



1.7.2020

Research Spotlight Forum

Advanced Manufacturing

SAND2020-0005PE

Advanced Manufacturing: Sandia Overview

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Sandia National Laboratories

Georgia Institute of Technology

ILLINOIS

NM

PURDUE UNIVERSITY

THE UNIVERSITY OF TEXAS AT AUSTIN

THE UNIVERSITY OF NEW MEXICO

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

- 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?

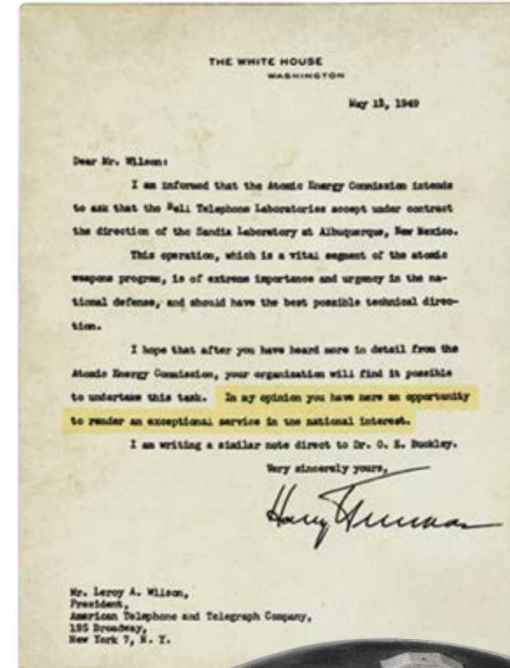
Sandia's mission responsibility to provide the highest quality engineered products for all national security needs demands we are the leaders in advanced manufacturing

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



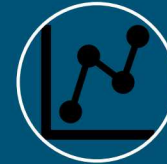
Qualification &
Quality



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

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

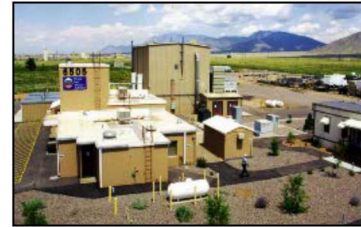
Multiple Large Materials R&D Facilities



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



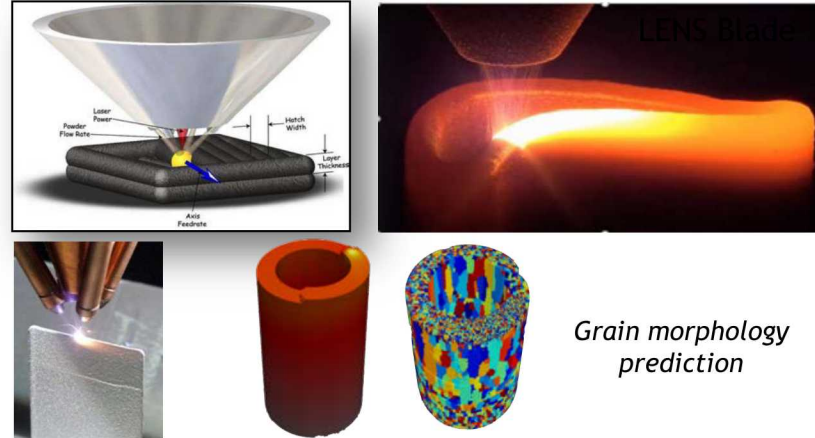
30+ Years of Sandia AM Technology Development & Commercialization

FastCast *



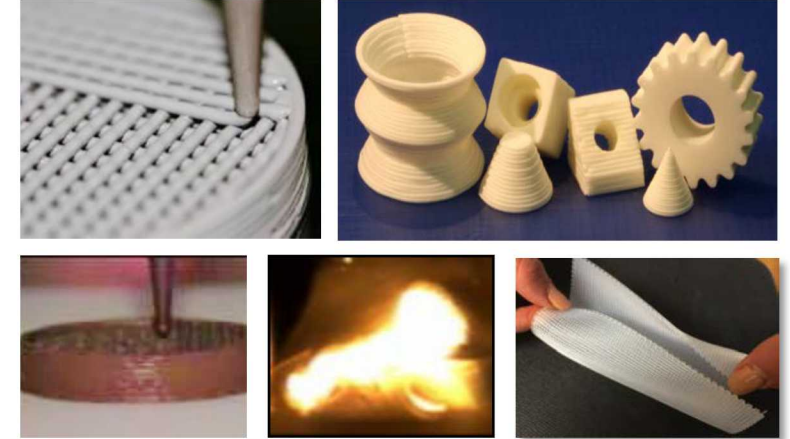
Development Housing

Laser Engineered Net Shaping LENS®



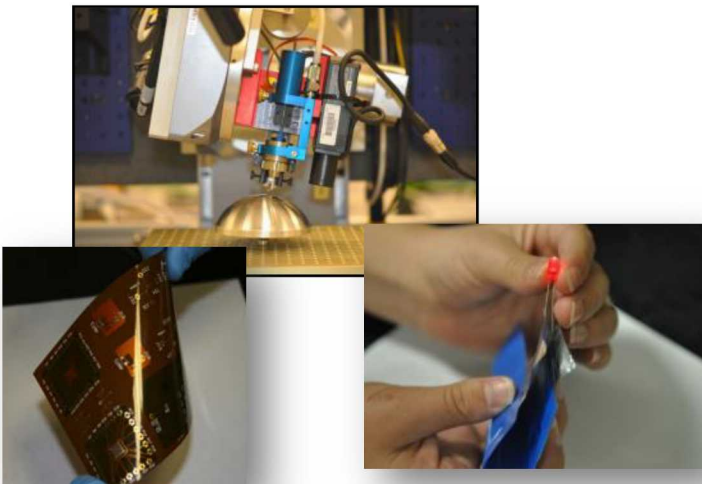
Grain morphology prediction

Robocasting *



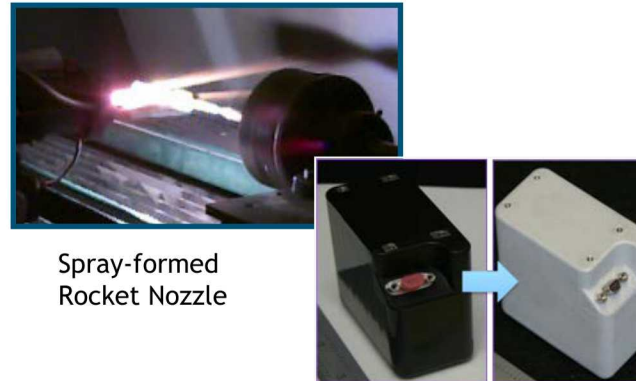
Ceramic, energetics, elastomers

Direct Write



Conformal Printing, flexible electronics, power sources

Thermal Spray

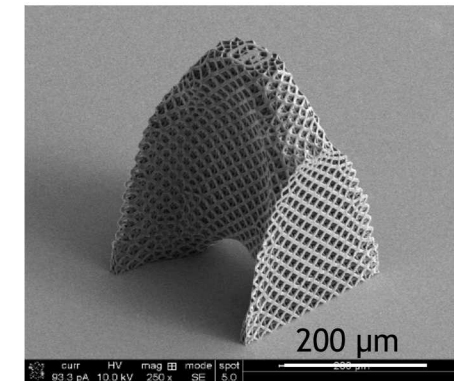


Spray-formed Rocket Nozzle

Metal on Plastic

Micro-Nano Scale AM

Lattice Structure



* = Licensed/Commercialized Sandia AM technologies

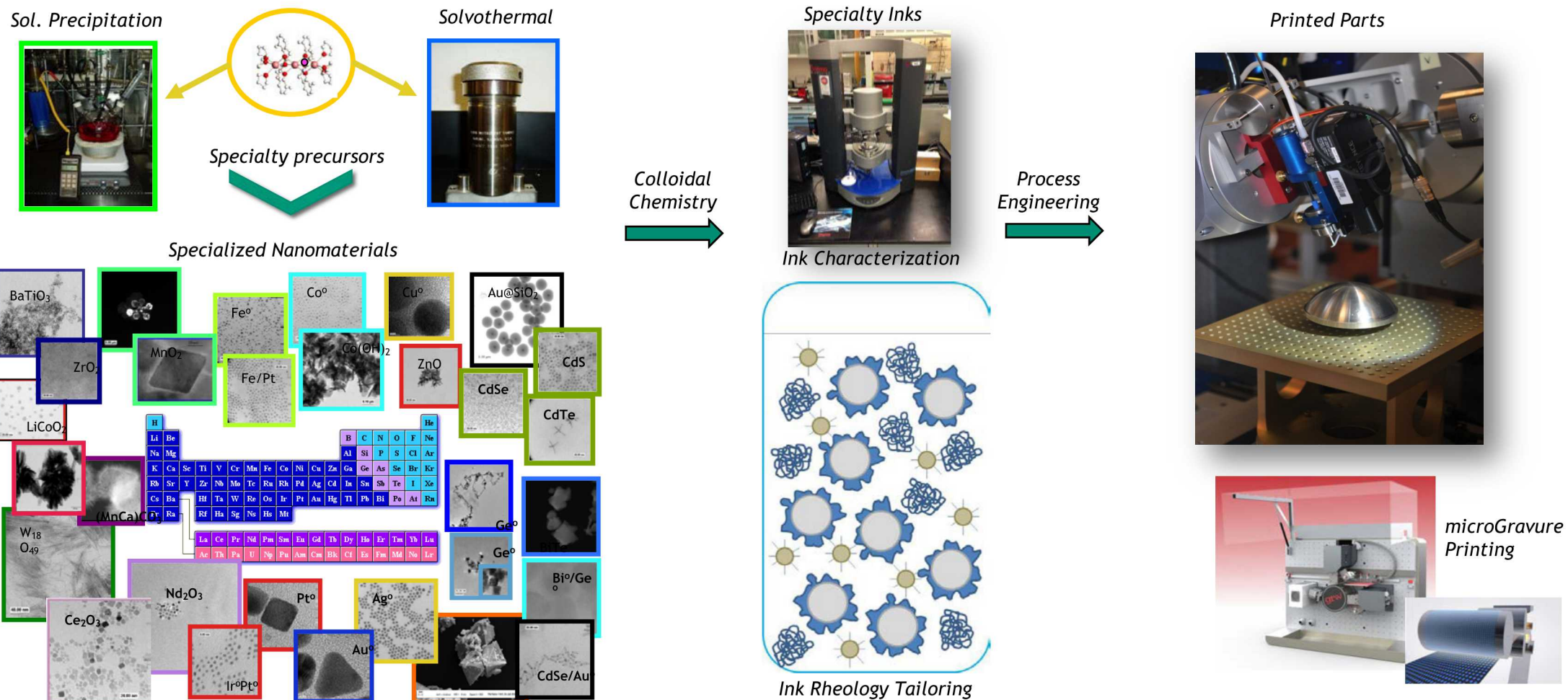
Underline = Current Capability/Activity

7 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.

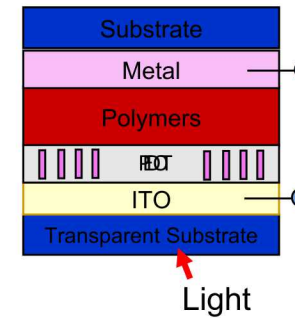
Application specific sensors (passive and active) – e.g. RF, stress, strain, EM, etc.

Electronics integrated with 3D metal and ceramic components

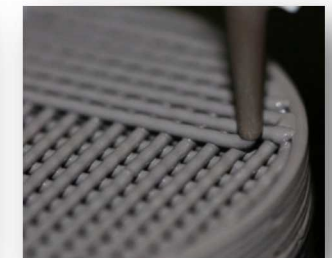
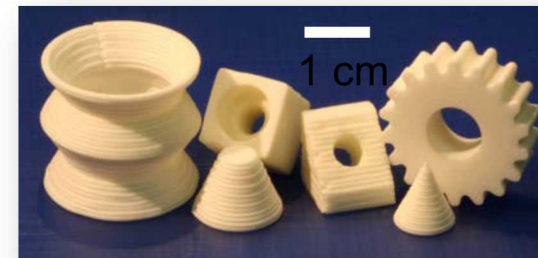
Printed electronics – packaging, interconnects (cables and connectors)

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

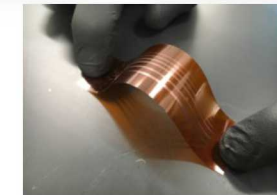
Energy Storage/Generation Materials



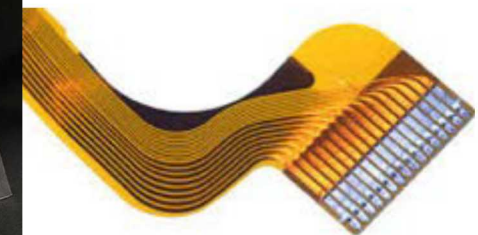
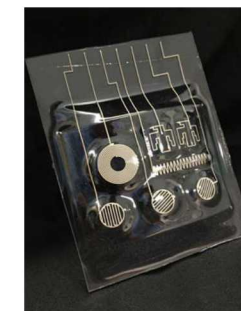
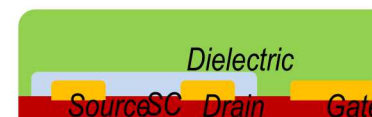
Ceramics



FLEX



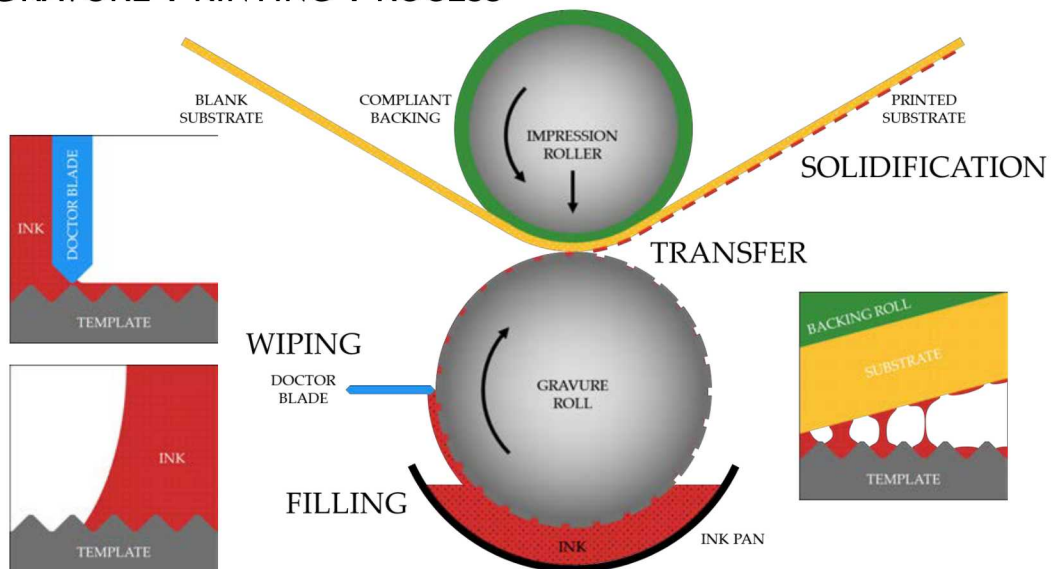
Logic devices/Memristors



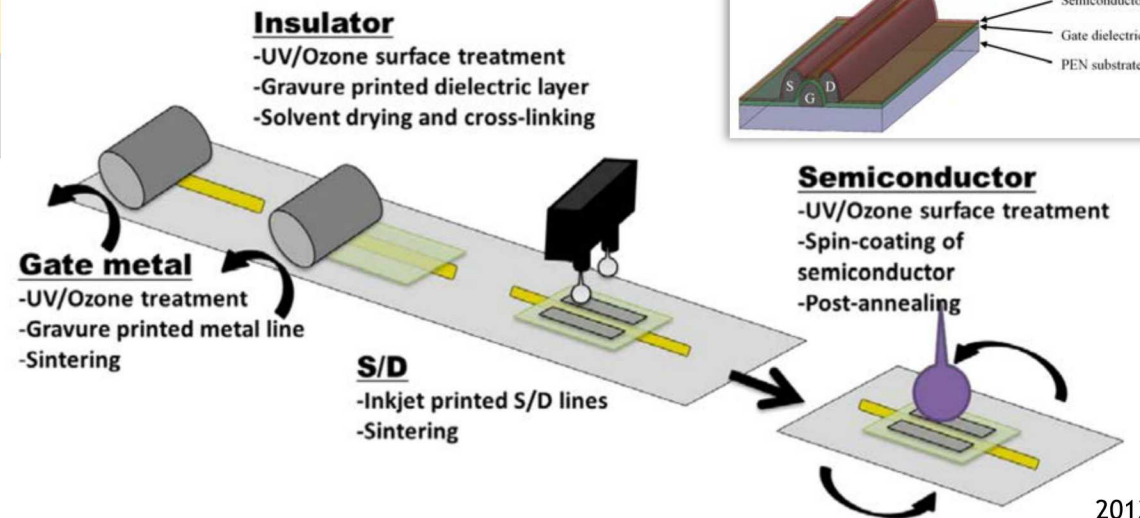
Defect Mechanisms in Gravure Printing (in collaboration with UCB/UTA)



GRAVURE PRINTING PROCESS

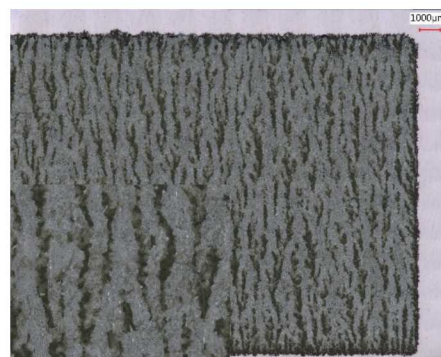
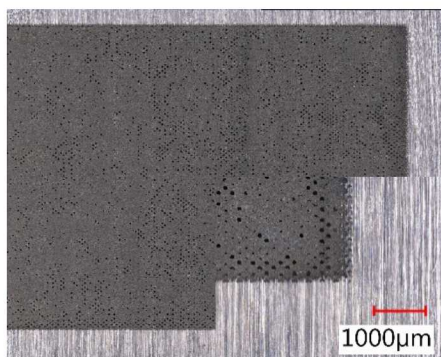


DEVICE MANUFACTURE

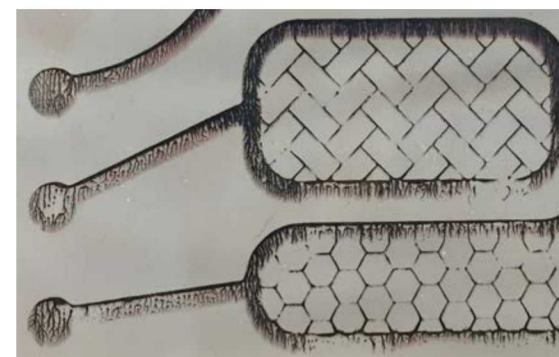


2013 Kang

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



Materials for printed electronics

Machine learning techniques for materials and manufacturing

Additive manufacturing of refractory metals