Electric Field Assisted Conductive Ceramic & Metal Manufacturing

S&T Campaign: Materials Research
Manufacturing Science

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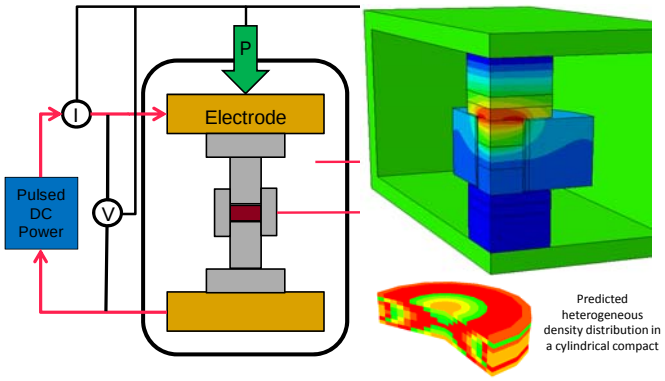
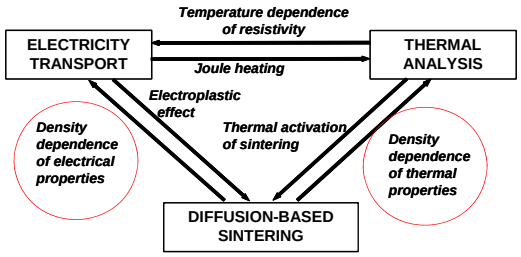
Research Objective

Develop enhanced multi-physics process models for a computational virtual manufacturing based framework for electric field assisted sintering of ceramics and metals which exploits field enhancements for net shape manufacturing of next generation ceramics and metals and promotes rapid transition of technologies



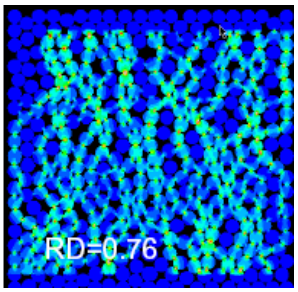
Challenges

- **Electric field effects on thermodynamics and kinetics of densification mechanisms in metal and ceramic particulates are poorly understood and difficult to de-couple in order to study independently**
- **Path dependant electric field effects from particulates to bulk materials are unknown**
- **Scaling up EFAS process for Army applications**



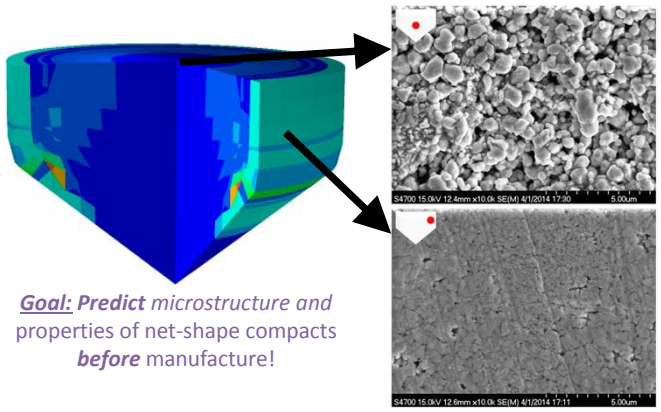
•Material properties evolve during powder processing and are f(T, P, ρ, E, …?)

•Micromechanical modeling tools to predict and understand the evolution of local transport pathways during densification



ARL Facilities and Capabilities Available to Support Collaborative Research

- **Instrumented EFAS capability with vacuum and supplemental external heating**
- **Multi-scale modeling expertise linking powder processing to application performance with access to the DoD Supercomputing Resource Center (DSRC)**
- **Multi-scale mechanical testing capabilities ranging from *in-situ* SEM to large scale bulk specimens**
- **Unique cryogenic processing to obtain/study nanoscale and multi-modal powders**
- **Significant enhancements in sintering kinetics in metallic and ceramic powders demonstrated using EFAS and "flash" sintering techniques**
- **McWilliams, B, Yu, J, and A. Zavaliangos, Fully coupled thermal-electric-sintering simulation of electric field assisted sintering of net-shape compacts, *J. Mat. Sci.* 50 (2015) 519-530.**



***Goal:* *Predict* *microstructure and* properties of net-shape compacts *before* manufacture!**

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- **Novel *in-situ* characterization of thermal-electric transport phenomena in porous and bulk materials**
- **Numerical and experimental characterization of diffusion mechanisms in metallic, ceramic, and composite materials under the influence of applied fields (not limited to *E*)**
- **Validated modeling tools which account for the effect of fields on the microstructure and properties of materials; e.g. grain growth kinetics, dislocation dynamics, and texturing**