Thermal Emission and Reflectivity of Shocked SiO$_2$ Aerogel for Broadband Optical Probing

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We have studied SiO$_2$ aerogel to develop a broadband optical source for high energy density physics (HEDP) experiments

- Traditional Thomas-Fermi models significantly overpredict brightness temperature (spectral radiance) in shock compressed aerogel, which can be attributed to a combination of microstructure effects and a radiative precursor.

- SiO$_2$ aerogel’s T-$u_s$ behavior was expected to be quadratic similar to higher density polymorphs (fused silica, quartz, Stishovite), however we observe a linear trend.

- A radiance model has been developed as a pragmatic approach to designing laser-driven shock experiments involving SiO$_2$. 
Collaborators


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Optical probes are necessary for measurements of optical and electronic properties at extreme conditions

- Optical spectroscopy can be used to observe band gap closure during compression

- Other topics of interest: d-band slitting in compressed aluminum, electride phases in alkali metals

* From D. N. Polsin PhD Thesis [See PI01:2]
Decaying shocks were driven through aerogel samples with initial densities of 0.1, 0.2, and 0.3 g/cc.

Quartz acts as a pressure and reflectance reference.
Results

Predictions of brightness temperature in shocked aerogel are significantly higher than the observed values.

- Disagreement between predictions and data might be due to:
  1. Overestimation of the emissivity
  2. Microstructure
  3. Radiative Precursor

*S. Crockett, SESAME Database, Accessed 8 May 2020
Reflectance measurements are similar to those of solid quartz, suggesting that the temperature discrepancy cannot be corrected further through the emissivity.

Results for 0.2 g/cc match well with QMD simulations.

Linear $T-u_s$ behavior was observed for silica aerogel, contrary to the predicted quadratic behavior exhibited by higher density polymorphs.

- SiO$_2$ aerogel was expected to have a higher brightness temperature than fused silica, quartz, and Stishovite.

- An emissivity correction is included in the shown data.


Results

A radiance model was developed for convenient use when designing experiments involving SiO₂

- On the right is a modeled three-component target with the same CH/Quartz/Sample configuration shown previously

- 0.1 and 0.2 g/cc aerogel produce the brightest shocks when driven with less than 4E13 W/cm². If you can drive a target with greater than 4E13 W/cm², then fused silica will produce the brightest shocks.

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