



U.S. ARMY
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Phenomenological Mechanochemistry of
Damage with Electromagnetic Influence

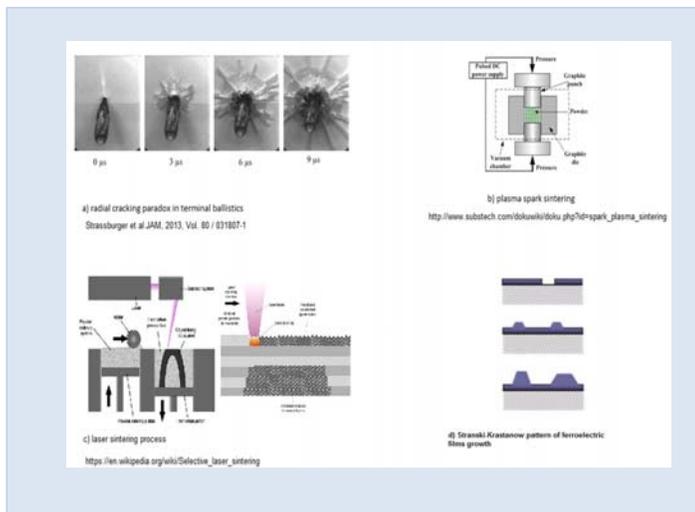


S&T Campaign: Sciences for Lethality & Protection
Ballistics and Blast

Dr. Michael Greenfield, (410) 278-7030
michael.greenfield4.civ@mail.mil

Research Objective

- Development of mathematically, thermodynamically, and electrodynamically consistent theory of damage of solids in electromagnetic fields
- Implementation of the analytical model into government computer code, including V&V procedures



Targeted physical phenomena

Challenges

- Development of thermodynamically consistent theory of ponderomotive forces
- Development of stable numerical codes, exact analytical solutions, and experimental set-up

“I have not been able to account by mechanical considerations... stresses in the dielectric.”
J.C. Maxwell, Treatise in electromagnetism

“The problem of ponderomotive forces is the eternal problem of electromagnetism.”
Vitaly Ginzburg, Nobel Laureate
“On physics, physicists, and myself”

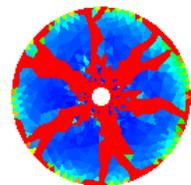
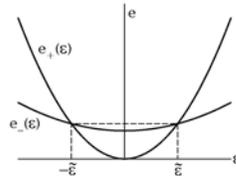
Classics about challenges of electromagnetism

ARL Facilities and Capabilities Available to Support Collaborative Research

- Laboratory for high-rate experiments in solids
- Laboratory for electromagnetic experimentation
- DoD High performance computing center with 100,000 compute cores and access to state of the art software

Phenomenological Mechanochemistry of Damage with Electromagnetic Forces

The asymmetric radial crack patterns that occur in brittle targets when impacted by high velocity projectiles are explained using a Phenomenological Mechanochemistry of Damage (PMD) engineering model. The developed model, reveals an energy instability during failure of brittle materials configured in a purely symmetric geometry and impact configuration.



Left: Energy density for two different values of damage.
Right: Damage morphology of a brittle plate (Bjerke et al, Procedia Engng, 2015, 103, 35-42)

Conceptually new features in the suggested theory:

- It is based on consistent usage of the Gibbs variational paradigm
- It rejects the concept of a scalar chemical potential, using, instead, various tensorial chemical potentials
- It rejects various ad hoc conjectures regarding the generalized Maxwell stress tensors and uses, instead, novel formulations, derived in a thermodynamically consistent way.
- It is based on the novel mechanisms of the bulk and interface instabilities, both: mechanical and electrodynamical.

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

We need experimenters and theorists equally experienced in fracture of solids, electromagnetism, and applied mathematics.