiF windows makes it possible for VISAR to probe the material interface

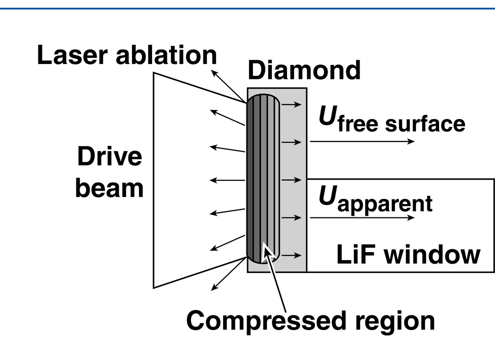


- Single shocks up to 160 GPa are transparent in LiF
  - multishocks up to 500 GPa are transparent
- VISAR probes through compressed material; this alters its sensitivity
- For shock compression up to 100 GPa, the refractive index scales linearly with density:* $n = a + b\rho$

E18046a

*J. L. Wise and L. C. Chhabildas, Shock Waves in Condensed Matter 1985, DEAC04-DP00789

Simultaneous measurement of free-surface and apparent particle velocities provide index correction



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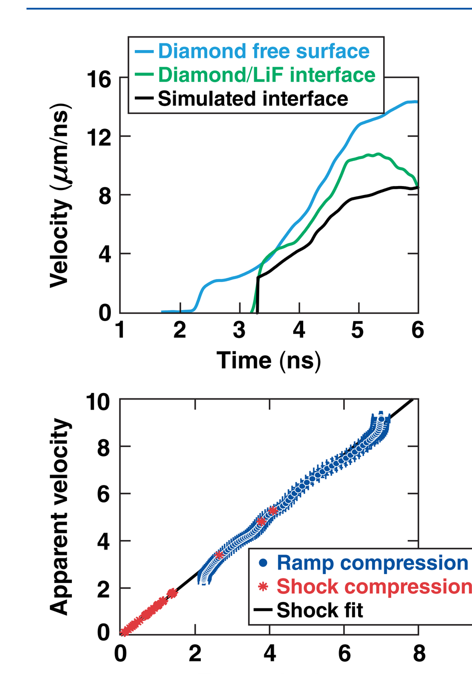
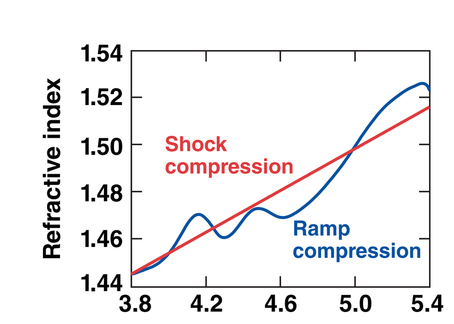
Refractive index is independent of loading history





Refractive index is determined from

$$\frac{dU_{app}}{dU_T} = n - \rho\frac{dn}{d\rho}$$

E18915

Summary/Conclusions

The refractive index of quasi-isentropically compressed LiF has been measured to ~800 GPa

- The shock-compressed refractive index of LiF was previously studied to 100 GPa*
  - demonstrated refractive-index measurements using laser-driven flyer plate
- LiF is observed to be transparent up to 800 GPa with quasi-isentropic compression
  - remains transparent for single shocks < 160 GPa
- Ramp-compressed LiF refractive index is in agreement with existing data
  - does not depend on loading technique (shock versus ramp compression)
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E18359a

*J. L. Wise and L. C. Chhabildas, presented at the American Physical Society Topical Conference on Shock Waves in Condensed Matter, Spokane, WA, 22 July 1985.

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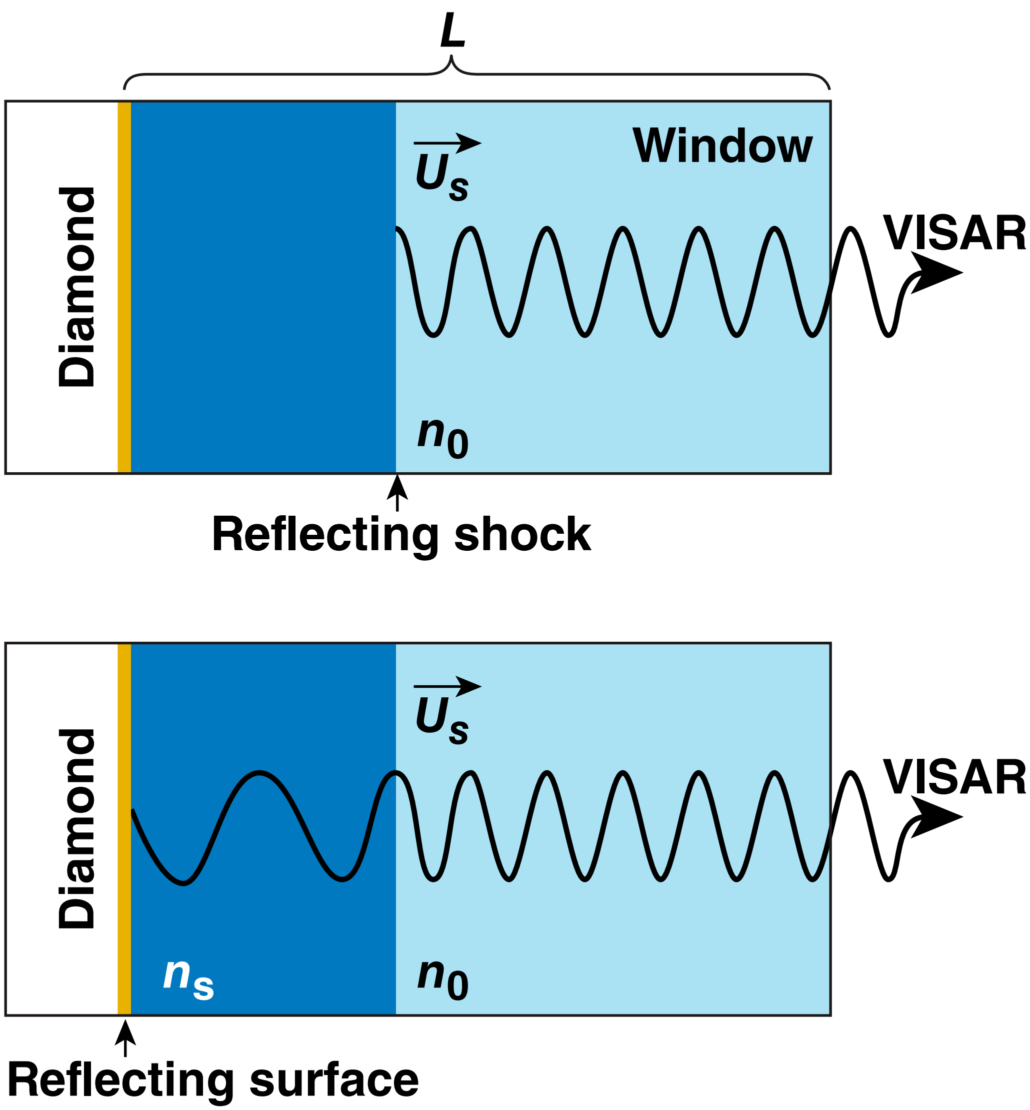

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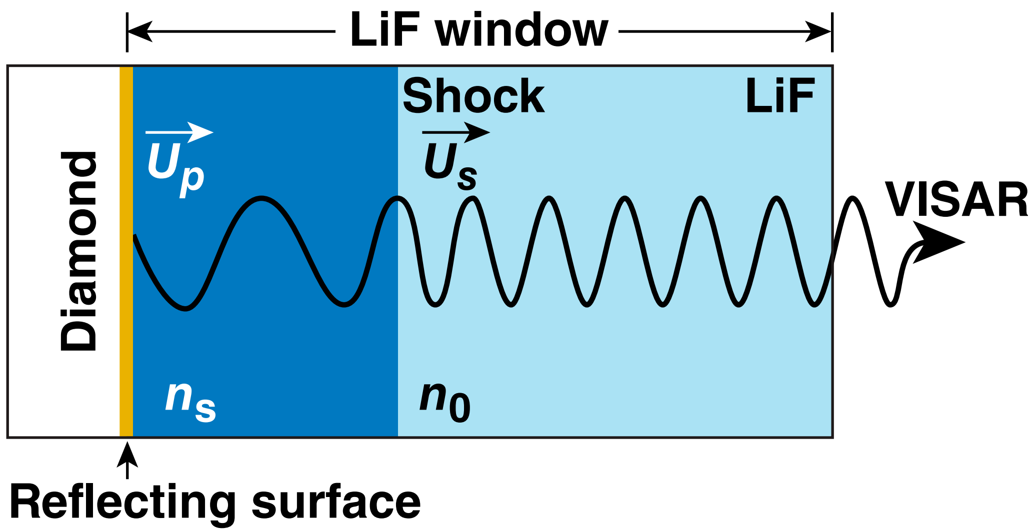

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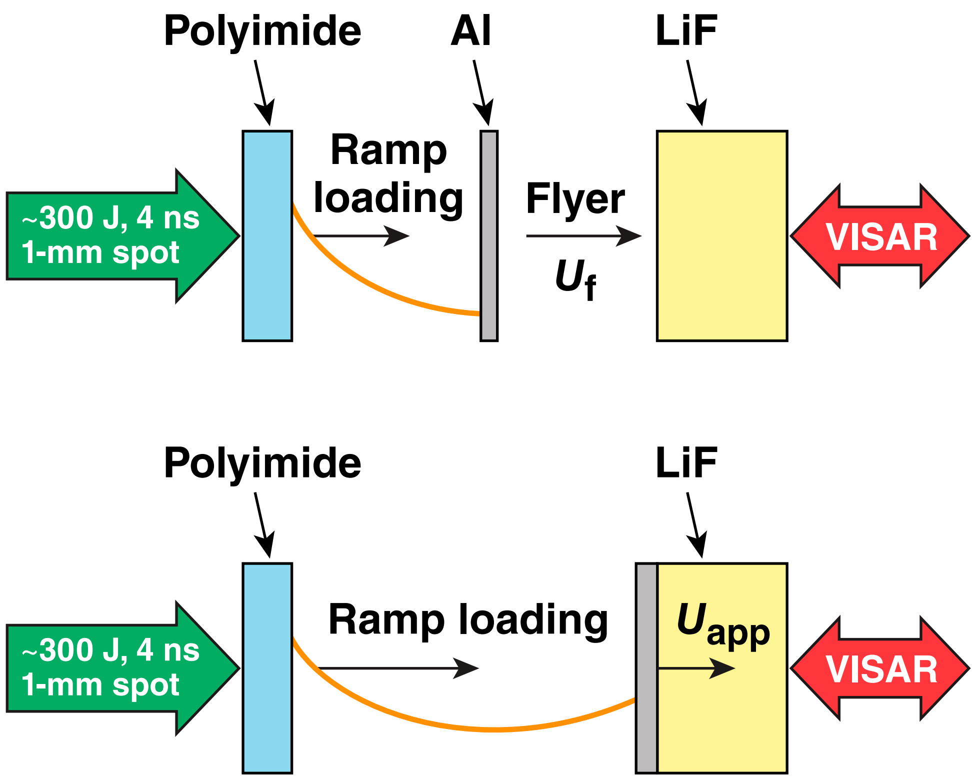

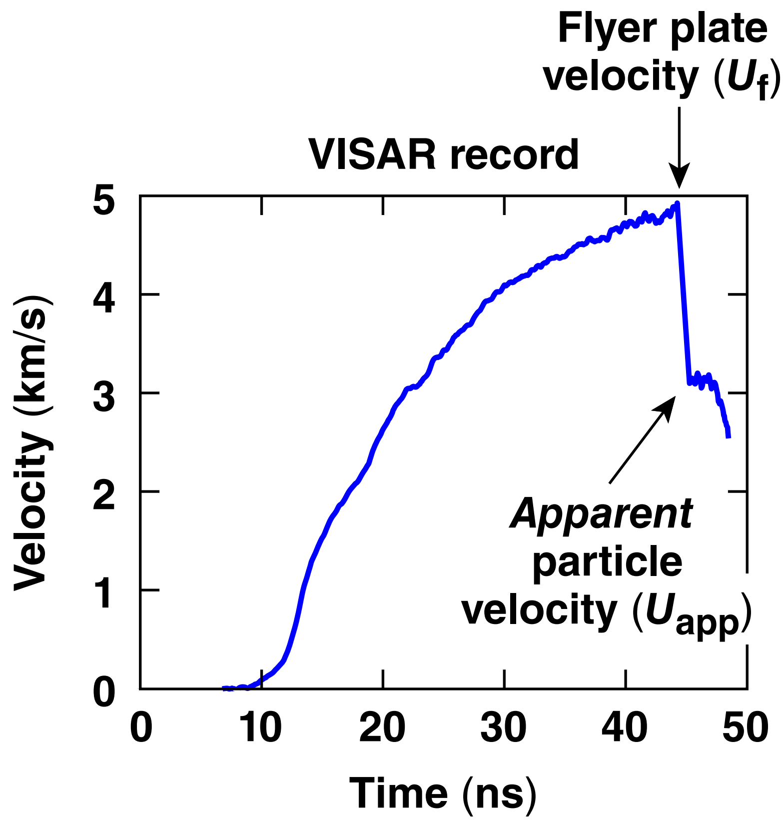

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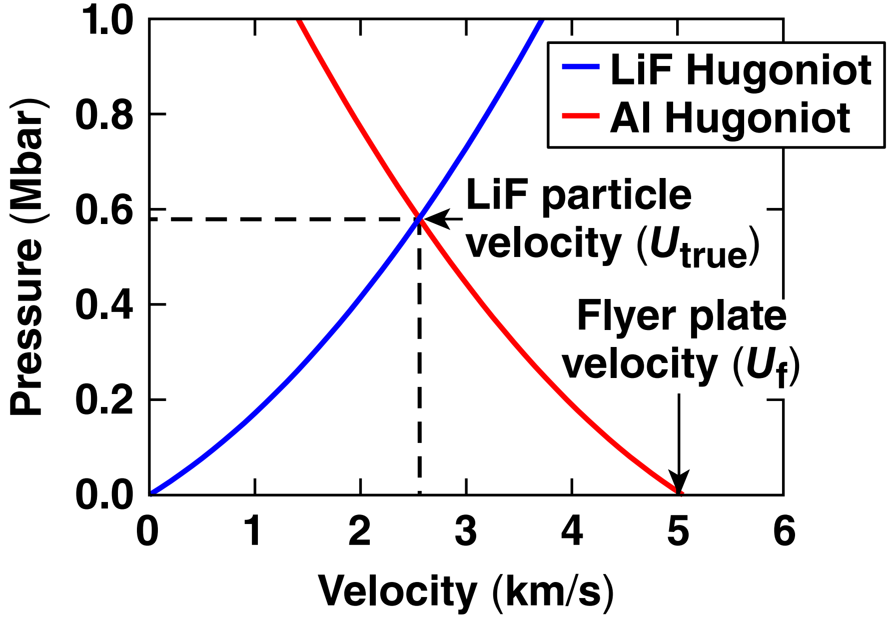

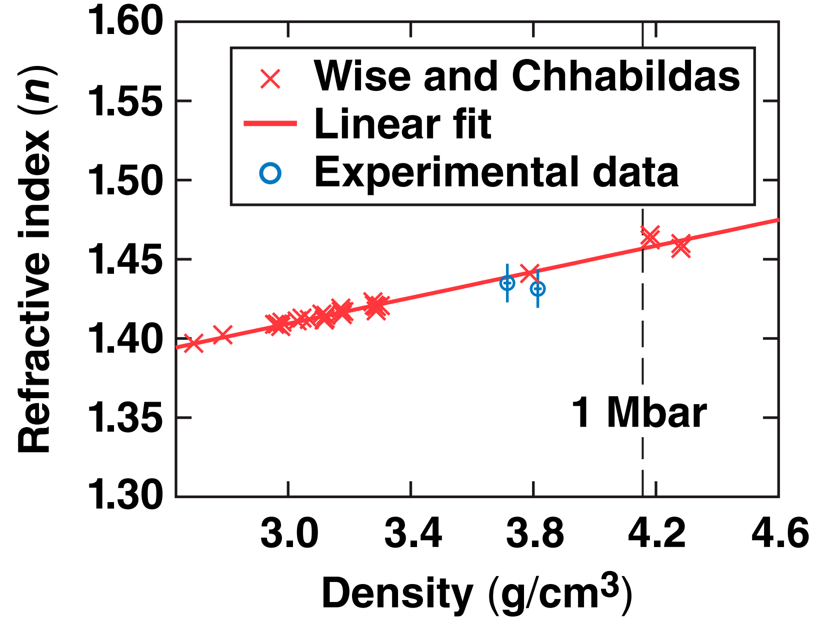

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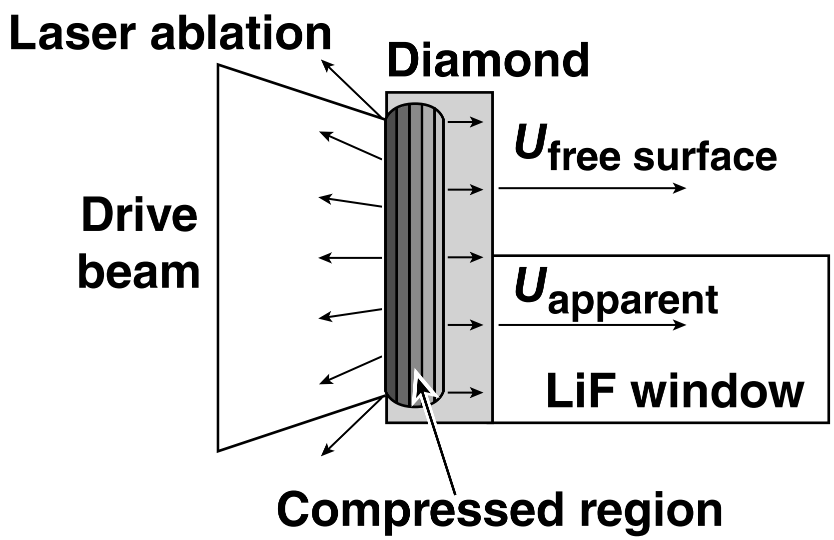

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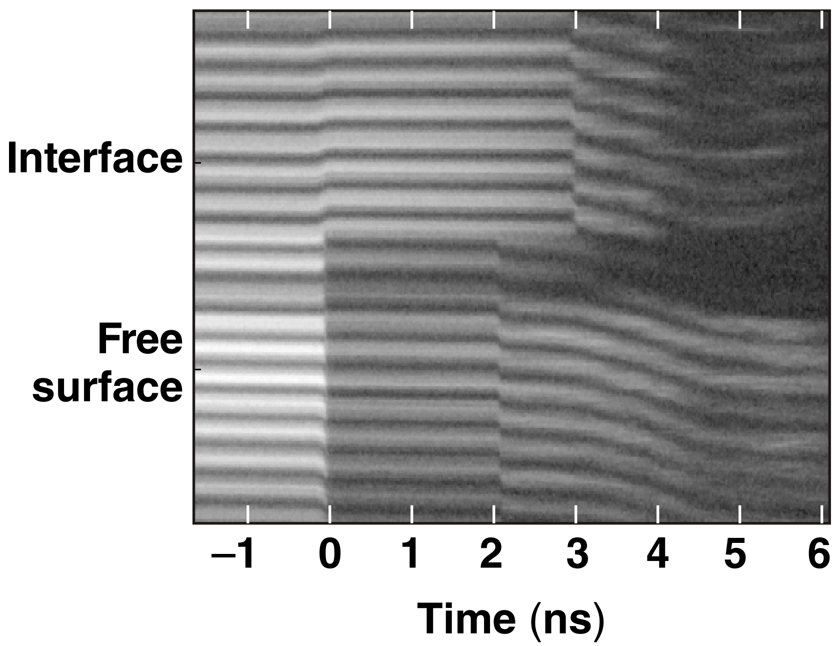

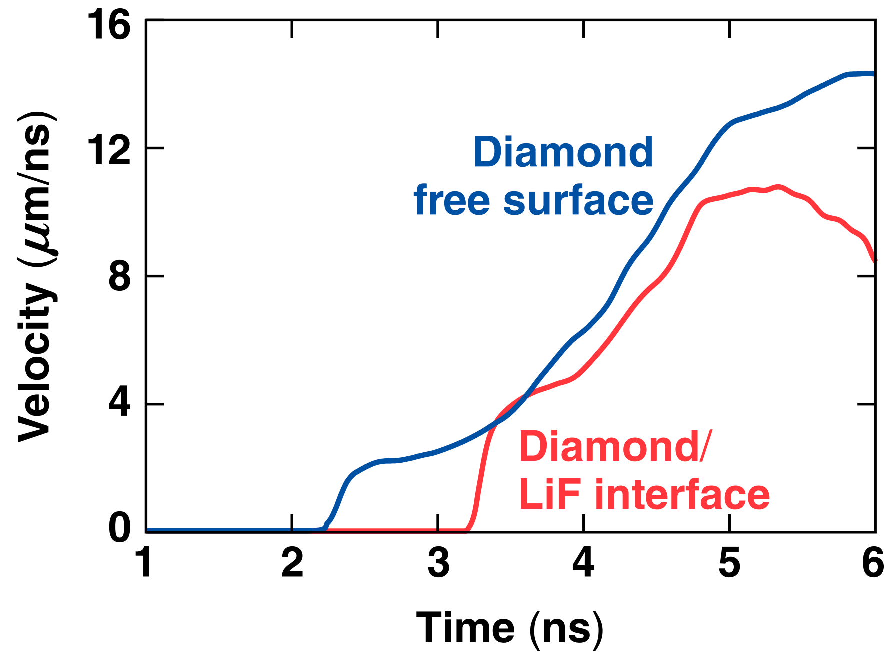

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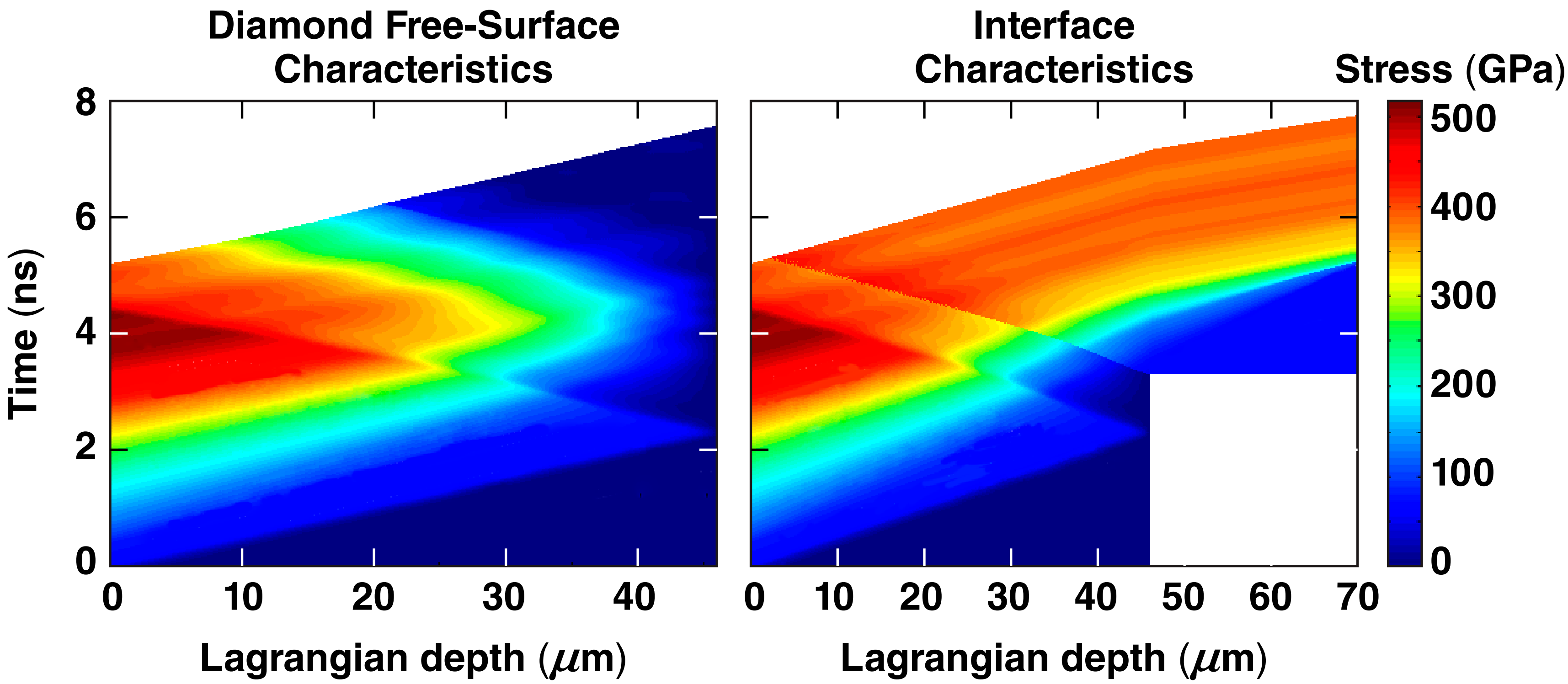

E18914

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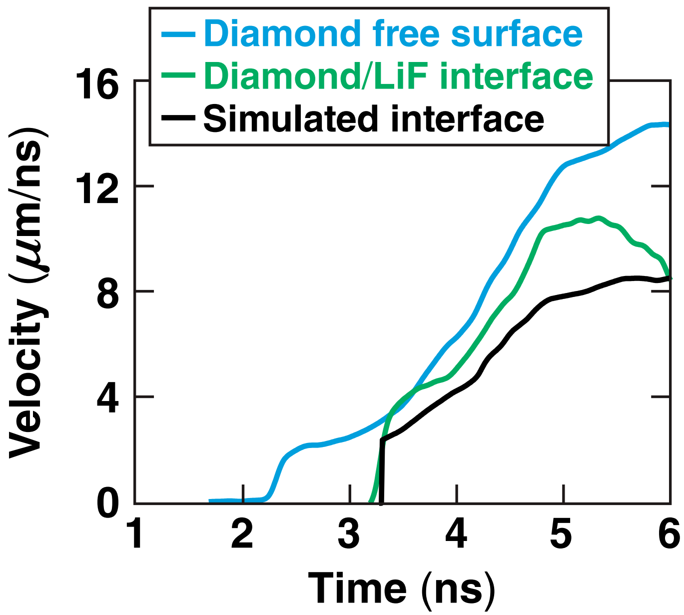

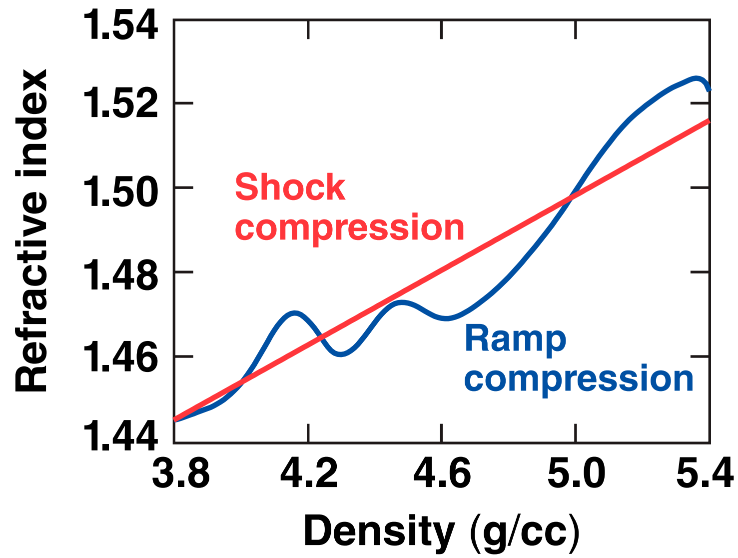

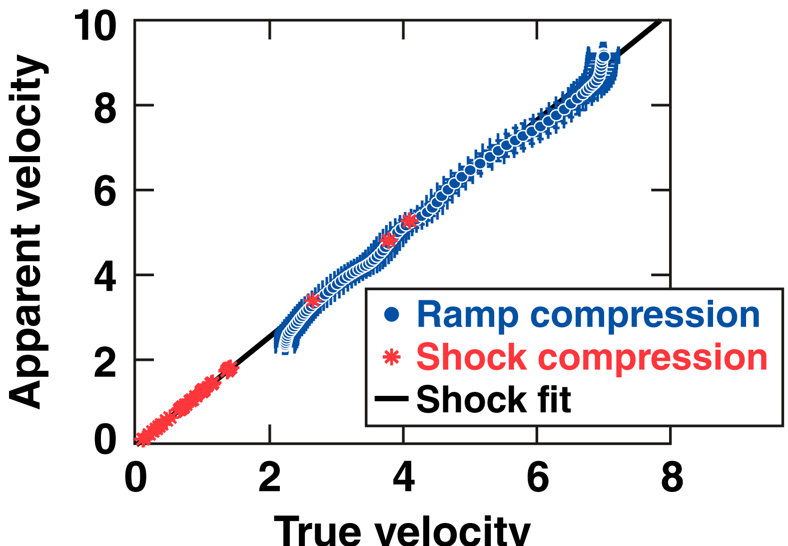

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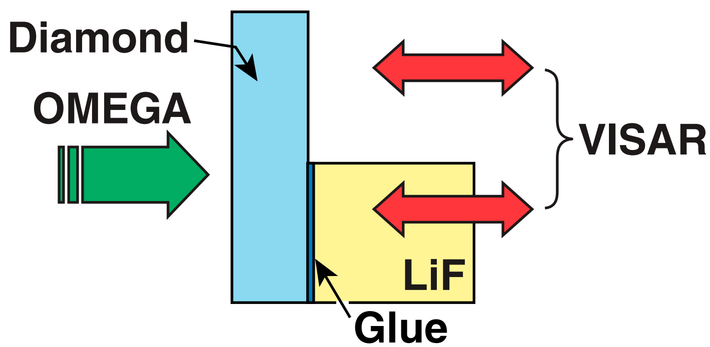

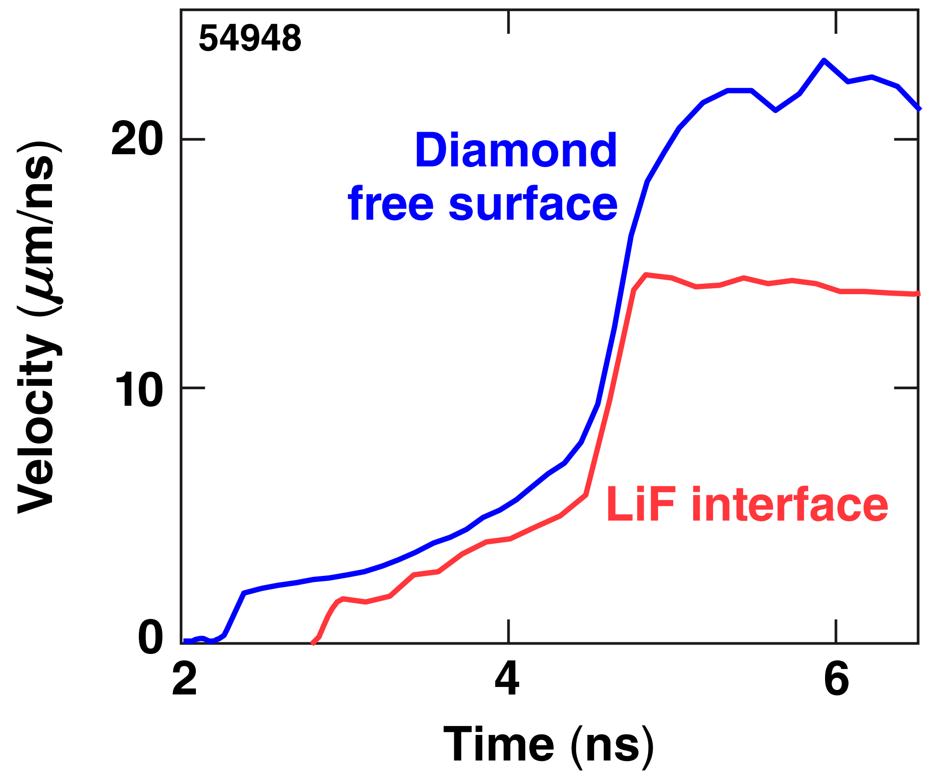

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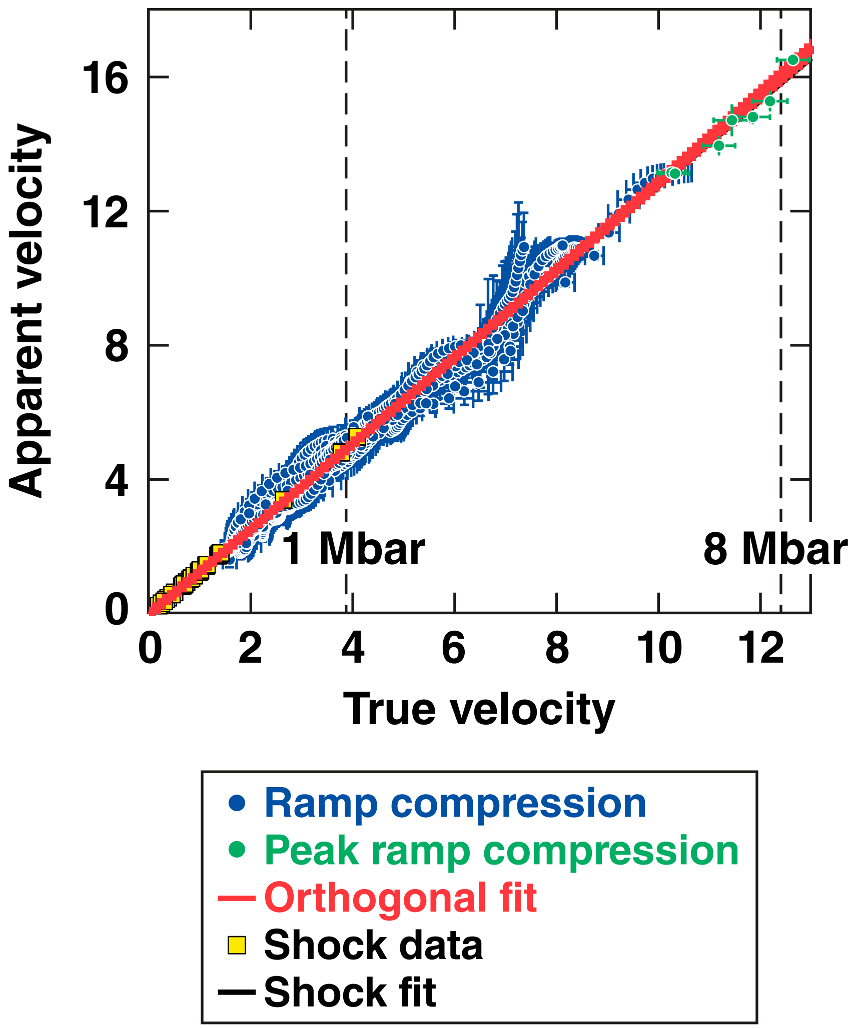

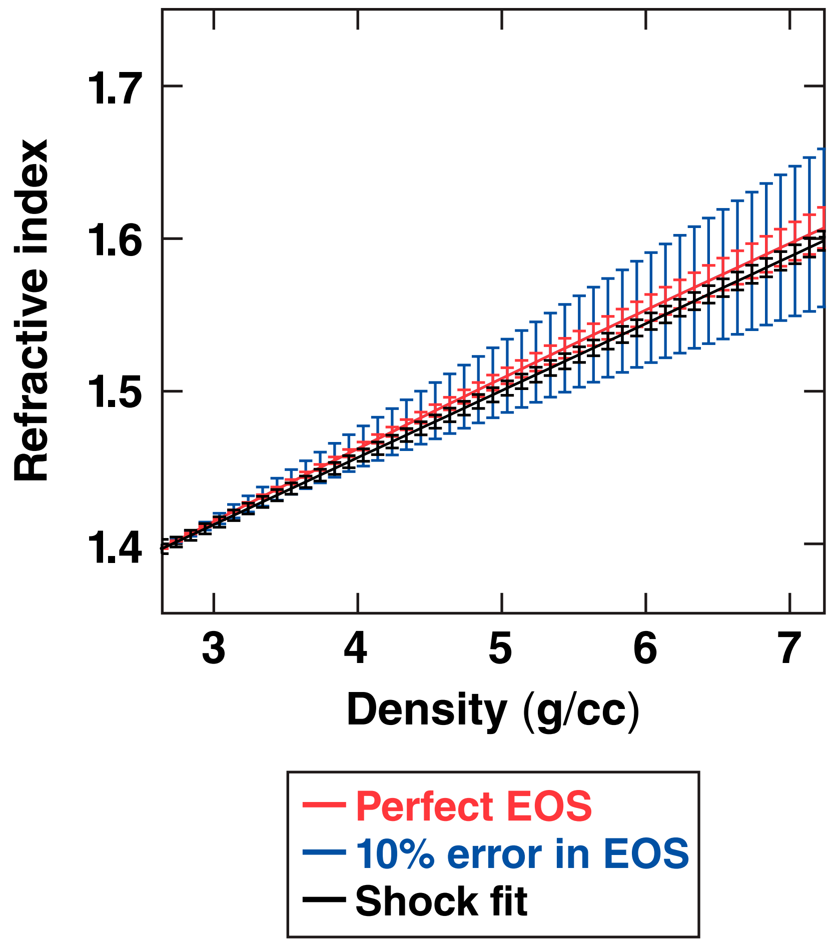

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