



MANUFACTURING

# The HPC4Mfg Program

**Lawrence Livermore National Laboratory, Lead  
Sept 2015 - Present**

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Milwaukee, WI  
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# The HPC4Mfg program is designed to bring the many benefits of high-performance computing benefits brings many benefits to US Industry

- Accelerate innovation
- Lower energy costs
- Reduce testing cycles
- Reduce waste/reduce rejected parts
- Quality processes and Pre-qualify
- Optimize design
- Shorten the time to market



# The HPC4Mfg program lowers the barriers to bringing the power of HPC to the manufacturing community

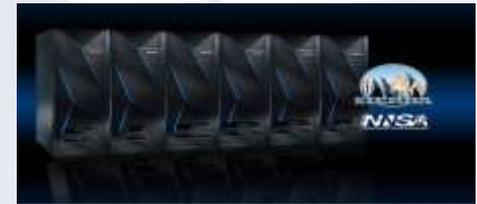
- **Industry Status:**

- Some larger companies use HPC, but struggle to stay current
- Few small to medium companies use HPC



- **DOE Status:**

- DOE labs possess 5 of the top 10 HPC systems worldwide; 2 of top 4 in Graph500
- Broad expertise in the application HPC
- Can be a challenge for industry to understand the best way to partner with DOE



*HPC4Mfg creates partnerships that leverage DOE lab expertise and compute resources to address critical problems in the manufacturing sector*

# The HPC4Mfg program is building an ecosystem to support HPC adoption by industry

- Showing what is possible with HPC through demonstration projects
  - AMO funds < \$300k to laboratories
  - Industry funds at least 20% in-kind support w/ optional cash contribution
  - Project duration < 1 year
- Encouraging the adoption of HPC through capability projects
  - Execution mechanisms and funding source varies
  - Project duration: multiple year
- Building the HPC Manufacturing community
  - Industry Engagement Day
  - Student intern programs



# Our unique approach to building teams helps ensure each project's success



**Engage industry**

Industry submits challenges

**Match challenge to PI**

AMO approval; Feedback to industry

Sign agreements

**Inform industry**

Concept paper

Full proposal

Award

Technical Review Committee

## Technical Merit Review Committee

- Partner labs and AMO representatives
- Heavy focus on **nation-wide** impact to energy efficiency and clean energy technology industry-wide

Execution streamlined through the required use of the DOE short form

# Status: The HPC<sub>4</sub>Mfg Program is growing...

**March – September 2015**

Launch program with seedling projects

- LLNL established the program
- \$1.5M: 5 seedling projects
- Industry outreach



**September 2015–March 2016**

Inaugural solicitation

- LBNL, ORNL join as partner labs
- \$3M solicitation: 10 demonstration projects to 8 companies

**March 2016 -**

Steady state

- Solicitation twice a year (typically \$3M each)
- Summer internships
- Implementation/Development projects
- Added participating laboratories: ANL, NREL, NETL
- Added new focus area of materials in severe environments

- *Compute resources from across the DOE complex*
- *Launched annual Industry Day*
- *Student internship programs*

# The HPC4Mfg program has a diverse portfolio

- \$>13M technical portfolio
  - Executing on 41 projects with 33 industry partners and 6 labs
  - 40 demonstration; 1 capability
  - Seedling project funded by Office of Transportation
- Spring 2017 Solicitation
  - \$3M available
  - New area of materials in severe environments
  - Other DOE offices informally involved
  - 57 Concept papers submitted; 26 moving forward to full proposals

8 RIVERS

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**SORAA**



**PURDUE UNIVERSITY**  
CALUMET

**TIMKEN**



**LanzaTech**



**Carbon**

**SEPION TECHNOLOGIES**



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CREATING THE NEXT WAVE OF INNOVATION



**SAMSUNG**  
SAMSUNG SEMICONDUCTOR USA

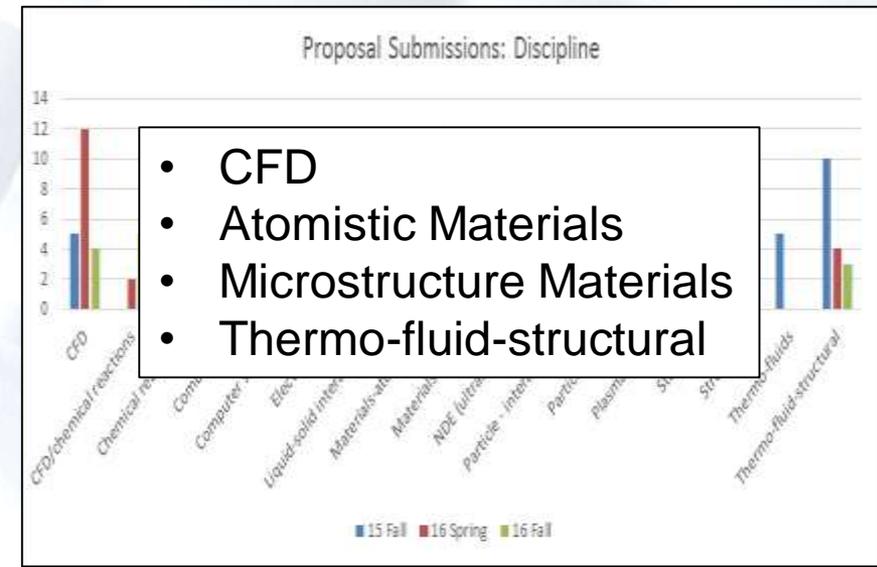
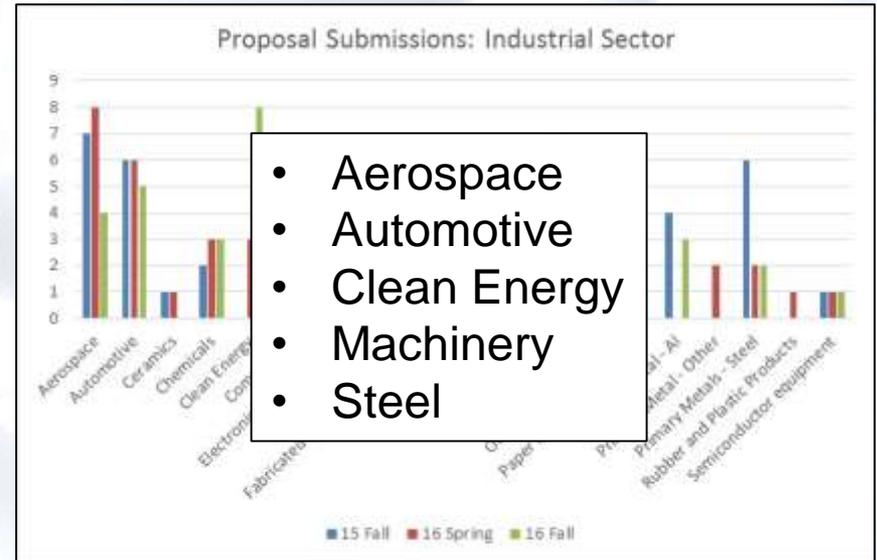
**APPLIED MATERIALS**  
make possible

**ALZETA CORPORATION**

**lift**

**GM**

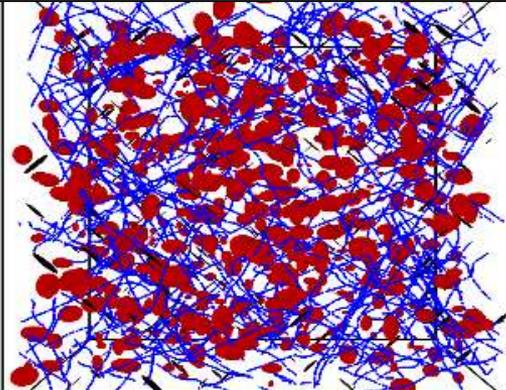
# The concept paper participation has been diverse in both geographic location and topic



# HPC<sub>4</sub>Mfg is extending our scientific knowledge in different industrial sectors

## Creating new lightweight alloys

**Goal:** Predict the strength of lightweight aluminum-lithium alloys produced under different process conditions; could save millions of fuel costs if used in aircraft design

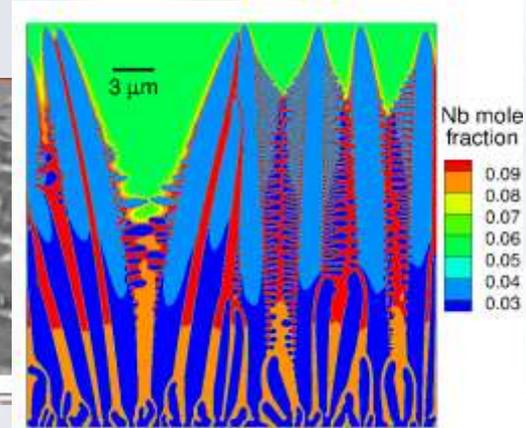
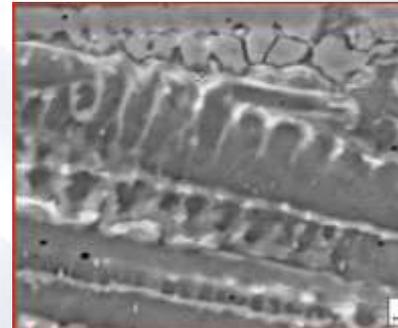


**Results to date:** Developed new dislocation mobility laws for Al-Li alloys; examining influence of different precipitate density; predicting yield strength for differing particle sizes

**Team:** LIFT with LLNL and Univ Mich.

## Dendritic Growth in AM Parts

**Goal:** Use HPC to model multi-scale morphology of solidification microstructure of Nickel base 718



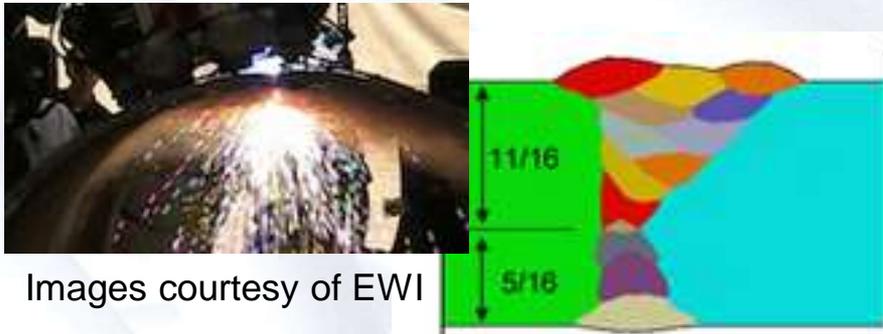
**Results to date:** Predicting crystal growth over large domains from multi-component alloys using phase field approaches; moving to new alloy systems and 3D

**Team:** UTRC with ORNL/LLNL

# HPC<sub>4</sub>Mfg is improving industrial workflows and speeding up modeling time using HPC

## Weld Predictor Tool

**Goal:** Develop an improved online welding software modeling application using advanced 3D models, more material hardening laws, and open source parallel codes



Images courtesy of EWI

**Results to date:** Developed new front end interface and automated meshing tools; working on new parallel simulation tools for thermal analysis, microstructure prediction, and mechanical analysis

**Team:** Edison Welding Institute with ORNL/OSU

## Paper Towel Design

**Goal:** Use HPC to evaluate different microfiber configurations to optimize drying time while maintaining user experience



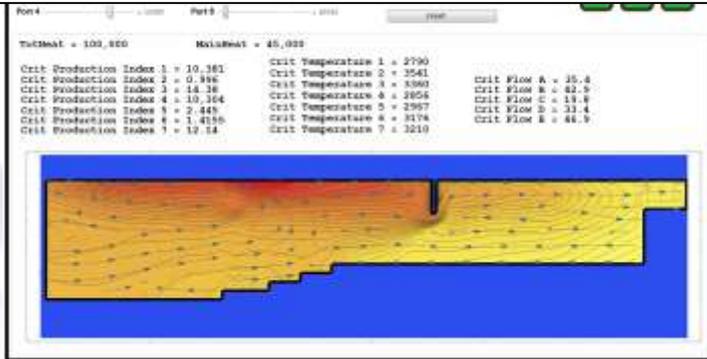
**Results to date:** New mesh tool reduces product design cycle by 2X cycle; additional cores by another 8X; largest non benchmark run of Paradyn code at LLNL

**Team:** Procter and Gamble with LLNL

# HPC<sub>4</sub>Mfg is improving manufacturing operation in energy-intensive environments

## Glass Making Operation

**Goal:** Optimize process operation and production of glass making using HPC; save 2 weeks of production per year per furnace; save 2.5 TBTUs of energy and avoid 130,000 metric tons on carbon dioxide emissions

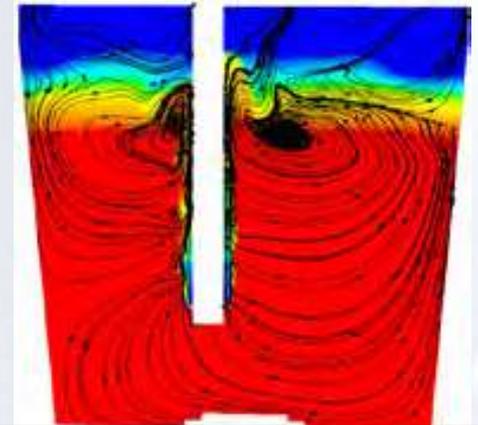


**Results to date:** Fully validated fluid model used for a parameterization study; statistical analysis and machine learning to create a reduced order glass furnace model for real time process adjustments

**Team:** Vitro Glass with LLNL

## Blast Furnace Operation

**Goal:** Optimize blast furnace operation to reduce coal coke usage, energy consumption



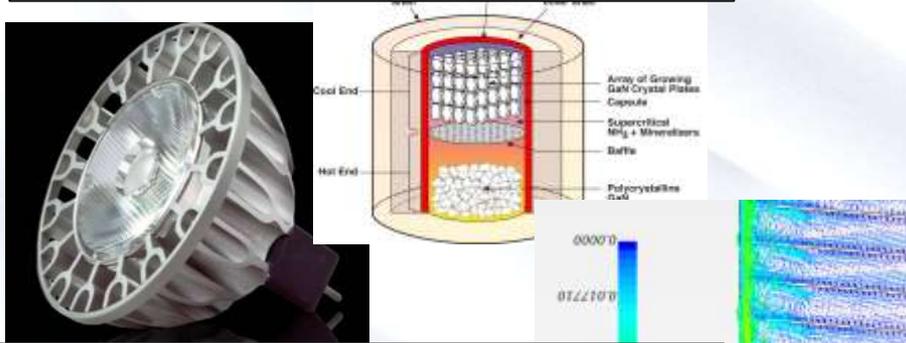
**Results to date:** Parallelized blast furnace code is 100X faster than previous code; studies conducted to evaluate coke usage as a function of operational parameters

**Team:** US Steel with Purdue and LLNL

# HPC<sub>4</sub>Mfg is leading to significant energy savings in new products or processes

## More efficient LED lightbulb

**Goal:** Model ammono-thermal crystal growth of GaN to scale up the process; reduce production costs of LED lighting by 20%

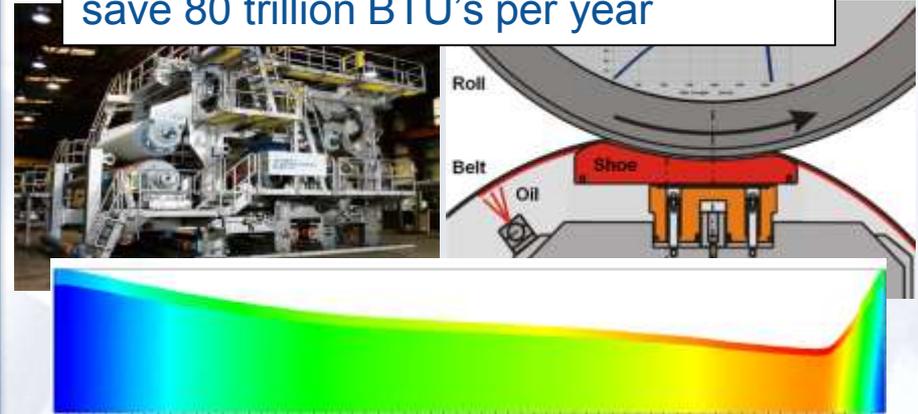


**Results to date:** HPC allows higher fidelity simulations showing more complicated flow structure, improved predictions of temperature and flow velocity in the reactor; now optimizing uniform growth of crystals

**Team:** SORAA with LLNL

## Energy savings in paper making

**Goal:** Use multi-physics models to reduce paper rewetting in the pressing process; reduce 3<sup>rd</sup> most intense energy consumer in paper making; save 80 trillion BTU's per year



**Results to date:** Using both continuum and pore-scale approaches to determine how water flows through porous paper pulp; simulations can be used to optimize drying

**Team:** Agenda2020 with LBNL/LLNL

# If HPC4Mfg is successful...

- The development and deployment of energy-efficient manufacturing is accelerated through funded projects
- The production or adoption of clean tech is enabled through funded projects
- HPC becomes a useful tool to a broad array of small, medium, and large companies in designing new products, reducing cost and energy consumption, accelerating time to market
- More collaborations between DOE labs and U.S. manufacturers are enabled increasing competitiveness
- Simulation capabilities at the DOE laboratories are improved

# The HPC<sub>4</sub>Mfg Program was designed to be scaled to other focus areas



AMO sponsor, working with Jeff Roberts and others, is planning a significant increase and expansion in next 4 years

# The HPC4Mtls program

- The purpose of the HPC4Mtls program will be to advance the design, performance, and understanding of in-service materials in severe environments.
- **Severe Environments:** Environments that will degrade and cause to fail widely available materials faster than is desired and for which alternatives are either prohibitively expensive or not available.
- Lead labs are : LANL, LLNL, ORNL, NETL
- Language included in 4<sup>th</sup> solicitation of HPC4Mfg on this topic
- RFI and notice of intent released soon; workshop in October
- Hoping to have a full solicitation in the fall under the HPC4Mfg/EnergyInnovation umbrella in January

# Questions?

Additional information at [HPC4Mfg.org](http://HPC4Mfg.org)

Questions can be sent to  
[HPC4Mfg@llnl.gov](mailto:HPC4Mfg@llnl.gov)

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***Session later this afternoon  
will highlight two projects  
from this program***

The screenshot shows the HPC4 Manufacturing website. At the top, there is a navigation menu with links for Home, Projects, Partner Laboratories, Solicitation, FAQ, Events, and Mailing List. The main heading reads "High Performance Computing for Manufacturing HPC4Mfg Accelerating Innovation". Below this is a large image of a colorful, abstract visualization, possibly representing a simulation or data analysis. To the right of the image is a "News" section with several items: "Fall 2016 Awardes", "Industry Engagement Day a success!", "Innovating in Foundational industries: Steel", "Fall 2016 Solicitation now closed", and "DOE Social Media posts: Facebook -> Round 2 Selection -> Round 3 Solicitation". Below the news section is a "Contact" section with the text "For additional information on the HPC4Mfg Program, email [hpc4mfg@llnl.gov](mailto:hpc4mfg@llnl.gov)". To the right of the main content is a "Partner Laboratories" section with logos for Lawrence Livermore National Laboratory, Oak Ridge National Laboratory, and Sandia National Laboratories. The main article text reads: "The DOE HPC4Mfg Program funds 13 new projects to improve U.S. energy technologies through high performance computing for a total of \$3.9M. The 13 new projects include: LLNL and ORNL partnering with various manufacturers (Applied Materials, GE Global Research, and United Technologies Research) to improve additive manufacturing processes that use powder beds to reduce material use, reduce defects and surface roughness, and improve overall quality of the resulting parts; LBNL partnering with Samsung Semiconductor Inc. to improve the performance of semi-conductor devices by enabling better cooling through the interconnects; Ford Motor Company partnering with ANL to understand how manufacturing tolerances can impact the fuel efficiency and performance of spark-ignition engines; and NREL partnering with TAC technologies to model liquid/membrane interfaces to improve the efficiency of air conditioning systems. In addition, one of the projects, a collaboration among LLNL, NETL, and B Rivers Capital to study coal-based Alam cycle combustors will be co-funded by DOE's Fossil Energy Program." Below the article text is a link "View full list of projects." At the bottom of the page, there is a section titled "The HPC4 for Manufacturing Program (HPC4Mfg) Program unites the world-class computing resources and expertise of Department of Energy national laboratories with the U.S. manufacturers to deliver solutions that could revolutionize manufacturing." followed by "Led by Lawrence Livermore National Laboratory (LLNL), and joined by its partners, Lawrence Berkeley and Oak Ridge national laboratories, HPC4Mfg offers a low-risk path for U.S. manufacturing companies interested in adopting high-performance computing (HPC) technology to advance clean energy technologies and increase energy efficiency while reducing risk of HPC adoption." and "The HPC4Mfg Program aims to:" followed by a bulleted list: "• Infuse advanced computing expertise and technology into the manufacturing industry.", "• Advance innovative clean energy technologies.", "• Reduce energy and resource consumption."