ENERGETIC MATERIALS

Energetic materials comprise explosives, pyrotechnics, and propellants. The science of energetic materials is dedicated to developing means to predict performance and safety characteristics with high fidelity. This is a particular challenge and is predicated on materials science and engineering, physics, chemistry, and dynamic response in extreme conditions. Fundamental elements of these complicated composite materials remain grand challenges—from the design of high-energy metastable molecules, to the engineering of composite formulations, to the processing parameters that link to safety and performance characteristics in as-yet undetermined ways. Key elements include crystalline mechanics, grain dynamics, multiphase interfaces, thermal and mechanical damage, and failure—all linked to multistep and high-rate chemistry and shock physics. A future revolution in our understanding and predictive capability for energetic materials behavior and responses is dependent upon sustained focus and advances in materials research and development.

Los Alamos Leadership in Energetic Materials

Los Alamos National Laboratory's diverse mission areas require full-spectrum energetic materials capability and expertise. With its joint nuclear mission, the Laboratory provides a unique high explosives capability compared to any other site in the nation, including in the Department of Defense. High explosives capabilities encompass both human and intellectual capital and facility and equipment assets. The Lab's high explosives workforce is about 30% larger than any other National Nuclear Security Administration (NNSA) site.

From bench-top to large-scale open-air experimentation, a broad suite of diagnostic, theory, modeling, and simulation capabilities is employed to evaluate nuclear weapon response as well as a wide range of global security program applications. Los Alamos is the NNSA's production facility for War Reserve detonators. The Laboratory's energetic materials capabilities are enabled by many foundational assets in research-scale synthesis and analytical chemistry, research- and pilot plant-scale formulation, powder production, pressing, crystallization, microstructural and materials characterization, and non-shock initiation characterization and testing to support research and development.

The Laboratory's breadth and depth in energetic materials—with nuclear application experience and integrated modeling and simulation capabilities—are unique within the National Nuclear Security Administration and the country. Here, an explosive compound is heated just past its melting point and is poured from the kettle into the experimental apparatus.

Materials for the Future

The Los Alamos National Laboratory Materials for the Future strategy derives from our vision to support the Laboratory's national security mission drivers.

We pursue the discovery science and engineering for advanced and new materials to intentionally control functionality and predict performance relevant to ensuring the success of the Lab's missions.

To deliver on our missions, our materials strategy builds on materials science and engineering, enabling the necessary Laboratory leadership in seven key areas:

- Complex Functional Materials
- Material Resilience in Harsh Service Conditions
- Manufacturing Science
- Actinides and Correlated Electron Materials
- Integrated Nanomaterials
- Energetic Materials
- Materials Dynamics

Los Alamos National Laboratory is a world-class leader in energetic materials and especially high explosives research, development, and applications. The Lab's breadth and depth in energetic materials—with nuclear application experience and integrated modeling and simulation capabilities—are unique within the NNSA and the country. Los Alamos has expanded focus to also include a vast range of energetic materials for non-nuclear strike, counter terrorist tactics, and counter weapons of mass effect, capitalizing on the base NNSA capability to meet global security program needs for many partners.

Key Science Questions

- How can we predict the outcome of thermal or mechanical insults to high explosives—will the insult induce ignition, quenching, burning, or detonation?
- How can we probe material response across the decades of relevant spatial and time scales to reveal materials dynamics that determine performance and safety responses?
- What are the characteristic signatures and techniques to advance high explosives detection and defeat missions?
- What are the relevant process-to-performance characteristics of high explosive materials to advance process controls, new high explosives development, and materials performance?

10-year End State

We will have achieved mesoscale-based understanding of energetic materials incorporated into codes for the purpose of accurate performance, safety, surety, and global security predictions—and specifically a predictive capability for explosive reactive burn based on microstructure that spans damage and deflagration or shock-to-detonation transitions at a level of complexity suitable for integration into continuum explosive burn models. We will be able to design and produce high explosives with desired sensitivity and performance on demand meeting the Department of Energy Insensitive High Explosives definition. We will have developed, as an enabling tool, diagnostics at submicrosecond time and microstructure scale to test hypotheses about temperature rises with ignition and will have demonstrated scale-bridging modeling tools. These advances in fundamentals of high explosives will enable new technologies in the global security program missions, including detection and defeat.

Los Alamos National Laboratory's energetic materials expertise ranges from bench-top to large-scale open air experimentation, employing a broad suite of diagnostic, theory, modeling, and simulation capabilities. An outdoor firing site is shown above.

Given the special requirements for energetic materials research, modernized facilities will be available in a revitalized high explosives campus, including office and laboratory space with collocation of theory and experiment to accelerate creativity and productivity. Already underway, the high explosives campus is described in detail with completed, in-progress, and planned efforts in the *2017 Los Alamos National Laboratory High Explosives Strategic Plan*. The campus will have established and functional staff, management, and program communication and integration in place, with a consistently improved strategic plan—with the goal to better integrate across the energetic materials and NNSA communities.

For more information, please see materials.lanl.gov or send email to materials@lanl.gov.

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