



# Research Spotlight Forum

1.7.2020

Advanced Manufacturing

## Advanced Manufacturing: Sandia Overview

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**Sandia**  
National  
Laboratories

**Georgia**  
Institute  
of Tech  
nology

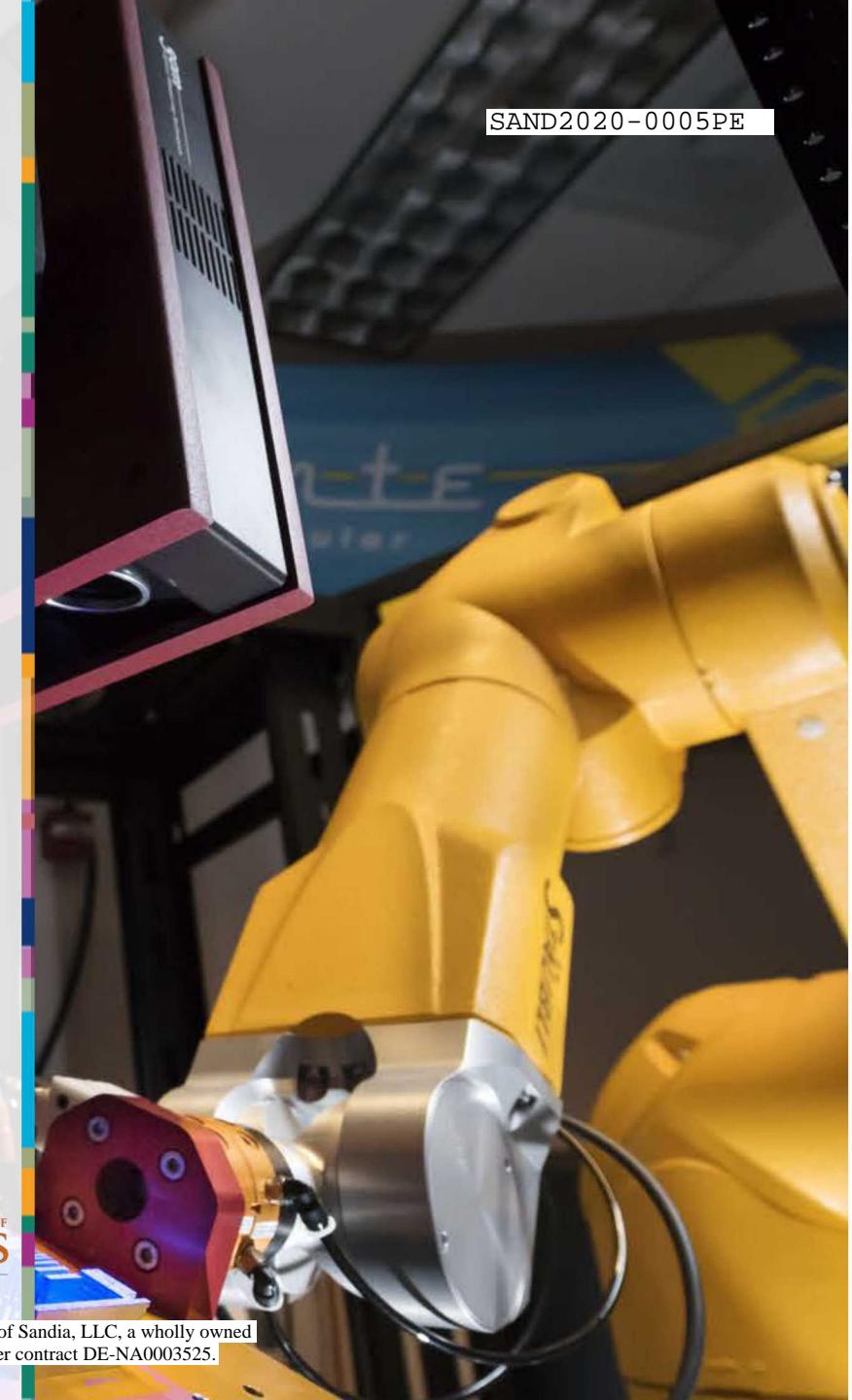
**ILLINOIS**

**NM** THE UNIVERSITY OF  
NEW MEXICO

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SAND2020-0005PE

## ABOUT YOURSELF – P. R. Schunk

- B.S. Chemical Engineering, University of Colorado (1984), Ph.D. Chemical Engineering and Materials Science, University of Minnesota (1989)
- Research Highlights
  - Manufacturing process science and engineering – Polymer processing, specialty metals processing, materials joining, solution deposition/solidification, ...
  - Applications – printed electronics, thin films, welding/soldering/brazing, super-alloy processing, molding/forming, nanomanufacturing.
  - Modeling and simulation tools development for Computational Mechanics, software engineering
  - Fundamental science work in polymer solution rheology, thin-region mechanics (tribology, thin film processing), physics of flow in porous media, etc.
- Research Group at UNM/CBE
  - Nanomanufacturing systems
  - Nanomaterials coating and printing
  - Modeling and simulation tools for printing, thin-film coating, thin-structure/media dynamics, viscoelasticity, and much more.

### Keywords:

Printed electronics, advanced manufacturing, computational fluid dynamics/mechanics, advanced high-temperature composites, R2R process technology.



# Why Advanced Manufacturing (AdM) At Sandia?

Sandia's mission responsibility to provide the highest quality engineered products for all national security needs demands we are the leaders in advanced manufacturing

Sandia has multi-disciplinary science and engineering capabilities that can result in best in class AdM

AdM enables the acceleration of new materials and processes to acceptance, supporting all national security missions

AdM represents a major opportunity to reduce materials development cycle time

AdM promotes material discovery and process engineering required for enhanced performance, improved reliability, and lower cost



# Advanced Manufacturing Technology Initiative

*Manufacturing:* to make something from raw materials or assembled components in a practical way

Accelerating new materials and processes to acceptance,  
supporting all national security missions.

## New Applications

- Printed electronics
- Metamaterials

## Emerging Applications

- Qualified AdM metal and polymer parts
- Thermal protection systems

## Mission Critical Production Applications

- NGs
- Thermal Batteries
- ASICS
- Energetics

## Qualification & Quality



## Automation, Metrology & Control



## Modeling & Simulation



## Data Science



## Digital mfg. (AdM), rapid prototyping



Materials, Chemical and Physical Sciences and Materials Processing Engineering Science  
Sandia National Laboratories and PA Partners



Research Spotlight Forum

## Sandia Materials & Process Science

- **Fundamental Materials & Process Science**

- Develop/integrate theoretical insights, computational simulation tools, and experiments to provide foundational, predictive understanding
- Develop innovative new materials and process technologies
- Create advanced materials analysis & process diagnostics tools

- **Materials & Process Advanced Development**

- Advanced & exploratory materials & process development
- Production process development & technology transfer

- **Materials Engineering/Production Support**

- Materials & process selection/optimization
- Problem solving, production support
- Understanding & quantifying the margins

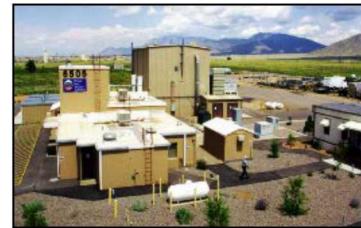
### Multiple Large Materials R&D Facilities



Processing & Environmental Technology Laboratory



Center for Integrated Nano Technologies



Thermal Spray Research Laboratory



Advanced Materials & Processes Laboratory



Ion Beam Laboratory



Integrated Materials Research Laboratory



Microsystems Science & Technology Center



Advanced Materials Laboratory



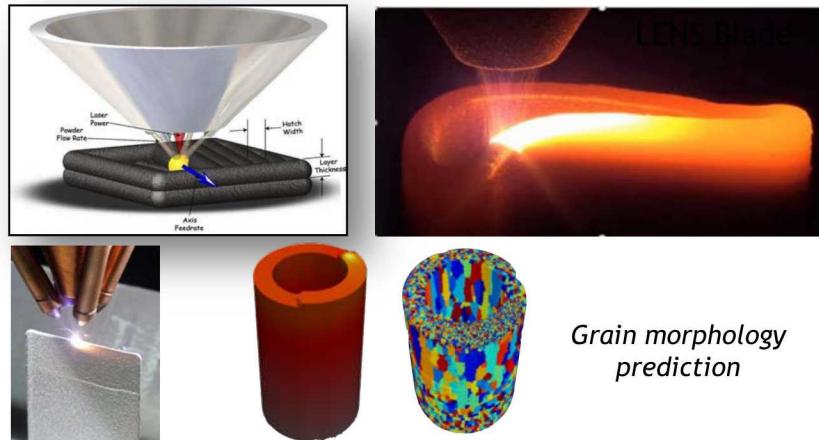
# 30+ Years of Sandia AM Technology Development & Commercialization

## *FastCast* \*



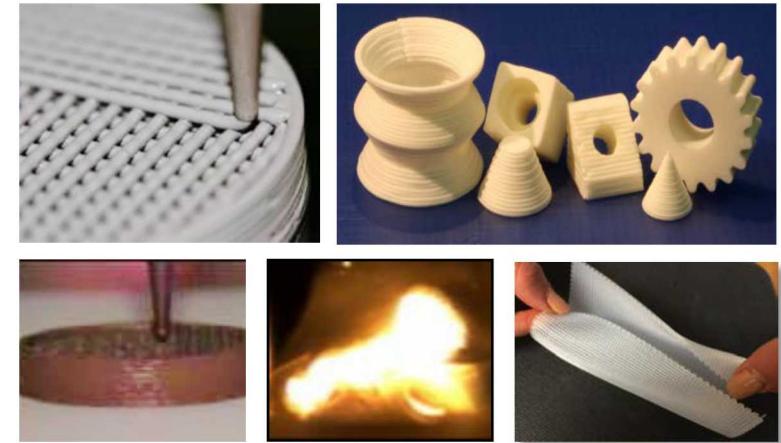
Development Housing

## Laser Engineered Net Shaping LENS®



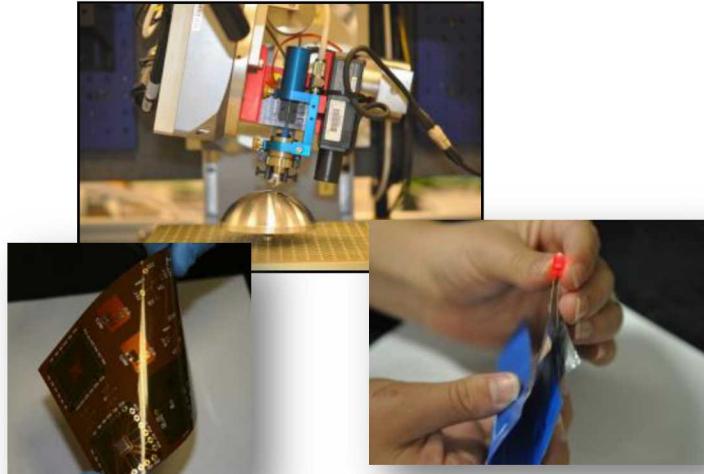
Grain morphology prediction

## Robocasting \*



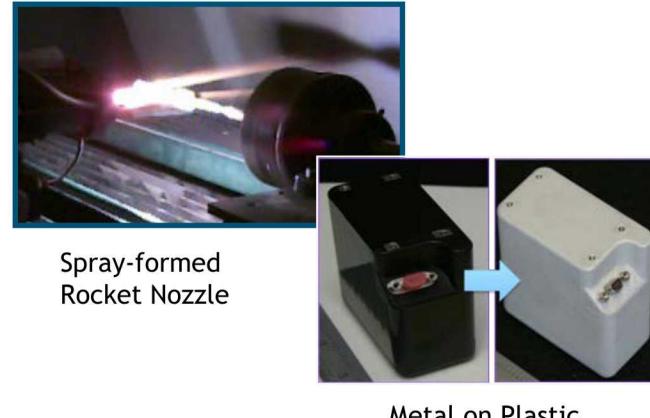
Ceramic, energetics, elastomers

## Direct Write



Conformal Printing, flexible electronics, power sources

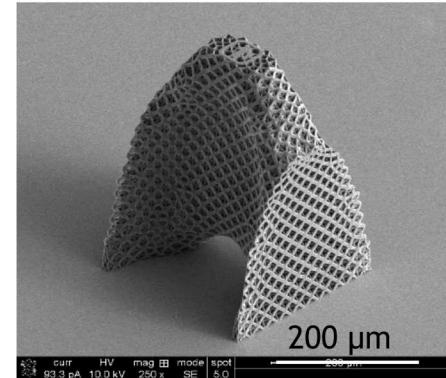
## Thermal Spray



Metal on Plastic

## Micro-Nano Scale AM

### Lattice Structure

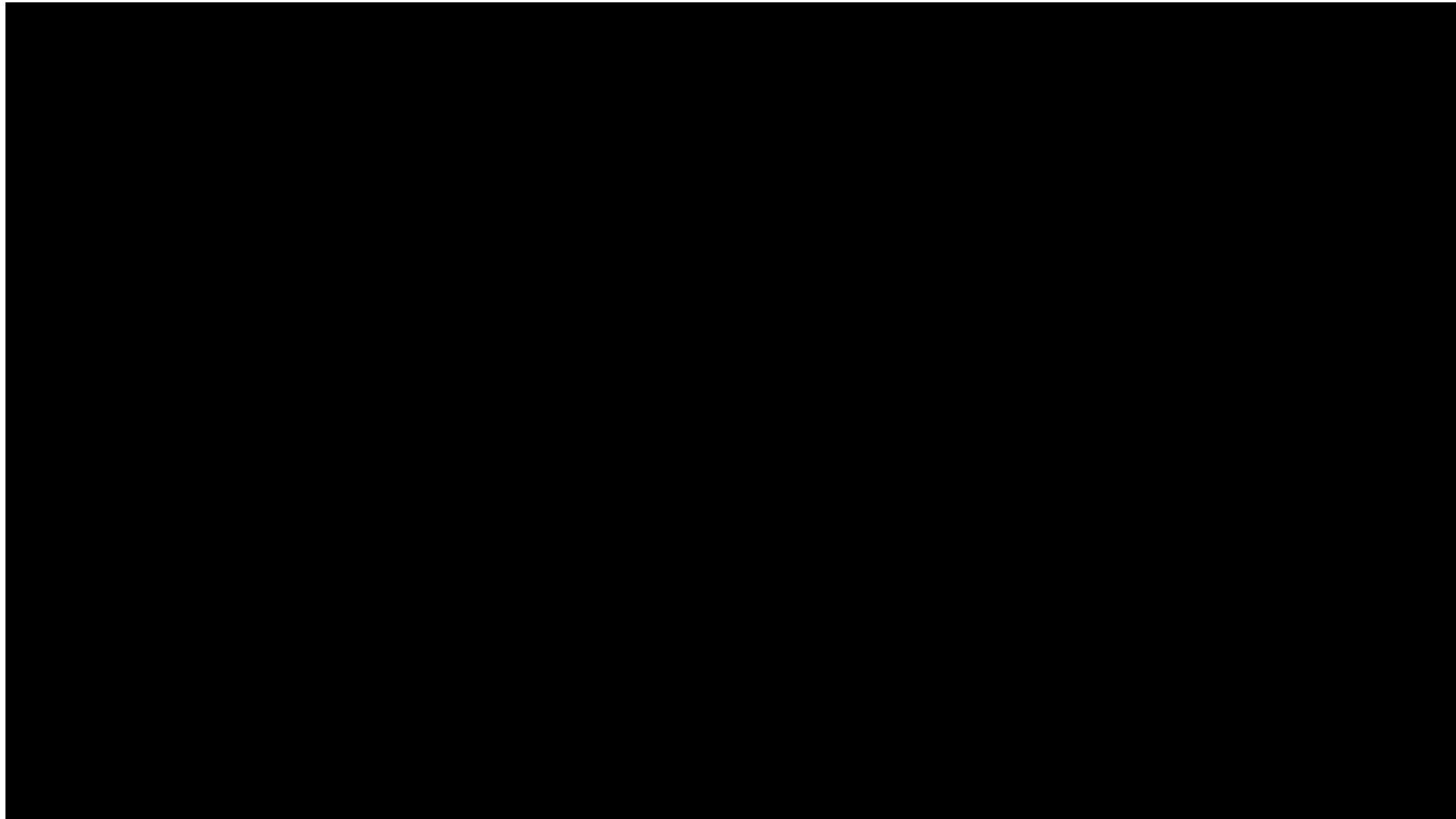


\* = Licensed/Commercialized Sandia AM technologies

Underline = Current Capability/Activity



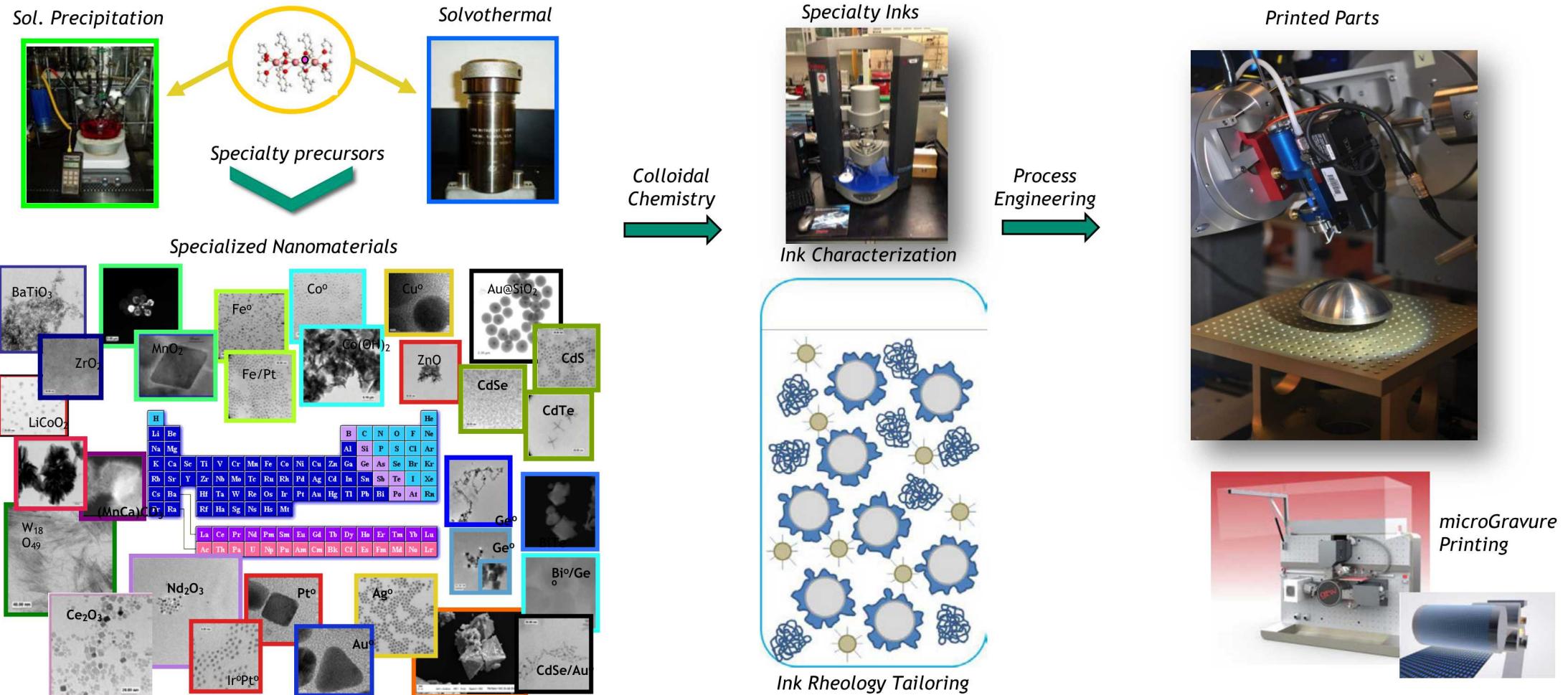
## Video clip – Three areas of AM strengths at Sandia



# AM with Particulate Inks at Sandia...Why ink-based processing?



The electronic device required for energy storage, power distribution, sensing, and RF needs require materials flexibility, low cost fabrication processes, and lean development cycles. Digital printing and templated deposition processes leverage the flexibility provided by ink based printing for advanced component research and development



# Sandia Mission needs for Printed Electronics/Photonics Legion, and Growing

Materials/devices for energy storage, generation, conversion.

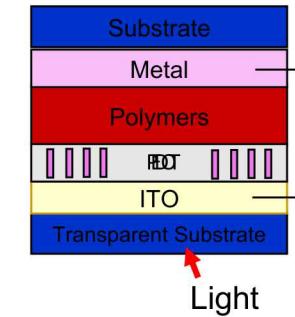
Application specific sensors (passive and active) – e.g. RF, stress, strain, EM, etc.

Electronics integrated with 3D metal and ceramic components

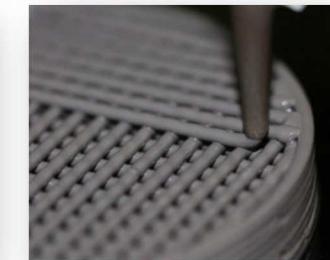
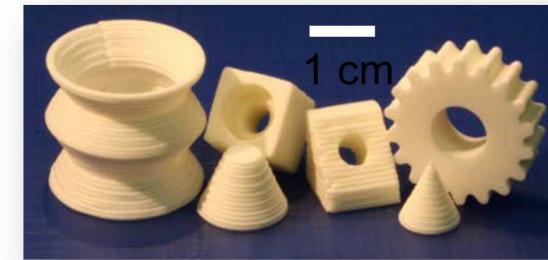
Printed electronics – packaging, interconnects (cables and connectors)

Precision interconnects and FHE. Integration of Si-CMOS devices with systems packaging, heterogeneous integration.

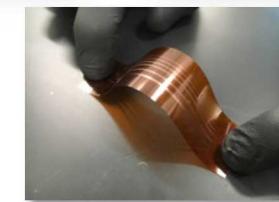
Energy Storage/Generation Materials



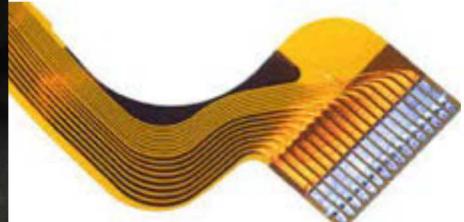
Ceramics



FLEX



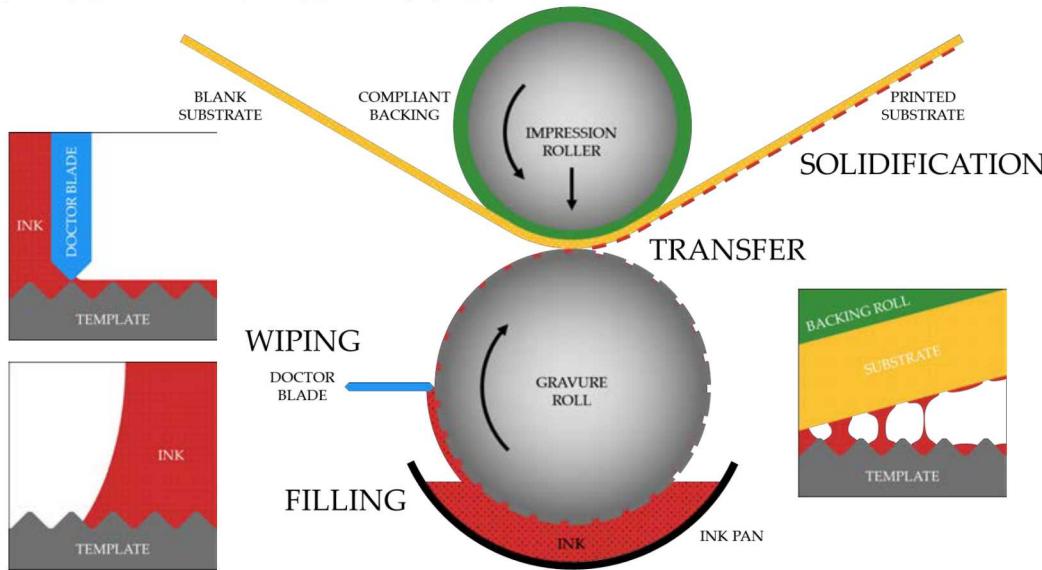
Logic devices/Memristors



# Defect Mechanisms in Gravure Printing (in collaboration with UCB/UTA)



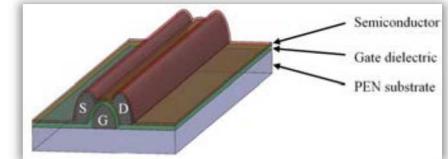
## GRAVURE PRINTING PROCESS



## DEVICE MANUFACTURE

### Insulator

- UV/Ozone surface treatment
- Gravure printed dielectric layer
- Solvent drying and cross-linking



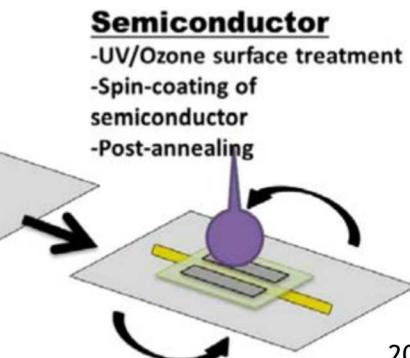
### Gate metal

- UV/Ozone treatment
- Gravure printed metal line
- Sintering



### S/D

- Inkjet printed S/D lines
- Sintering

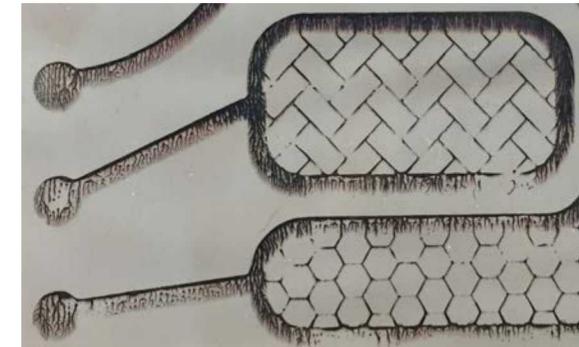


2013 Kang

## DEFECTS: INSUFFICIENT SPREADING, CONTAMINANTS, STRIATIONS



## PERFORMANCE DISRUPTION



# FUNDING SOURCES



DOE/EERE/Advanced Manufacturing Office

DOE/NNSA Advanced Manufacturing Development Program

Industry – 3M, P&G

NSF – NASCENT Engineering Research Center

Other program development sources



## RESEARCH NEEDS

Materials for printed electronics

Machine learning techniques for materials and manufacturing

Additive manufacturing of refractory metals

