Summary

- At planetary interior conditions, diamonds are formed from polystyrene
- Simultaneously, a rise in reflectivity suggests that the hydrogen in the sample may be becoming metallic, which is energetically favourable at the conditions
- Repeating shots with these and other samples would help confirm this

Experimental Setup

- Shaped laser pulse can drive multiple shocks
- We reach high pressure states with lower temperatures than on Hugoniot

Demixing

- A mixed system splits into regions with different atomic ratios
- Most studied example is H/He demixing
- Has implications for thermal transport, EOS etc.

Metallic Hydrogen

- VISAR probe shows rise in reflectivity with second shock
- Signature of metallization
- Diamond formation occurs in metallic H stability region
- Possible evolution:
  - 1st shock melts sample
  - After 2nd shock, hydrogen-rich regions metallize
  - Carbon-rich remnant crystallizes into diamond

Diamond Formation

- Diffraction data shows clear new peaks from polystyrene (CH)
- Conditions are 150 GPa, 5000 K
- Around 50% of carbon has crystallized within 10 ns

Carbon-Hydrogen Demixing and Hydrogen Metallization

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Figure 1: Experimental schematic, with optical laser drive beam, XFEL probe and VISAR

In CH mixture, demixing is expected to change diffraction

We do not observe demixing in fluid CH at 50 GPa or 190 GPa (on Hugoniot)

Enthalpy calculations suggest that we should

Figure 2: Diffraction signal from shocked CH

Figure 3: H/He enthalpy of mixing at 4 Mbar, from Lorenzen et al., PRL (2009)

Figure 4: CH scattering with (de)mixed fits from DFT-MD

Figure 5: VISAR signal, with reflectivity rise at 2nd shock

Figure 6: CH phase diagram, with metallic hydrogen stability