

**S&T Campaign: Materials Research  
Manufacturing Science  
Energy Coupled to Matter**

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## Research Objective

To discover, explore, and exploit interactions between materials and intense energy fields (magnetic, electric, acoustic, etc.), thereby enabling significant property enhancements and unique property combinations, overcoming traditional engineering trade-offs (e.g. strength vs. ductility) and allowing responsive on-demand structure-property modification

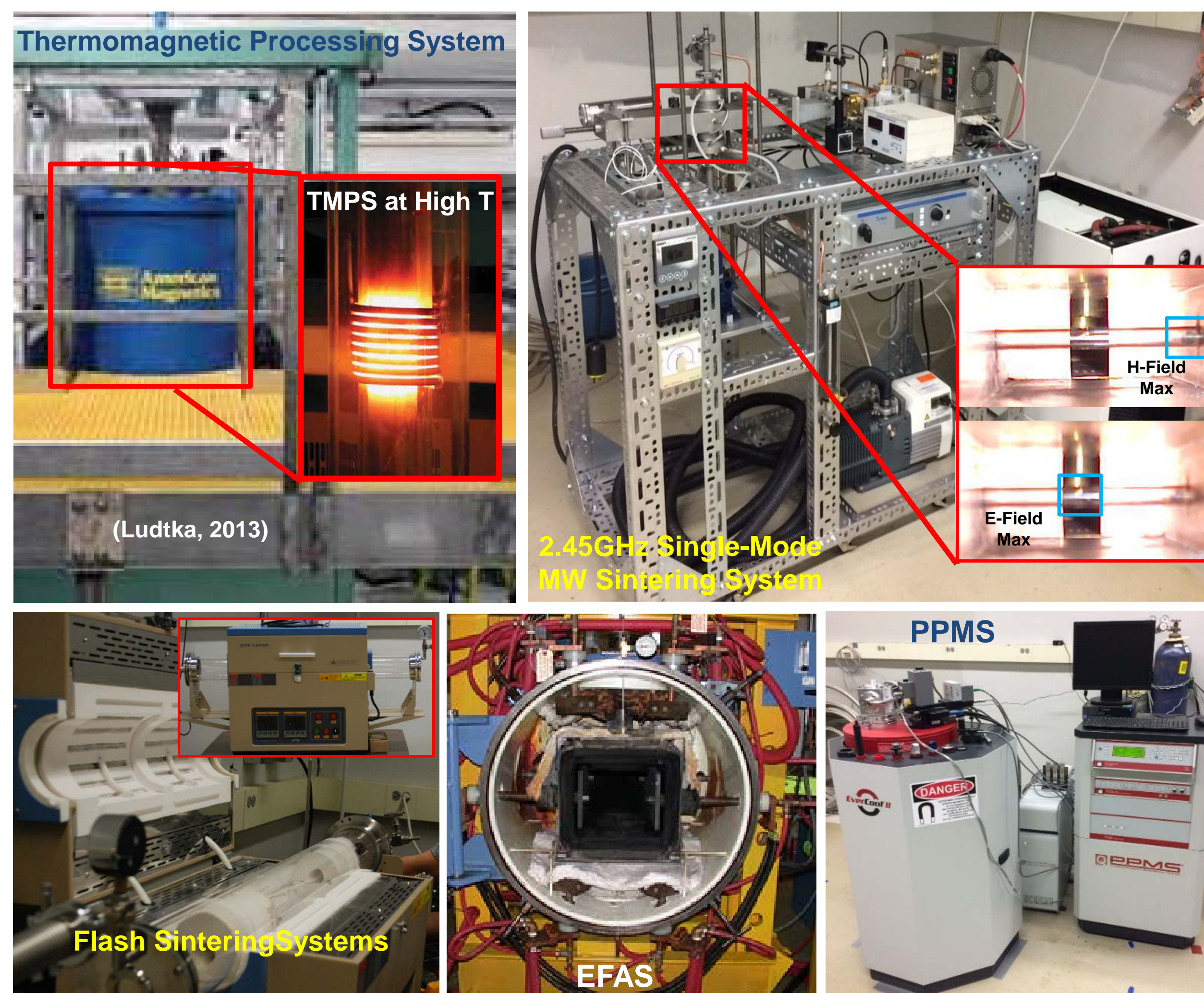
- Utilize **physics-based fields** to produce outcomes that are otherwise unattainable, expanding materials-by-design & manufacturing science innovation capabilities for:
  - Novel materials with **tailored microstructures** and **unprecedented properties** (e.g. **1.5-10X property/performance improvements**)
  - New **processing & manufacturing** capabilities for rapid materials production
  - Selectively enhanced time-dependent effects via **dynamic stimulation**

## Challenges

- Developing fundamental understanding of mechanisms that influence field-material interactions
- Identifying phenomena that control applied field manipulation
- Developing approaches to demonstrate enhancement in properties
- Performing numerical modeling/simulation to predict influence of applied fields
- Developing methods of in-situ characterization during high energy field application to materials

## ARL Facilities/Capabilities Available to Support Collaborative Research

- ECM Laboratory:
  - Flash Sintering (30 kV, 10 mA, 1200°C)
  - Electric Field Assisted Sintering (12 V, 10 kA, 2000°C)
  - Single Mode Microwave Sintering Systems (915 MHz & 2.45 GHz, 2000°C, 5,000 psi pressure)
  - Thermomagnetic Processing Systems (9 Tesla, 8" bore, 2200°C, 2,000 psi pressure)
  - Physical Property Measurement System (PPMS)
  - Ultrasonic Additive Manufacturing (UAM)



## Complementary Expertise/Facilities/Capabilities Sought in Collaboration

- Novel processing capabilities for applying individual or combined fields (electric, magnetic, acoustic, microwave, radiation, microgravity, etc.) to materials
- Insight into fundamental mechanisms & physics behind high energy field-material interactions
- Modeling & simulation expertise and research tools for predicting high energy field-material interactions
- In-situ characterization technologies for accessing and studying behavior of materials in high energy fields

**Novel Materials**

- Influence Over: Phase Diagrams, Microstructures, Texturing



• Property Improvements: Strength, Hardness, Fatigue Life

**New Processing Tools**

- Enhanced Additive Manufacturing
- Possible Manufacturing Revolution



• Lower T, Shorter t = Energy Savings

**Adaptation In-Theater**

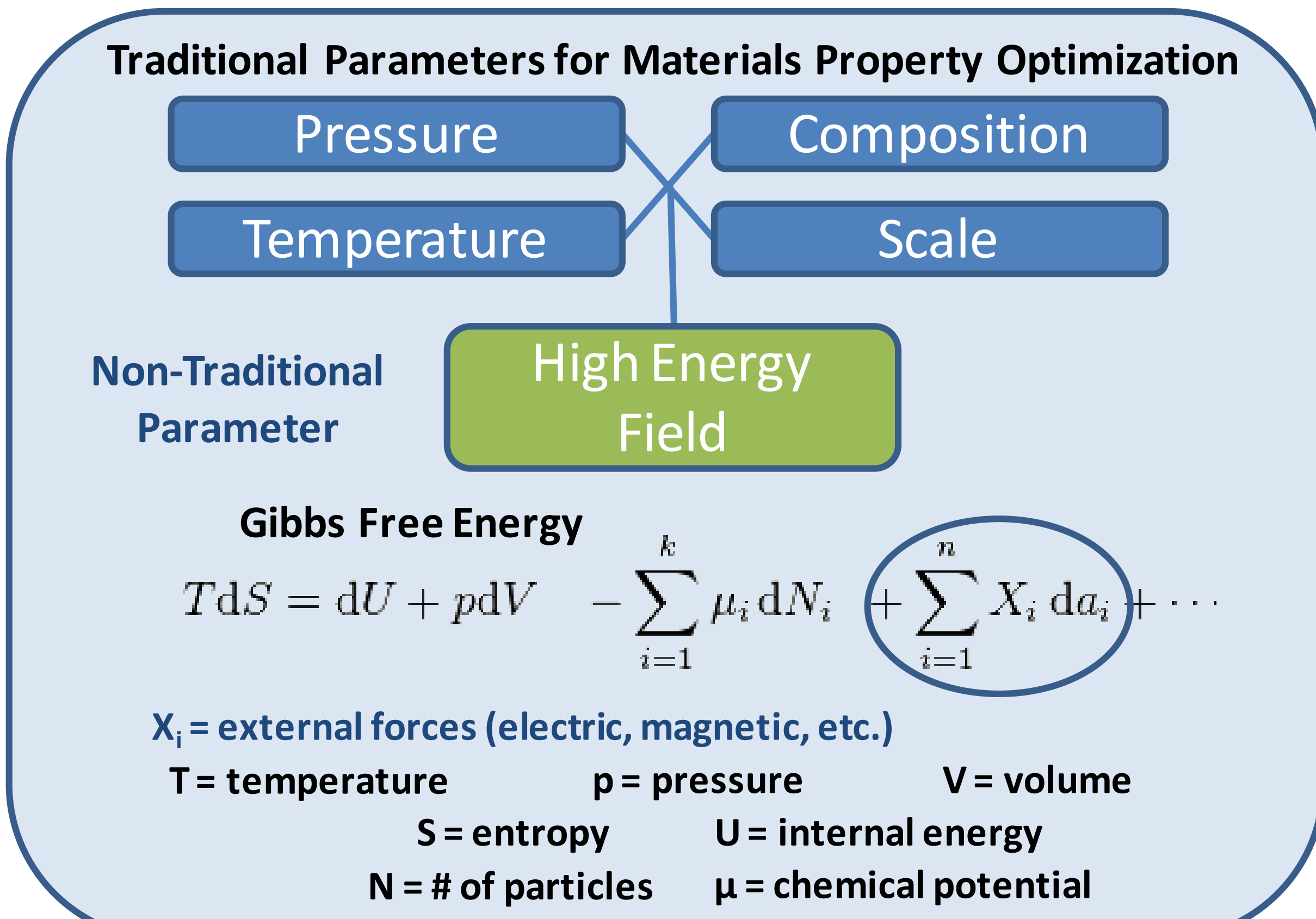
- Adaptive Systems: Shape Memory; Magneto/Electro-Rheological



• Design Armor/Weapons w/ New Materials for Defense Innovations



ECM Research Areas for Discovery, Innovation & Transition



Influence of High Energy Fields on Thermodynamics