Research of Exothermic Nanolaminates and their Structure-Property Relationships

LABORATORY DIRECTED RESEARCH & DEVELOPMENT

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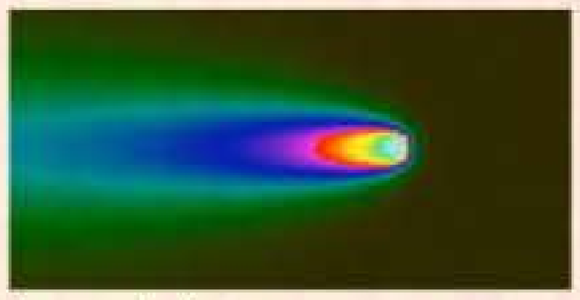
Problem

Although exothermic nanolaminate foils show potential as local heat sources, the scientific community does not fully understand the structure-property relationships of these materials.

Approach

Approach (Experiment and Modeling):



Research of ignition thresholds:
- global and local stimulus
- effects of pulse duration

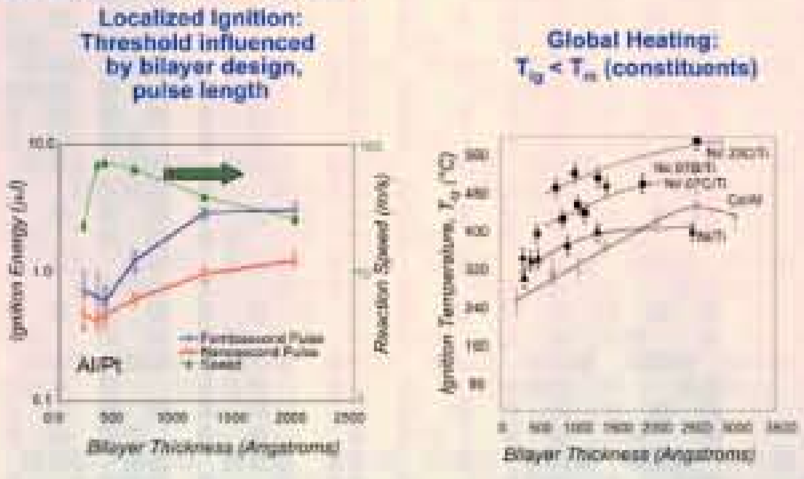
Studies of reaction dynamics and transient behaviors:
- high-speed photography (micrometer/microsecond scales)
- *dynamic transmission electron microscopy (nanometer/nanosecond scales)

Investigation of aging:
- kinetics, loss of stored chemical energy

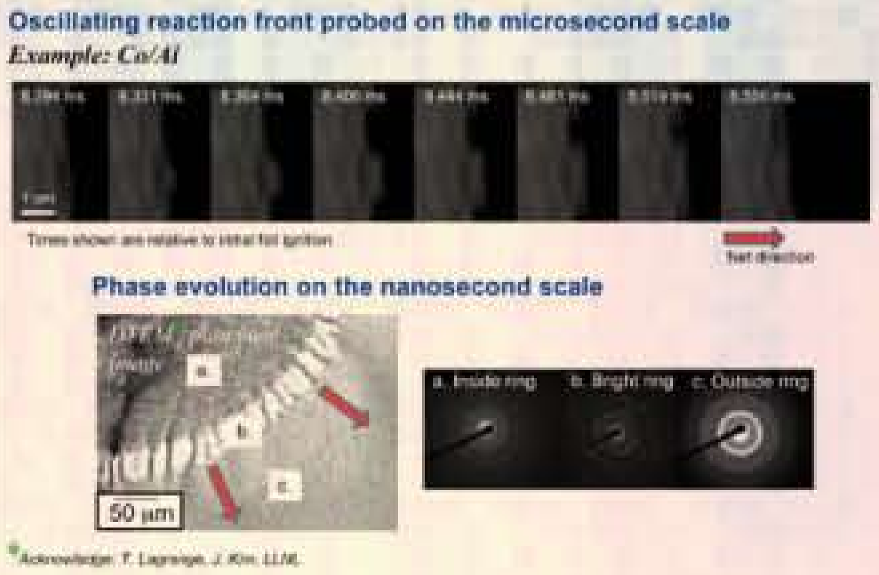
Examine the properties of transformed multilayers:
- heat output, optical, magnetic

* Acknowledge: T. Lagrange LLNL

Experimental Studies of Ignition



Studies of Self-Propagating Reactions



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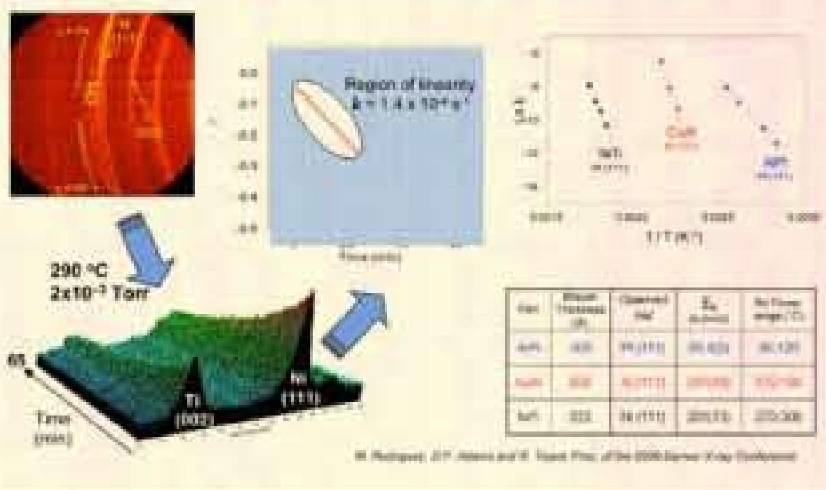
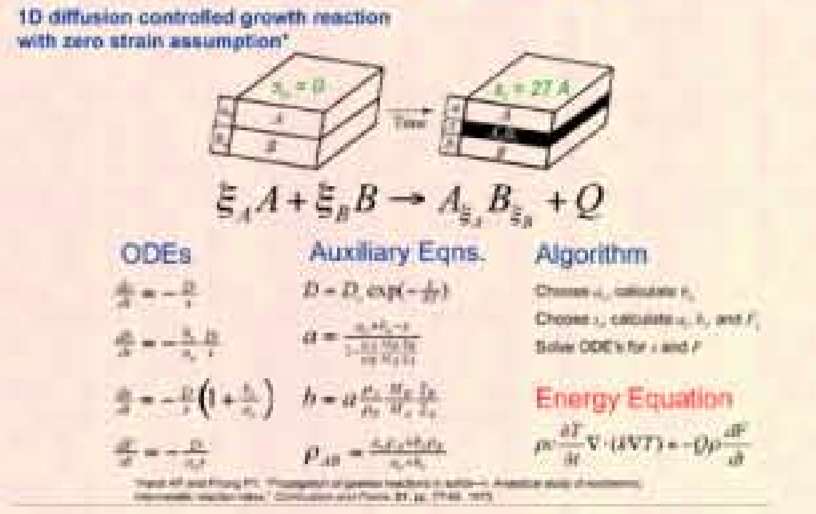
Accelerated Aging of Exothermic Nanolaminates

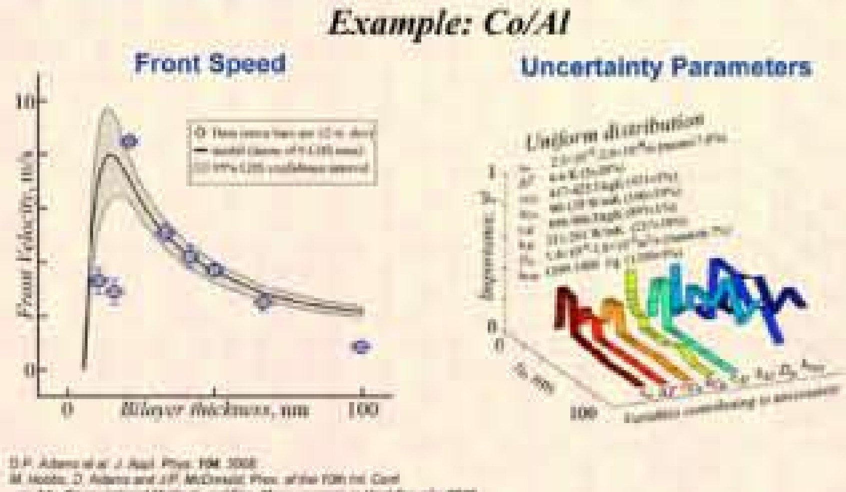


Modeling Exothermic Nanolaminate Behaviors



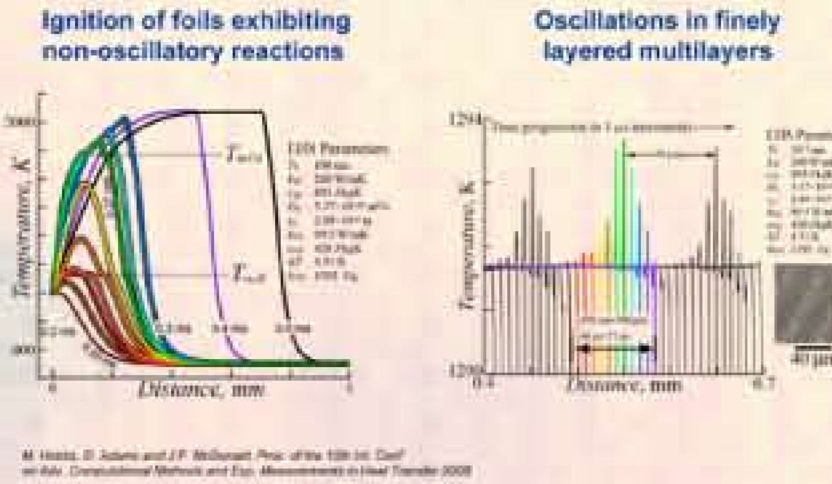
Modeling the Steady-State Reaction Rates of Exothermic Nanolaminates

Example: Co/Al



Predicting Transient Temperature Profiles

Example: Co/Al



Significance

Fundamental:

- Improved understanding of ignition
- Improved understanding of the dynamics of high-rate reactions
  - morphology evolution
  - phase formation (includes metastable phases),
  - oscillatory behaviors
  - effects of boundary conditions
- Discovery of new exothermic systems
- Predictive modeling of reactions in metal-metal systems
- Assessment of aging (shelf life)

Potential new applications:

- Sensors/actuators
- Power systems
- Improved joining processes

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