Outline

1. Background on NIST (AMTech) Program, Why ATIC? and PM Industry
2. Overview of Atomization Technology Innovation Consortium (ATIC)
3. ATIC Project Plan and Roadmapping Steps
5. ATIC Workshops in 2016
6. Feedback and Questions for PM Management
NIST Advanced Manufacturing Technology (AMTech) Program

Launched by the National Institute of Standards and Technology in FY 2013 to incentivize the formation of and provide resources to industry-driven consortia for U.S. manufacturing industries:

- Support basic and applied research
- Focus on long-term, pre-competitive and enabling technology development

Goal of AMTech-supported consortia: Strengthen the capacity of U.S. industry and the nation to compete in global markets
Why ATIC?

• Atomization is a technology that is widely used across a range of industry applications, including powder materials production, industrial and chemical sprays, atomization of fuels and industrial combustion

• A survey of U.S. companies determined that approximately 19,500 companies manufacture or use atomized products or apply atomized sprays

• Because advanced atomization and spraying technologies have the potential to improve the efficiency, productivity, and global competitiveness of a wide range of U.S. materials manufacturing and value-added end user industries, it was proposed to NIST to form the Atomization Technology Innovation Consortium (ATIC)
Impact of Atomization Technologies

Atomization Profile

Atomization Technology

- Electric power generation
- Industrial chemical production
- Motor vehicles
- Paints, coatings, & adhesives
- Powder production
- Pharmaceutical products
- Paper manufacturing
- Air transport
- Agricultural sprays & fertilizers
- Impacted Industries

Source: U.S. Census Bureau 2011, Annual Survey of Manufacturers

- 2.22M employees
- 19,500 companies
- $1.46T value of shipments
- 94.4% small and medium enterprises
PM Industry Roadmap: 2012

Powder Metallurgy Industry Profile:
• Estimated Sales in North America of $7 billion
• Historical annual growth rates of 11 percent
• Employment exceeding 25,000 people
• Majority of PM companies are small; 90 percent classified as small businesses by U. S. government standards.
• Current market driven by automotive applications
• Future growth markets over next 10 years: electrical and electromagnetics, alternative energy, aerospace, medical, defense, industrial and consumer products.

PM Industry Roadmap: 2012

PM Application Advantages include:

1) Net-shaped PM parts that are a cost-effective alternative to machined parts, castings or forgings

2) Loose powders or mixtures are used for welding, joining and spray coating for fabrication, repair or surface texturing

3) PM can produce components such as carbide cutting tools, porous bearings, filters hard and soft magnetic parts that are difficult to produce by other methods

- PM is also recognized as a green technology!

Overview of Atomization Technology Innovation Consortium
Atomization Technology Innovation Consortium (ATIC)

• Planning grant for ATIC was awarded in May to ASM International by the NIST Advanced Manufacturing Technology (AMTech) program office
• 24 month duration (starting June 1, 2015)
• $480,000 grant
• Two parallel efforts:
  - Create an Atomization Technology Innovation Roadmap (Jan. 2017)
  - Establish the Atomization Technology Innovation Consortium (ATIC) (May 2017)
Desired ATIC Outcomes

• ASM International will lead the development of the consortium, which will comprise members from key industry associations and facilitate technology implementation and sustainability.

• To achieve this goal, ATIC is working to develop a comprehensive R&D roadmap that will identify common atomization needs and priorities across industries.

• The Atomization Technology Innovation Consortium (ATIC) will lead and coordinate a national initiative to develop and deploy advanced manufacturing technologies across the broad atomization community.
ATIC Vision

The Atomization Technology Innovation Consortium: “Will lead and coordinate a national effort to develop and deploy advanced manufacturing technologies across the broad atomization technology community that will significantly increase sustainability and U.S. global competitiveness.”
ATIC Goals-Goal 1

1. Lead and coordinate development of the first comprehensive atomization technology roadmap for use throughout the entire atomization community.

- Identify common atomization technology needs and opportunities across industries to enable new products, reduce costs, increase productivity, create jobs, reduce energy use and lower emissions

- Gather input from the complete value chain, including raw materials suppliers, product manufacturers, and end users as well as technology suppliers within academia, national laboratories, and trade associations and professional societies
ATIC Goals-Goal 2

2. Facilitate implementation of advanced manufacturing technologies in atomization-driven industries.

- Bring together key academic centers and departments, national laboratories, and industry associations that provide access to companies of all sizes, especially small and medium enterprises
- Incentivize participation through increased access to technology and process information and opportunities for development and implementation activities
ATIC Goals-Goal 3

3. Facilitate formation of a consortium to address R&D opportunities through cross-sector engagement with the atomization technology value chain.

- Build upon a committed consortium nucleus that represents the full range of the value chain
- Develop a low-cost consortium funding structure to support ongoing consortium operations
- Aggressively pursue efforts to raise federal and state funding to support development and implementation efforts
ATIC Leadership Team

NIST
Jean-Louis Staudenman
Federal Program Officer
Titilope Akinyosoye
Grants Specialist

ASM International
Terry Mosier
Project Lead

Roadmapping Support
Nexight Group

ILASS-Americas
Scott Parrish
Research Engineer, General Motors Research and Development, ILASS Board Member

America Makes
Rob Gorham
Director of Operations, America Makes

Metal Powder Industries Federation
James Adams
Vice-President, Technical Services, Metal Powder Industries Federation

Thermal Spray Society
Mitch Dorfman
Mettco Fellow, Oerlikon Metco, Board Member, Thermal Spray Society

The Ames Laboratory
Iver Anderson
Senior Metallurgist, The Ames Laboratory

UCI Combustion Laboratory
Vincent McDonell
Associate Director, UCI Combustion Laboratory
ATIC Project Roles

**ASM:** Lead the team as well as provide overall consortium development, communications, and project management

**NIST:** Provide AMTech Program guidance and support

**Leadership Team:** Provide technical expertise, community connections, and strategic advice

**Nexight Group:** Facilitate workshops and support the technology roadmapping process
ATIC Leadership Team: Organization Profiles

Leadership Team Representation

ATIC will leverage the networks and expertise of professional societies, academia and national laboratories to advance atomization and spraying technologies.
ATIC Project Plan and Roadmapping Steps
ATIC Project Plan

Establish Vision and Goals — June 2015

Create ATIC Website (atechinnovation.org) — August 2015

Conduct State-of-the-Art Assessment and Expert Interviews — July to December 2015

Workshop 1 (following ILASS Meeting, Dearborn, MI) — May 2016

Workshop 2 (following PowderMet 2016 Conference, Boston, MA) — June 2016

Final Roadmap — January 2017

Consortium Launch — May 2017
ATIC Timeline

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- **Vision & Goals Statement**
- **Launch Meeting**
- **Consortium Structure**
- **State-of-the-Art Summary**
- **Interview Synthesis**
- **Workshops 1 & 2**
- **Workshop Briefing Document**
- **Preliminary Roadmap**
- **Final Roadmap**
- **Launch Kit**
- **ATIC Implementation Plan**
- **First full ATIC Consortium Meeting**

◆ = Key Milestone  ◆ = Interim Milestone
Roadmapping Overview

**Roadmapping Process**

**STEP 1: Establish Vision and Goals**
- Early facilitated processes establish the strategic framework that enables more focused downstream work

**STEP 2: Vision & Goals Statement**
- ATIC Leadership Team launch meeting

**STEP 3: Develop Expert Assessment**
- Targeted literature review and expert interviews frame relevant issues and focus workshop discussions

**STEP 4: State-of-the-Art Summary**
- ATIC Leadership Team drafts consortium structure
- ATIC Leadership Team provides guidance on experts for interviews

**STEP 5: Hold Two Collaborative Workshops**
- A consensus-based approach that identifies gaps, uncovers opportunities, drives prioritization, builds actionable timelines and next steps ensures full engagement and results that drive decisions

**STEP 6: Interview Synthesis**
- ATIC Leadership Team provides input to workshop participants

**STEP 7: Prioritized Obstacles, Actions & Targeted Plans**
- ATIC member recruitment launched

**STEP 8: Prepare Preliminary Roadmap**
Roadmapping Overview

STEP 5: Prepare Preliminary Roadmap
Our innovative communications team works closely with our technical experts to convert raw inputs into compelling roadmap products and also gathers critical input from stakeholders during a structured, expanding review process.

STEP 6: Launch & Implement Roadmap
The final roadmap in a range of media and with supporting communications tools enables effective engagement with target communities.

STEP 7: Consortium Launch & Planning
With roadmap in hand, the Leadership Team will launch the consortium. An implementation plan for the roadmap will be developed during this phase.

ATIC Leadership Team facilitates draft roadmap reviews

Final Roadmap

Launch Kit

ATIC Leadership Team guides distribution of final roadmap

ATIC holds first full consortium meeting
State-of-the-Art Review: Atomization and Spraying
ATIC State-of-the-Art Review

• **Purpose of the State-of-the-Art review is to characterize:**
  - Atomization and Spray Technology Processes
  - Markets and Products/Applications
  - Value Chain: Industry, Technology Suppliers & End Users
  - Application of Advanced Manufacturing Technologies to Atomization Processes

• **Expert Interviews are also being conducted with the goal of identifying barriers, gaps and defining opportunities to:**
  - Gain insights from experts representing diverse elements of the atomization and spray communities
  - Engage key experts in a discussion of atomization and spraying technologies to frame the workshop questions and activities
ATIC Builds on Previous Roadmaps

Interview Questions

Limitations of the Current State-of-the-Art:

• What are the top three technical barriers or gaps limiting the development, adaptation and implementation of atomization or spraying technologies?

• In what ways are atomization and spraying processes limited by the atomization equipment or materials of construction that are used to produce powders or dispersed droplets?
Interview Questions

Opportunities for Advancement:
What are the major opportunities to advance the state of atomization and spray technologies? Specifically, what advances in materials, process knowledge, process equipment, or enabling technologies would make the largest impact?

Value of ATIC:
What type of engagement through ATIC would be most valuable to you?
State-of-the-Art: Technologies

Two-Fluid Atomization & Spraying Processes:
- Gas, water and oil atomization
- Air atomizing sprays

Single-fluid (Pressure) Atomization & Spraying Processes:
- Centrifugal atomization
- Vacuum or soluble gas atomization
- Ultrasonic atomization
- Spray drying
- Pressurized fluid sprays & injectors

Note: For each process, identify key attributes including: atomized powder or sprayed droplet characteristics, energy use, gas or water consumption, effect of atmosphere, nozzle materials
Close-Coupled Gas Atomization

Image of world’s first close-coupled gas atomization processing of molten Ti-alloy with spray temperature over 1700°C.

Micrograph of resulting Ti-alloy powders showing near ideal spherical shape with high flowability.
State-of-the-Art: Markets/Products & Applications

- Electrical power generation (e.g. gas turbines, CO₂ scrubbers, cooling towers, slurry atomization)
- Industrial chemical production
- Motor vehicles (e.g. internal combustion gasoline and diesel engines)
- Paints, coatings, and adhesives production
- Paper manufacturing
- Pharmaceutical products
- Powder metal production (P/M and metal injection parts, additive manufacturing, spray deposition)
- Aerospace (coated jet engine blades, fuel nozzles, liquid fuel rocket nozzles)
- Agricultural sprays & fertilizers
- Clay product and refractory manufacturing
Powders for Thermal Spray

Turbine Performance and Thermally Sprayed Coating Materials

Thermal Spray markets: Estimated $6.5 billion

Increases in turbine engine operating temperature are partly enabled by thermally sprayed materials.

Credit: Oerlikon Metco
Additive Manufacturing: Market Projections

“Industry Grows to $4.1 Billion in 2014!”

Wohlers Report 2015:
• Industry expanded by $1 billion in 2014
• AM products and services worldwide, grew at a CAGR of 35.2%
• Currently 49 manufacturers are selling industrial-grade AM machines

www.wohlersassociates.com/press69.html
Additive Manufacturing: Powder Applications


➢ Reduce weight and cost of producing fuel nozzles for jet engines
➢ 3D Printing enabled integrated design and manufacture of a complex part to improve the function of fuel nozzles
➢ Extensive modeling by numerical simulation was used to simulate atomization of fuel spray
➢ Small changes in nozzle geometry leads to significant improvements in engine performance
➢ A $50 million plant was constructed in 2015.

http://www.gereports.com/post/91763815095/worlds-first-plant-to-print-jet-engine-nozzles-in
Benefits of Additive Manufacturing Fuel Injector Nozzles from Powders:

• 25 percent lighter and five times more durable than current nozzles
• Simplified design: Previous nozzle fabricated from 20 different parts; the number of brazes and welds reduced from 25 to 5
• Small changes in nozzle geometry in additive manufactured nozzles led to significant improvement in engine performance
• The LEAP engine is 15 percent more fuel efficient with an equivalent reduction in CO2 emission
• Each LEAP engine has nineteen 3D-printed fuel nozzles, which will multiply the advantages of producing nozzles by additive manufacturing
• The first LEAP engine is scheduled to enter service in 2016
Additive Manufacturing: Will the 3D Boom Continue?

ASME Podcast by Terry Wohlers, President of Wohlers Associates, Inc.
(August 10, 2015)

- AM grew 35% in 2014; CAGR of 27% during the past 26 years
- Primary users of AM: aerospace and medical for parts with low volume, high complexity & value
- General Electric Aviation beginning production of AM fuel nozzles for the LEAP engine
- AM Parts: Aerospace parts in design & certification; Medical Hip cups (50,000 produced);
- Main AM Alloys: Ti-6-4, Co-Cr, IN718
- Standards are essential: ASTM F42 and ISO TC261 committees are working together on standards
- Currently there is a high level of investment in R&D and technology transition to manufacturing
- Major areas of growth (next five years): Aerospace, Medical, Oil & Gas and Automotive

Reference: https://www.asme.org/engineering-topics/media/manufacturing-processing/video-terry-wohlers-3d-printing-boom-continue
State-of-the Art: Value Supply Chain

• Material/Component Suppliers:
  o Raw materials (feedstock)
  o Materials of construction (nozzles, spray nozzle system components, equipment)

• Equipment: OEM Suppliers

• Technology Users: e.g., OEM powder producers, thermal spray or atomized spray users

• Technology Development & Support Organizations:
  • Academia
  • National labs
  • Professional societies

• End users: atomized powders, coated products or equipment that uses atomization e.g., fuel injectors
State-of-the Art:
Advanced Technology & Materials

• Modeling & Simulation, Verification & Validation (e.g. liquid stream fragmentation)
• Sensors & Data Analytics
• Automation & Robotics
• Advanced Materials:
  o Integration in processing technology/equipment
  o End-use products enabled by advanced materials
  o Example of a plan for development advanced materials development is the Consortium for Additive Manufacturing Materials led by Penn State
Consortium for Additive Manufacturing Materials (CAMM) Roadmap

• Roadmap offers a strategy for building the fundamental knowledge needed to accelerate the design and demonstration of new AM materials over the next 10 years.

• Coupling focused fundamental materials research with AM’s cornerstone advantage of accelerated product development through simultaneous design and manufacture will transform U.S. advanced manufacturing, possibly propelling the nation into a new industrial revolution.

• The R&D activities identified in this roadmap will accelerate the design of new materials and encourage their widespread use by AM users in the next ten years.

• These activities can also serve as a feeder to future America Makes programs.
(T1) Enabling Integrated Design Methodologies for Materials, Processes, and Components

(T2) Developing AM Process-Structure-Property Relationships

(T3) Establishing Feedstock and AM Part Testing Protocols

(T4) Assessing AM Process Analytics

(T5) Exploring Next-Generation AM Materials and Processes
The AM community faces a number of cross-cutting challenges impeding the development of new material systems.

These characteristics can add a dimension of intricacy to materials development by exploiting the unique processing advantages of AM to create state-of-the-art multi-materials that combine more than one type of material.

The five strategic thrusts in this roadmap acknowledge the fundamentally unique AM processing considerations of these material classes and call for research needed to create new AM-based metal, polymer, and ceramic materials.
ATIC Workshops in 2016
Two workshops are planned to obtain input from invited participants on:

1) Challenges & Gaps that limit atomization and spraying technologies and
2) Identify Opportunities to advance application of atomization & spraying

ATIC workshops will be held in conjunction with the following meetings:

- ILASS-Americas 2016 meeting, May 15-18, Dearborn, MI.
  Workshop 1 will focus on atomization technologies across a wide range of industries and spraying applications
- PowderMet2016, June 5-8, 2016, Boston, MA.
  Workshop 2 will focus on atomized or sprayed metal powder technologies.
Feedback and Questions for PM Management
Limitations of the Current State-of-the-Art:

• What are the top three technical barriers or gaps limiting the development, adaptation and implementation of atomization or spraying technologies?

• In what ways are atomization and spraying processes limited by the atomization equipment or materials of construction that are used to produce powders or dispersed droplets?
Opportunities for Advancement:

• What are the major opportunities to advance the state of atomization and spray technologies? Specifically, what advances in materials, process knowledge, process equipment, or enabling technologies would make the largest impact?

• What are opportunities for New products & Applications?
What are new opportunities for powders in the P/M industry?

- Based on the many advantages of using atomized powders for near-net shaped P/M parts, coatings and new processing methods such as 3D printing, the future is bright.

- The challenge is to set high goals for PM Industry Growth:
  “The greater danger for most of us lies not in setting our aim too high and falling short; but in setting our aim too low and achieving our mark!” Quote by Michelangelo (1475-1564)