Argonne NATIONAL LABORATORY

# ADDITIVE MANUFACTURING TO ADVANCE NUCLEAR MATERIALS

*Approach improves performance and lifetime, lowers costs*

## CHALLENGE

A number of advanced reactor systems are under consideration by industry for near-term and long-term deployment. Those advanced reactor concepts require corresponding innovation in materials to meet the demand of their aggressive environment, which can include high-temperature corrosion challenges (e.g., molten salt, lead), enhanced accident tolerance, and high irradiation doses.

Some of the older existing reactors will soon be in need of replacement parts, but industries that supplied those parts might no longer exist. A cost effective way of replacing those legacy parts is potentially through the use of additive manufacturing (AM) on demand.

## WHAT ARGONNE DELIVERS

Argonne has world-class expertise in materials and nuclear science and the development and application of advanced materials synthesis techniques, such as Atomic Layer Deposition (ALD); a growing program in metal AM; and a suite of user and research facilities enable advanced characterization at the Advanced Photon Source and Center for Nanoscale Materials, simulate irradiation effects in nuclear materials at ATLAS (Argonne Tandem Linac Accelerator System) and modeling and simulations at the Argonne Leadership Computing Facility.

## RESULTS

Advanced ceramic-ceramic and metalceramic composite materials developed for harsh nuclear reactor conditions, using a hybrid low temperature deposition technique that provides the benefits of both ALD and thick coating techniques.

Compared to other synthesis techniques these materials have:

- improved high-temperature corrosion resistance
- better mechanical properties than existing materials and corrosion protection with lower thickness
- manufacturability of high-density composites at low temperatures while allowing composite to conform to the shape of a complex geometry substrate.

Advanced synthesis techniques to provide protective coatings.

Benefits are:

- delay or reduce impact on cladding by coating accident tolerant fuels
- mitigate normal operations material degradation
- enable the use of LEU fuel in high-power research reactors

A novel high-resolution AM method based on stereolithograpy. The benefits compared to direct energy synthesis such as SLS or DLS 3-D printing are:

- less expensive
- less waste and contamination risk (using encapsulated powder)
- multi-material capability
- can use micro or nano powders
- printing of metastable and high entropy alloys

The development of unique chemistries for high resolution 3-D printing of metal and ceramic powders.

Benefits are:

- print fuel structures
- high resolution metal printing
- can use low cost printers


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April 2018