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CRYSTAL ORIENTATION EFFECTS IN PETN EXPLOSIVE WITH 4 GPA SHOCK

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CRYSTAL ORIENTATION EFFECTS IN PETN EXPLOSIVE WITH 4 GPa SHOCKS

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Shock initiation of detonation has been observed in PETN crystals of \( \{110\} \) orientation at the low shock strength of 4.25 GPa. This result explains some observations by other workers at Los Alamos National Laboratory that were considered anomalous. Chemiluminescent emission from the shock induced decomposition reactions has been observed using OMA spectrographs, photomultiplier, and imagers for cameras. The emission is not seen in the insensitive orientations \( \{100\} \) and \( \{101\} \); these orientations can deform using the primary slip plane \( \{110\} \).

There have been indications of anomalous deformation near 4 GPa in previous work at Los Alamos on PETN crystals. Shock wave velocity measurements by S. P. Marsh recorded anomalously high velocities on some shots. P. M. Hallock and Jerry Wackerle observed a pressure excursion at the impact face about 0.3 \( \mu \)s after impact. A wedge record obtained by B. G. Craig shows an unusual transition to an intermediate velocity. D. Vier found brightness temperatures from high-intensity camera (HIC) photos of 3000-4000 K.

We decided to do a wedge experiment to verify Craig's result. Our crystals were thicker than his results are shown in Fig. 1. Our records show a transition to intermediate velocity followed by a transition to detonation. Results for run to detonation for all pressures are displayed in Fig. 2 including Craig's work. It shows that the run at 4.25 GPa is the same as 4 GPa and shorter than at 8.5 GPa, a very unusual double-valued behavior. This behavior is believed to be due to plasticity effects that occur near 4 GPa because this is the shock stress at which maximum resolved shear stress is achieved. The two independent stresses are believed to collapse above this stress level in this weak material.

In previous work we indicated that shock initiation at higher shock stresses occurred at 1000 and \( \{100\} \) orientations. In our work we were able to shock initiative in the \( \{110\} \) plane all current work we are able to

The difference in behavior among orientations near 1 GPa. Snapshots were taken with the shock 0.8 mm 0.2 \( \mu \)s and 2 mm 0.5 \( \mu \)s into the explosive. Substantial light from chemiluminescent emission was recorded from a \( \{110\} \) crystal taken from a different crystal of \( \{100\} \) and \( \{101\} \) orientations. Emission from \( \{101\} \) crystals recorded on film with 10 \( \mu \)s exposures grew between the two snapshots in a manner consistent with the pressure record of Ref. 1. Film density at 5 \( \mu \)s was six times greater than at 2 \( \mu \)s. No spatial structure to the emission was discernible. Spatial structure associated with adiabatic shear might be expected in association with the high strain rate plastic flow of the material. Spatial resolution was about 70 \( \mu \)m.

Emission and absorption UV visible spectra have been obtained for both \( \{110\} \) and \( \{101\} \) crystal types. Spectral data was taken beginning at 0.17 and \( \pm 0.5 \) \( \mu \)s after shock entry for about 0.13 \( \mu \)s. Photodiode measurements of the total time-resolved emission were also taken. Very 14C photos indicated that \( \{101\} \) crystals emitted light but at lower levels than \( \{110\} \) at 2.2 GPa. Both orientations are in the sensitive range not having \( \{100\} \) planes available for slab but 101 is more sensitive than 110 at higher pressures. Emission and absorption spectra were obtained for both orientations. At 1.9 GPa there was no detectable change in the absorption edge at 370 nm. There were two maxima in the visible spectrum, a very broad absorption band and a second larger and less intense absorption band that is about 50 nm at half-maximum at early and later times. The extinction could be from
light scattering or molecular absorption. The source is not known, but it is similar to what we have seen in sapphire at 12.5 GPa. Thus, if plastic flow began in sapphire, we are unable to show that the light emission in PETN is also related to plastic flow.

Emission spectra at 3.5 GPa were strong across the visible. Levels were low at early times (keeping with the fast and photodiode records, Fig. 3). After correction for spectrometer efficiency, the emission is strongest in the UV at 300 nm or shorter wavelengths. Data were taken with the shock part way through the crystal, so the emission was viewed through another PETN which cut off emission at 320 nm. Emission lifetime was slightly higher for 110 than 110. This is surprising since 110 is more sensitive at higher pressures. This is the first spectral information on shocked PETN. Using Wien's limit results would indicate a black-body temperature of at least 5000 K. The calculated shock particle bulk temperature using Trouton PETN as an example is less than 2000 K. The 5000 K value is high for a detonation. Yet temperatures were based on spectral information only, and it is possible that the shock body source. We conclude that the

FIGURE 2
Run-difference to detonation vs shock stress for 1100 PETN. Diamonds are data of Ref. 2.

FIGURE 1
Wedge record for 1100 PETN. Solid line is B. The Craig record at 3 GPa, dashed and dotted lines are out records at 4.26 GPa.
REFERENCES


