Micro- and Meso-Scale Detonics of Explosives

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LDRD
LABORATORY DIRECTED RESEARCH & DEVELOPMENT

Sandia National Laboratories

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Steve Harris (PM) NW/MTIA, FY05-07

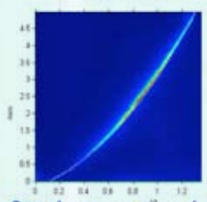
Problem

- The significant phenomena in transient explosive behavior occur at *interfaces* and are strongly affected by *explosive properties*
  - Interfaces: Explosive-bridgewire, explosive-confinement, explosive-explosive
  - Explosive Properties: Chemical and mechanical nature of materials
- These phenomena can only be described properly at the *micro-* and *meso-scales*
  - Initiation length scales, crystal size scales
- Transient explosive behavior include *initiation* and *failure*
  - Implications to *reliability, safety, design, surveillance…*
- Science-based engineering for future component development and miniaturization demands study of these phenomena

Approach

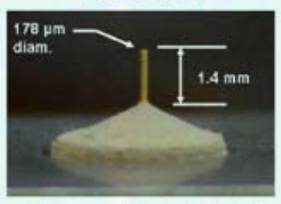
- Experiment configuration development, diagnostic development, and model development on explosives that are important for future development and miniaturization
  - Multidisciplinary team from multiple centers, using Sandia's unique capabilities
- Study of interfacial phenomena important to transient explosive behavior; especially initiation, but also failure
- Development of manufacturing capabilities, improved diagnostics capabilities, and improved modeling capabilities, while generating critical data

Center 02500



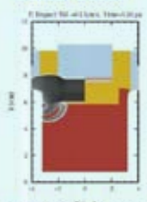
Streak camera record of DDT in CL-20.

Center 02400



HNS rate stick with bevel.

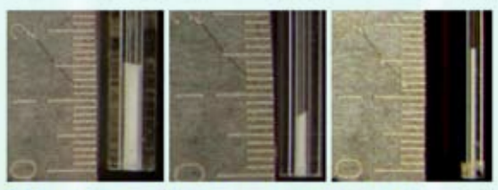
Center 01500



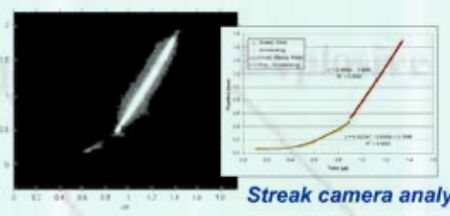
Simulation of gas-gun experiment.

Low-Energy Initiation Deflagration-To-Detonation Transition

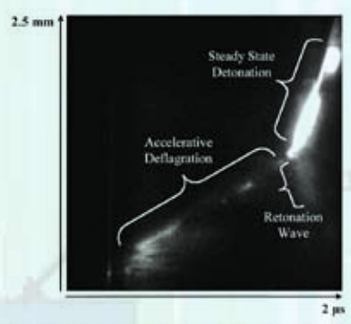
- Understanding initiation and growth in miniaturized primary explosives
- Sample preparation development – fluid-based deposition/filling
- Diagnostic development – sub-mm streak camera photography



200-, 100-, and 50-µm diameter charges of lead azide.



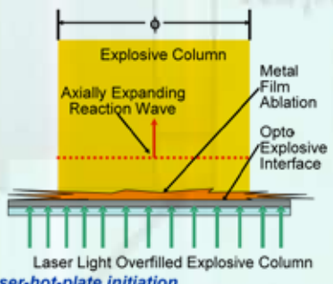
Streak camera analysis in 50-µm lead azide charge.



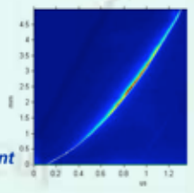
Streak camera record of initiation and growth in 200-µm lead azide charge.

High-Energy Initiation Shock-/Deflagration-to-Detonation Transition

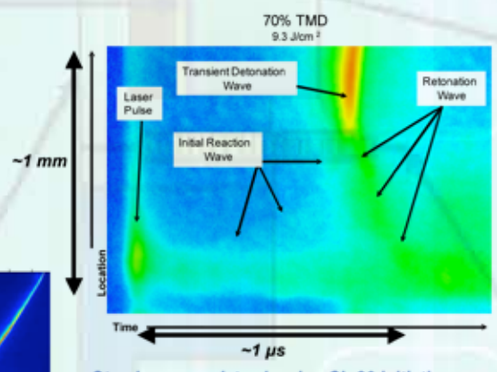
- Understanding initiation and growth in Laser Exploding Bridge Wires
- Planar initiation, compaction, modeling



Laser-hot-plate initiation experiment to provide quasi-2-D, planar, initiation conditions.



Laser-hot-plate experiment showing initiation and growth in CL-20.



Streak camera data showing CL-20 initiation phenomena in laser-hot-plate configuration.

High-Energy Initiation Shock-to-Detonation Transition

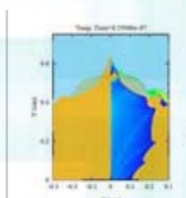
- Understanding initiation and growth in shock-initiated explosives
- Gas-gun experiments coupled with Baer-Nunziato multiphase modeling

Snapshot of simulation of experimental configuration.

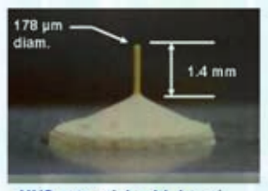
Gas-gun particle velocity results from threshold initiation experiments.

Detonation Failure Serendipitous Nanoparticle Production

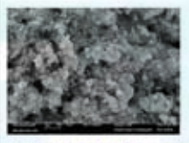
- Understanding failure of miniaturized explosives
- Femtosecond laser micromachining, streak camera, shadowgraphy, modeling
- Serendipitous discovery of nanoparticles from machining process



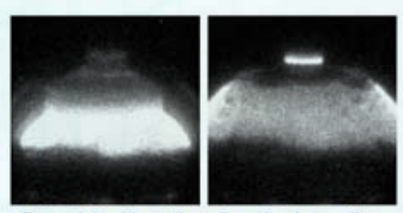
Model prior to machining.



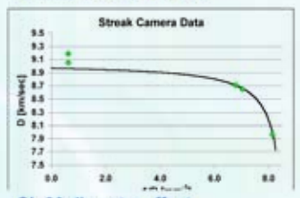
HNS rate stick with bevel.



HNS nanoparticles discovered during machining process.



Rate stick with potting. Reaction in smaller diameter clearly visible.



CL-20 diameter effect.

Significance

- Development of advanced manufacturing techniques for miniaturized explosive charges – femtosecond laser micromachining
- Development of diagnostics for miniaturized systems – sub-mm streak camera and shadowgraph photography
  - Applies to conventional and miniaturized systems
- Critical data generation for miniaturized systems
- Development of initial models for CL-20
- Design rules for CL-20 and future components
  - Safety enhancements (Laser EBW), further miniaturization
- Development of powerful experimental tool for laser-material interactions
- Numerous publications, technical advances, patent (1), students (Master's thesis), university/lab collaborations

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