SAND2012-1406 C

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The Shock Thermodynamics Applied Research

The Shock Response of Granular and Consolidated Ta_2O_5

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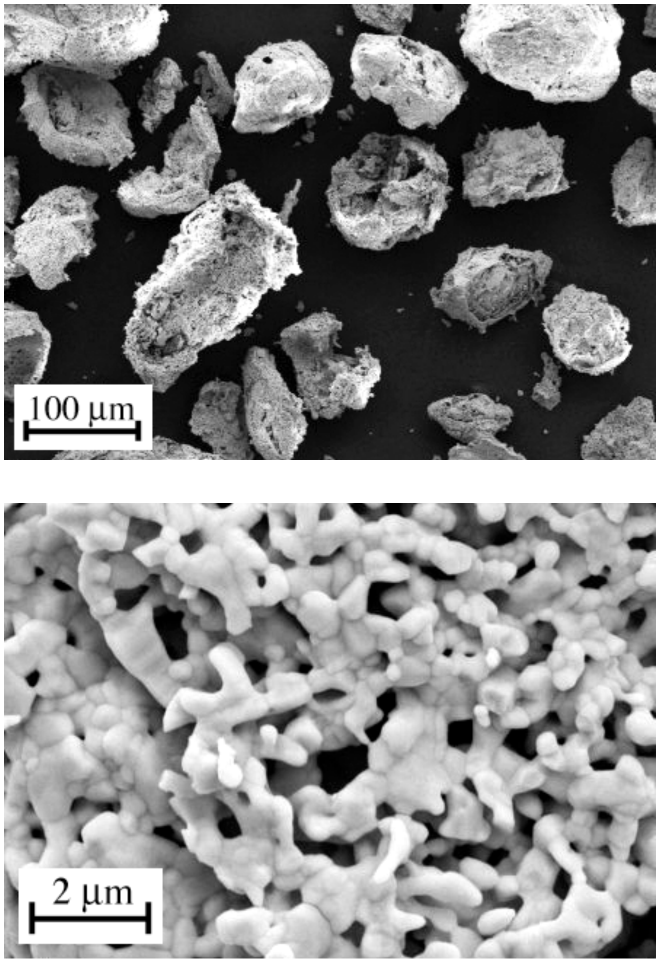
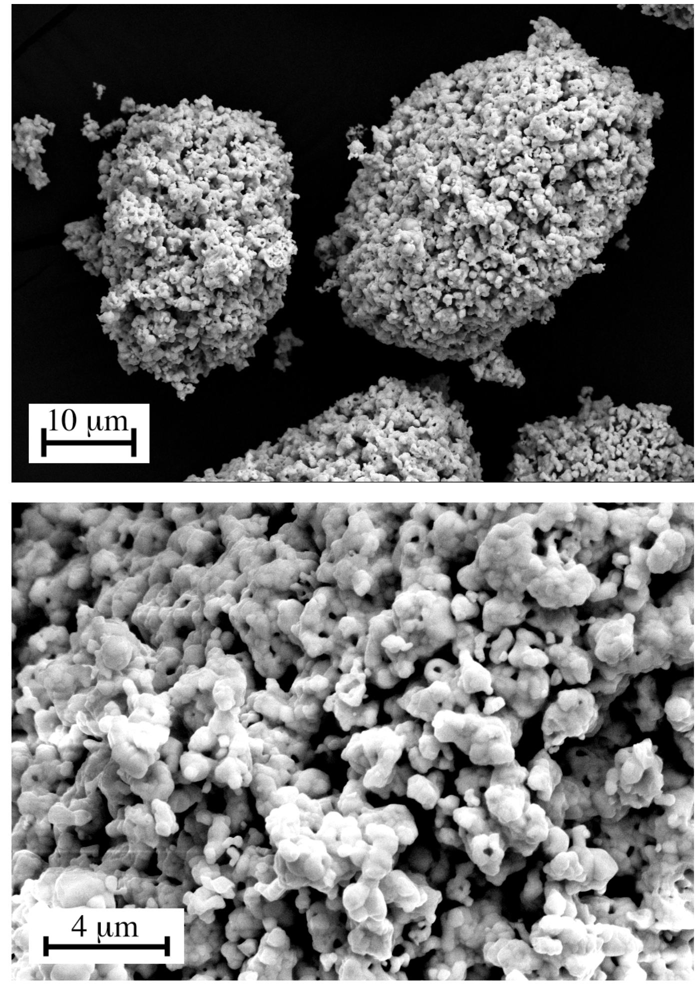
Two Different Forms of Granular Ta_2O_5

~1.3 g/cc from Cerac



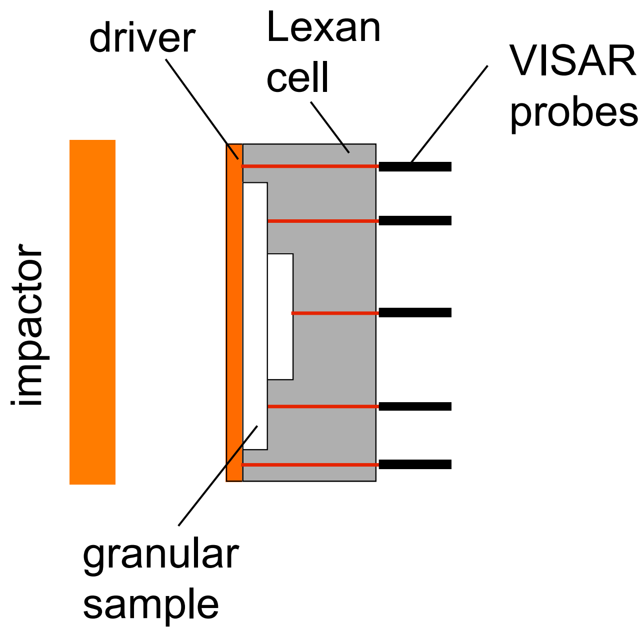
~3 g/cc from American Elements

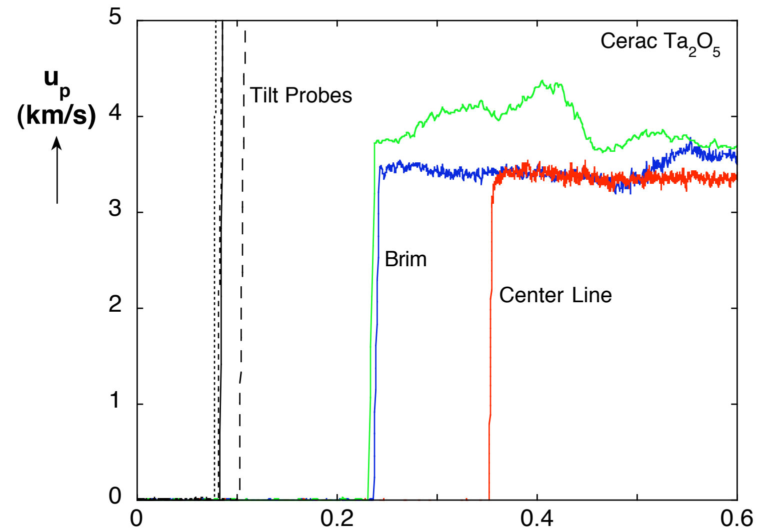


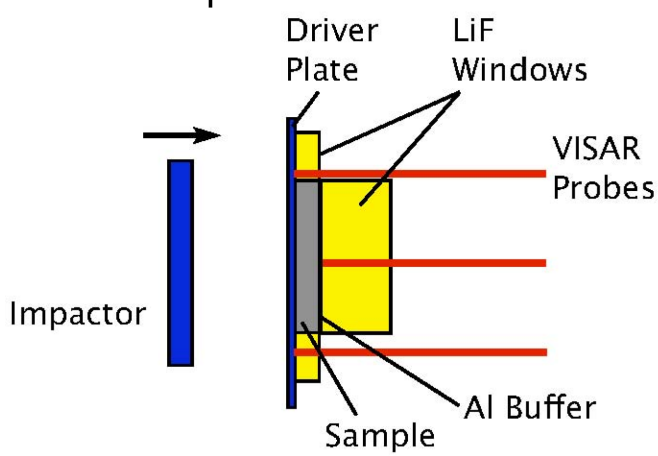
X-ray diffraction shows all material is in orthorhombic form

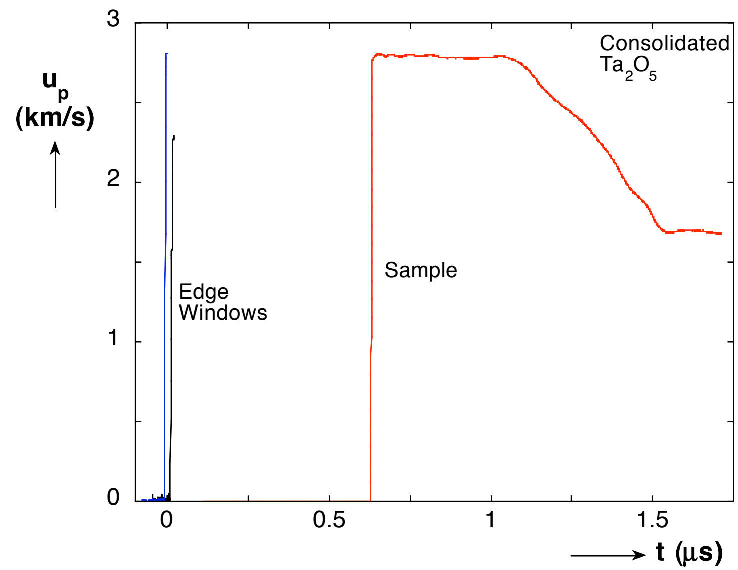
also 90% dense disks from cold pressing or low temperature sintering

2-Stage Gas Gun Experiments on Granular and Consolidated Ta_2O_5



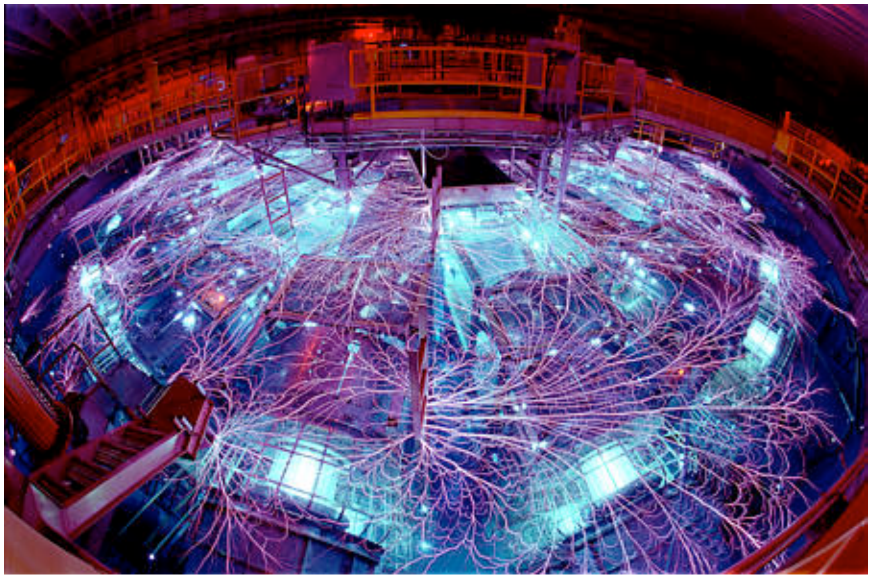


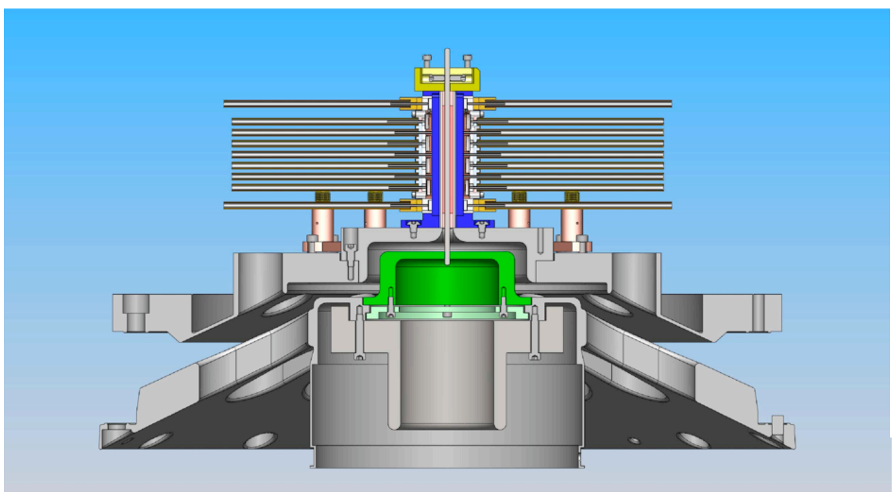


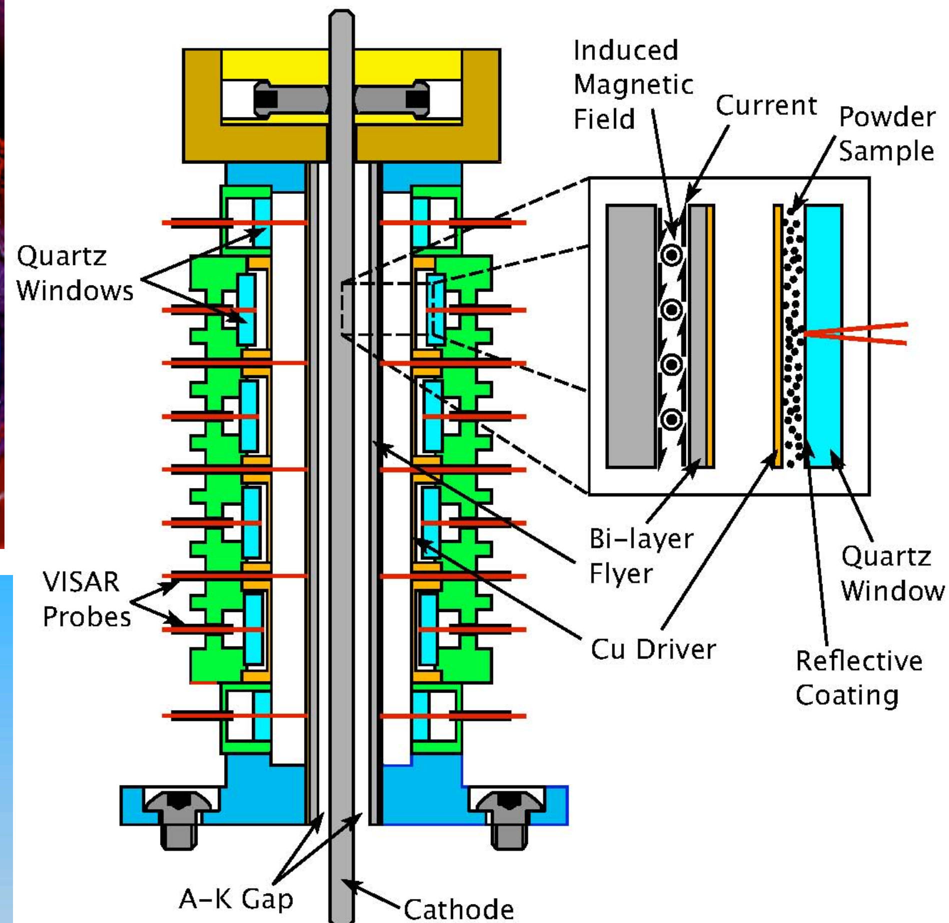


samples vented to vacuum (50-100 mTorr) of target chamber

Ultra-High Pressure Z Experiments

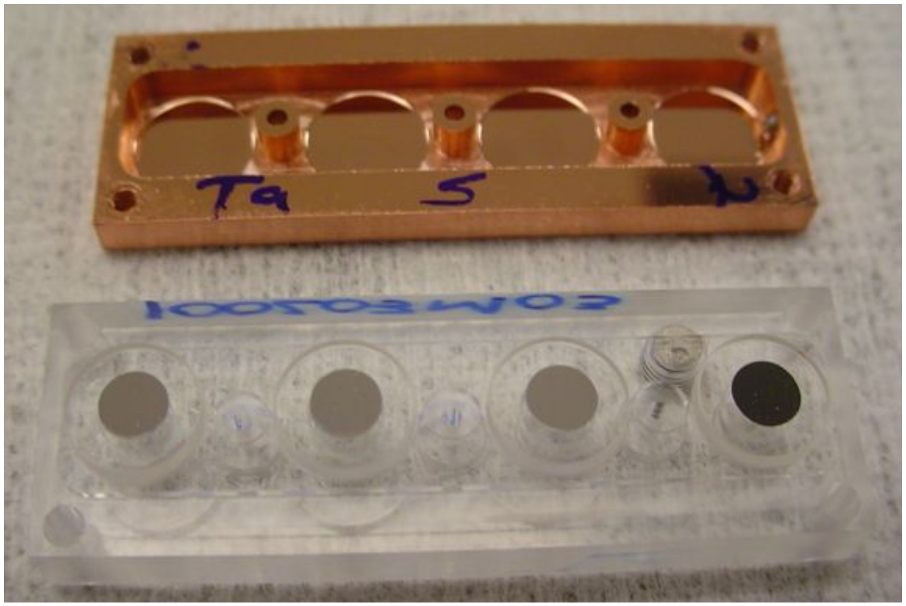


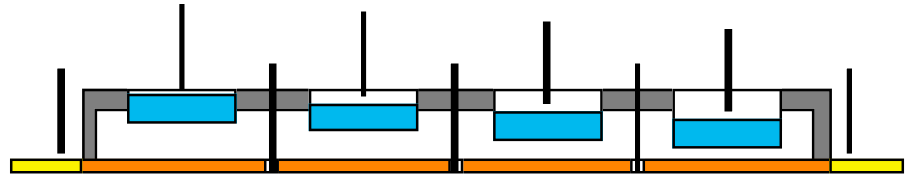




V = 9.9-10.3 and 11.2-11.4 km/s

Z Powder Capsule



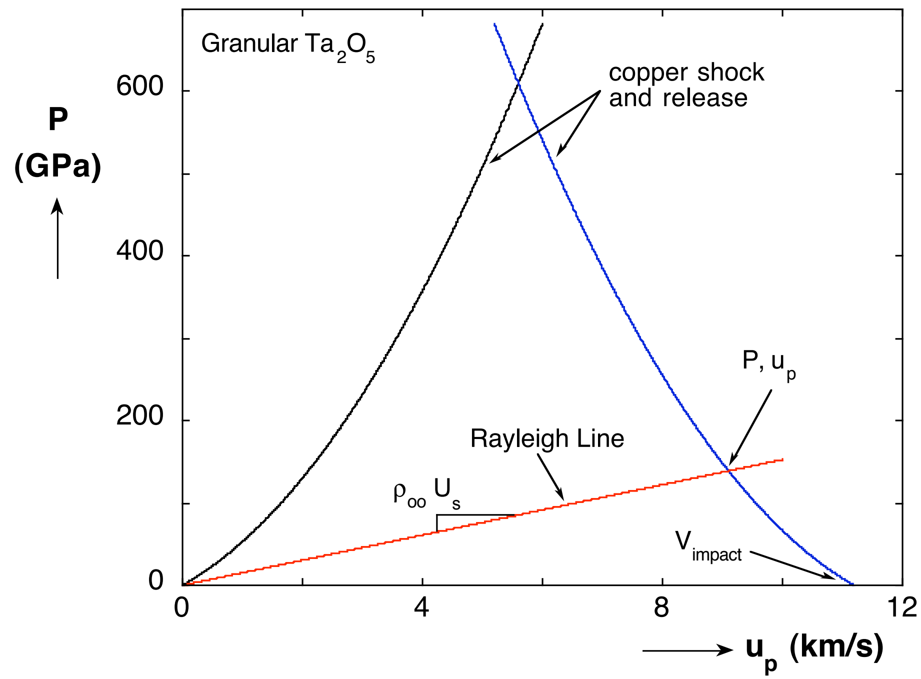


each target consists of:

- 300 μm Cu flyer on 700 μm Al
- 300 μm Cu driver
- four sample thicknesses of 400, 600, 800, and 1000 μm
- quartz windows.

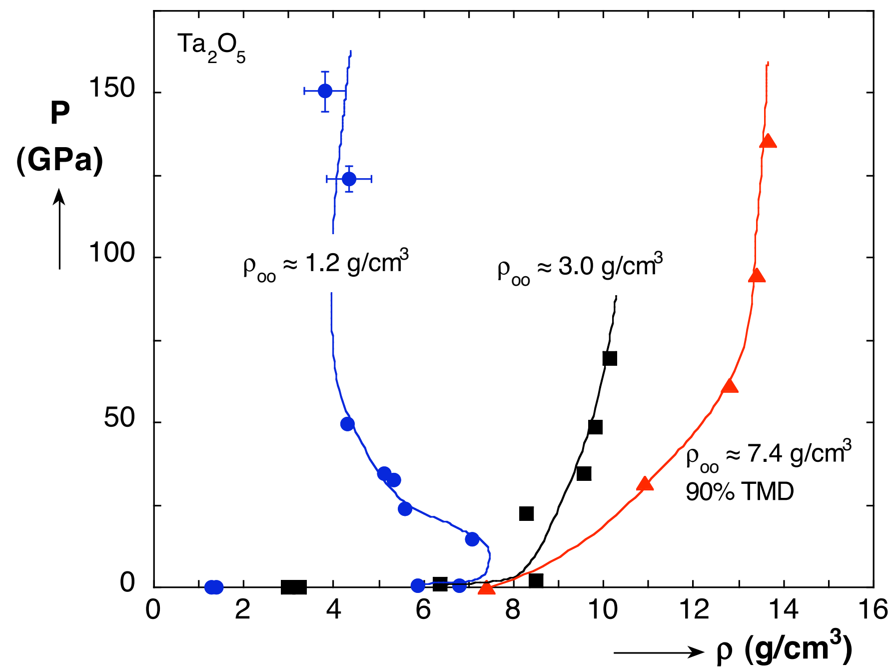
VISAR measurements made at each sample/window interface and above, below, and between the samples

Impedance Matching Used to Calculate Hugoniot States

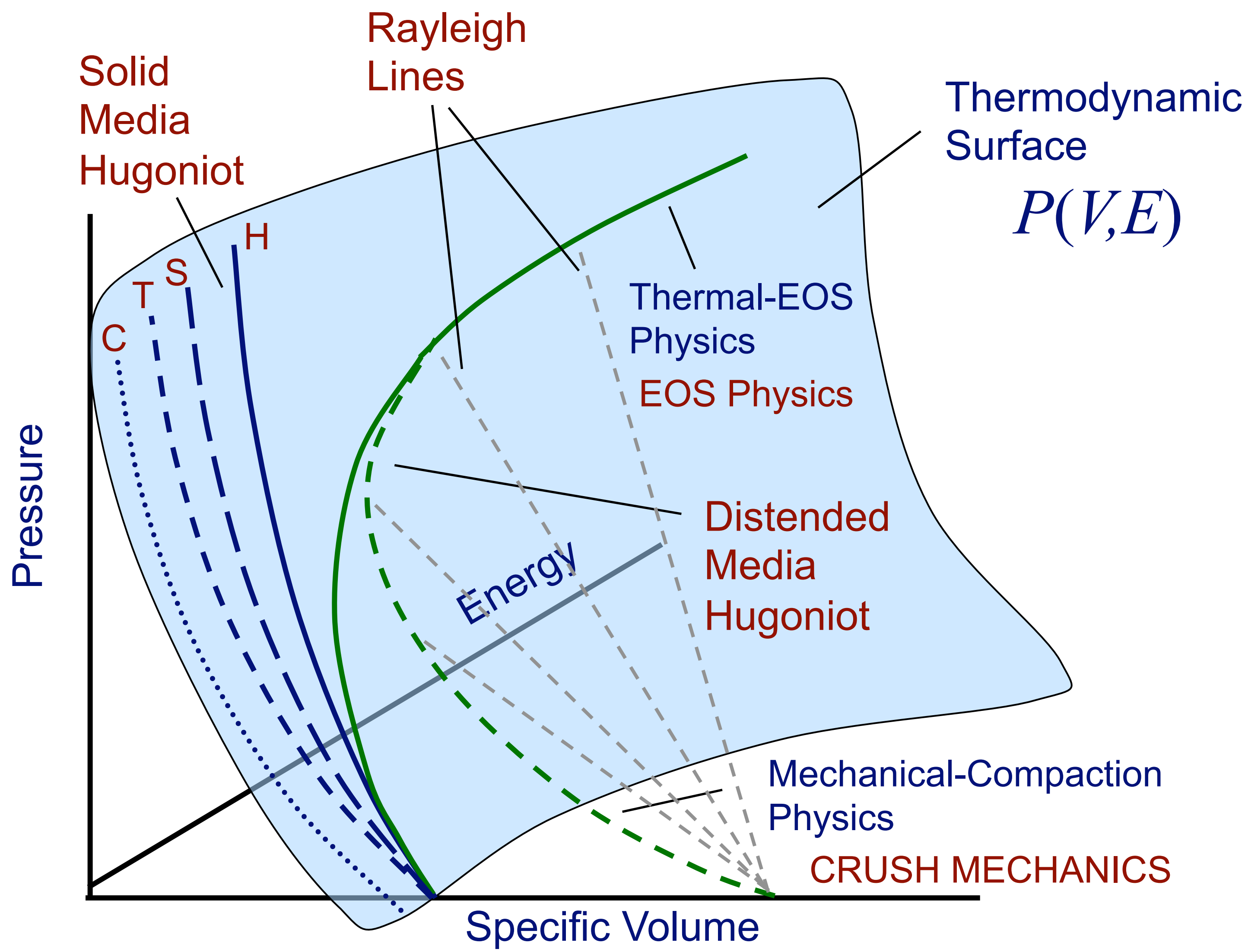


lower density material shows "anomalous" compressibility due to thermal effects

suggestions of phase transformation in vicinity of 40-50 GPa, but more data needed



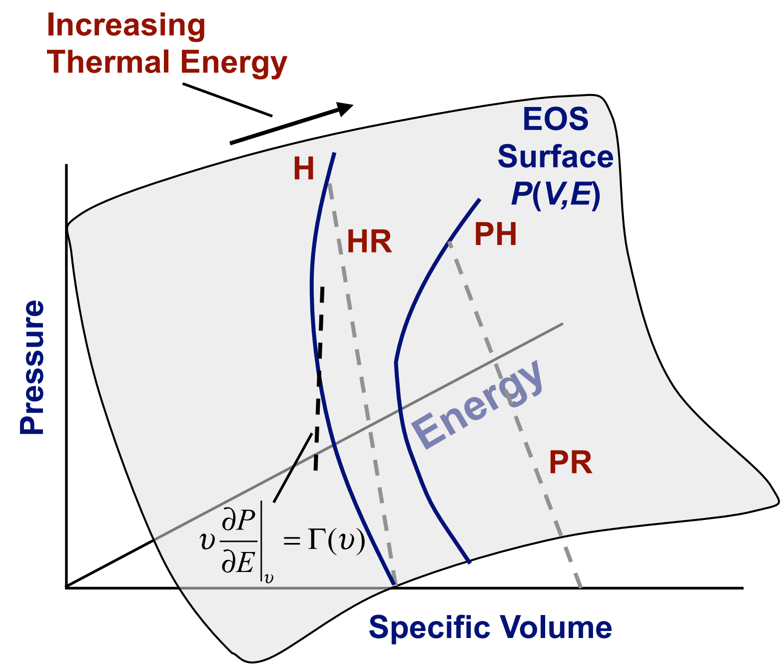
Distended Media EOS



EOS for Distended Media: the Isochoric Approach

$$\Gamma(\upsilon) = \upsilon \frac{\partial P}{\partial E}\bigg|_{\upsilon}$$

$$P(\upsilon, E) = P_H(\upsilon) + \frac{\Gamma(\upsilon)}{\upsilon}\left(E - E_H(\upsilon)\right)$$



$$P_{PH}(\upsilon) = P_H(\upsilon)\left(\frac{2\upsilon - \Gamma(\upsilon)\left(\upsilon_o - \upsilon\right)}{2\upsilon - \Gamma(\upsilon)\left(k\ \upsilon_o - \upsilon\right)}\right)$$

$$k = \frac{\upsilon_{oo}}{\upsilon_o} \equiv \text{ distention}$$

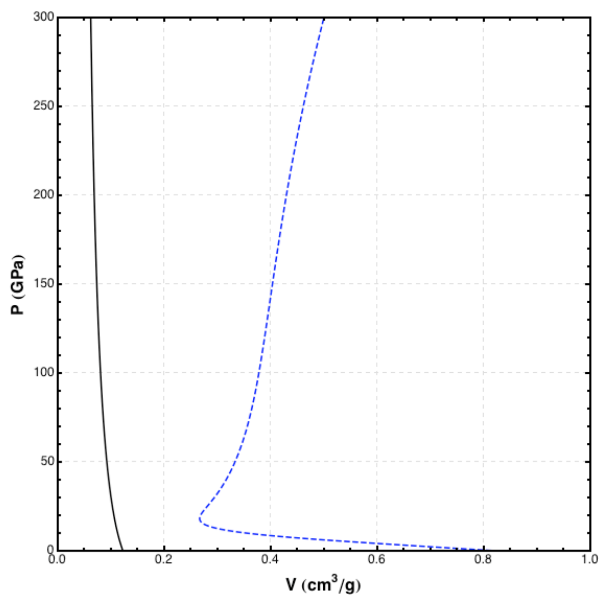
isochoric approach problematic for anomalous compressibility due to multi-valued response

EOS for Distended Media: the Isobaric Approach

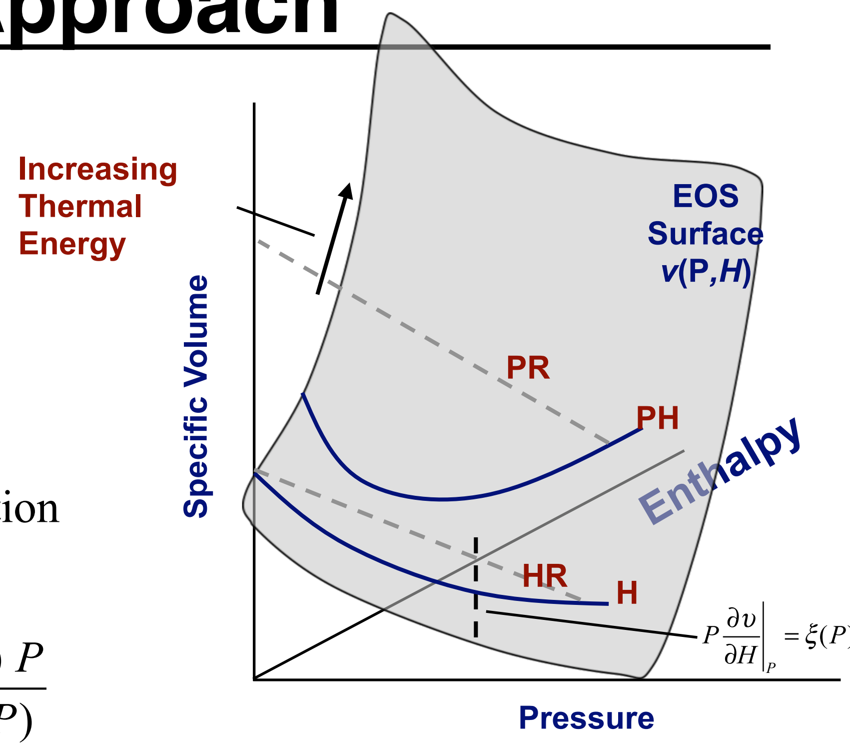
$$\xi(P) = P \left.\frac{\partial \upsilon}{\partial H}\right|_P$$

$$\upsilon(P,H) = \upsilon_{HR}(P) + \frac{\xi(P)}{P}\left(H - H_{HR}(P)\right)$$

$$\upsilon_{Ph}(P) = \upsilon_{HR}(P) + \frac{(k-1)\upsilon_o}{\frac{2}{\xi(P)} - 1} \qquad k = \frac{\upsilon_{oo}}{\upsilon_o} \equiv \text{ distention}$$



where $\xi(P) = \frac{\Gamma(P)\, P}{K_s(P)}$



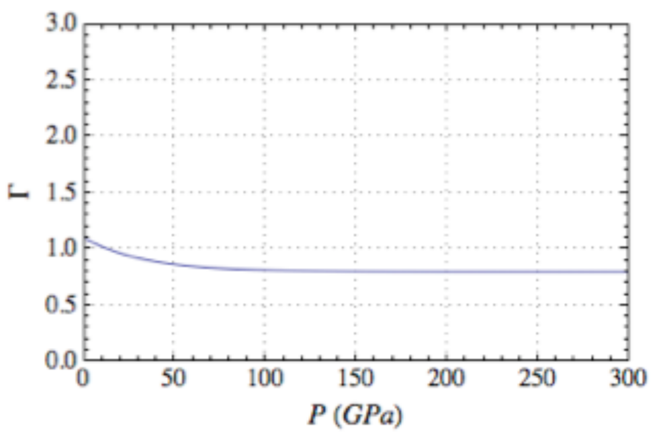
The Rice-Walsh EOS (RW EOS)

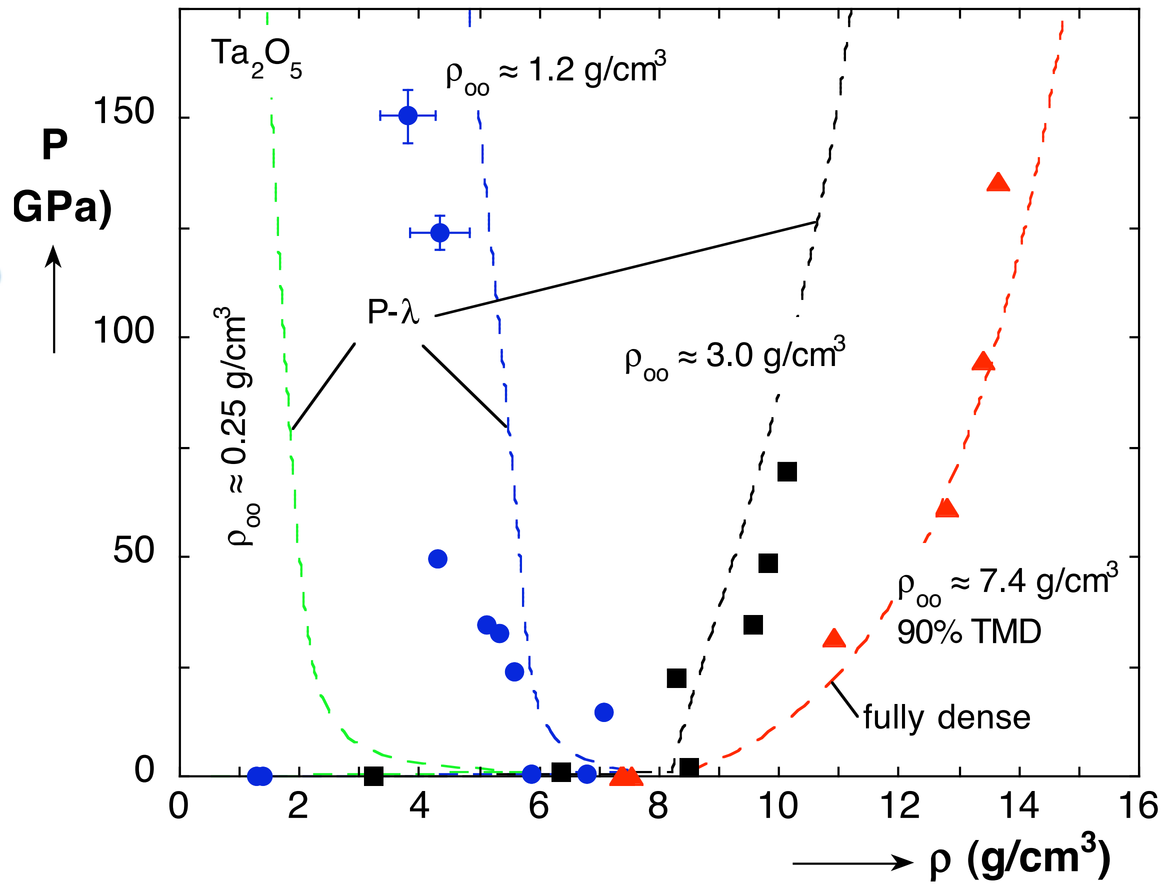
isobaric approach better suited to highly distended materials

Fenton et al. (2011). Intense Shock Compression of Porous Mixtures: Application to WC and Ta_2O_5 APS Shock Conference

Model Results for Ta_2O_5

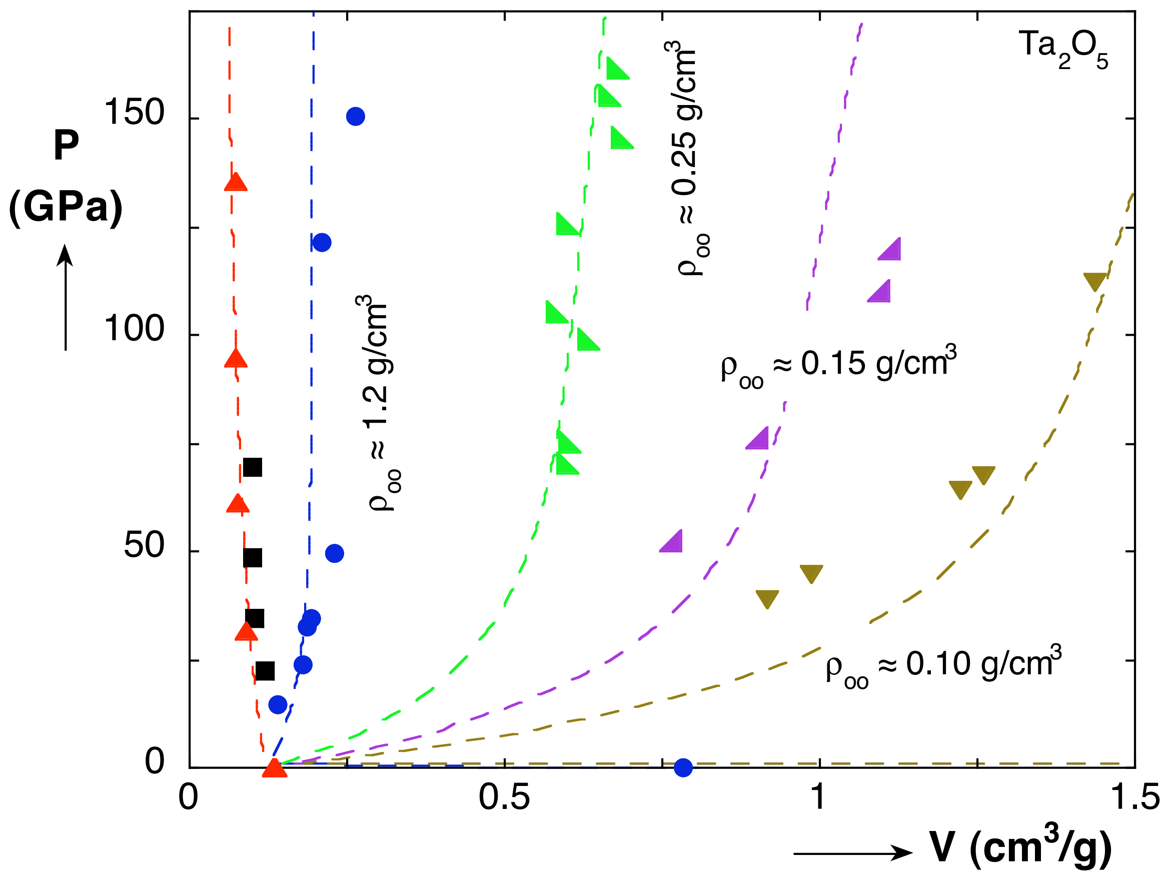
$$\Gamma(P) = \Gamma_o \, e^{-\left(\frac{P}{K_o}\right)^n} + \Gamma_\infty \left(1 - e^{-\left(\frac{P}{K_o}\right)^n}\right)$$





Comparison with Aerogel Results from LLNL

Miller et al. (2007). *Shock Compression of Condensed Matter – 2007*, 71-74.



good agreement with results for very low density aerogel

Conclusions

- new high-pressure Hugoniot results for granular Ta_2O_5 from a 2-stage gun and Z
- varying particle morphologies lead to different initial densities and shock responses
- Rice-Walsh isobaric formulation added to P-λ model to capture anomalous compressibility
- model calibrated to granular form of Ta_2O_5 does credible job of capturing response of low density aerogel
- study of mixtures of Ta_2O_5 and Al powders in progress