LIFT HIGH-BAY

Cold Spray Additive

VENDOR

SPEE3D

MATERIALS

Various metal powders

Cold Spray Additive Manufacturing employs low-temperature kinetic deposition of various types of metal powders, supporting the production of custom components and functionally-graded materials.

During the process, fine powder particles are accelerated in a high-velocity compressed gas stream, and upon the impact on a substrate or backing plate, deform and bond together creating a layer. Moving the nozzle over a substrate repeatedly, a deposit is building up layer-by-layer, to form a part or component.

The world's first metal 3D printer to use patented SPEE3D technology enables significantly faster, more cost-effective and more scalable production than traditional manufacturing.

The SPEE3D process is also 100 to 1000 times faster than traditional 3D metal printing, making it the world's fastest way to turn your design into a usable printed metal part.

SPECIFICATIONS

- Maximum part size: Ø350 x 300mm (27L)
- Maximum part weight: 4 kg
- Deposition rate: 100g/minute (maximum)
- Materials: Copper, Aluminium
- Deposition spot size: 6 m
- Noise: < 85dBA @1m
- Machine footprint: 3130 x 1460 x 2325mm
- Machine weight: Approx 2500kgm

LIFT HIGH-BAY

CT Scanner

VENDOR

Lumafield, Nikon

MATERIALS

Various metal powders

Computed Tomography, or **CT scanning**, is used in industrial and medical applications. This imaging technique is incredibly powerful and uses x-rays to produce three-dimensional representations of the scanned object both externally and internally.

Industrial CT scanning is used for nondestructive internal investigation of components.

Some of the key applications for CT scanning have been flaw detection, failure analysis, metrology, assembly analysis, and reverse engineering applications.

The LIFT CT Scanners are configurable with several micrometer-focus x-ray tubes for high resolution applications and high-power millimeter-focus x-ray sources for castings, munitions, automotive assemblies, aerospace assemblies and other nondestructive test inspections.

APPLICATIONS

X-ray technology allows manufacturers to easily scan components for flaws, to investigate internal structure and geometry, or for reverse engineering purposes.

SPECIFICATIONS

- Lumafield Neptune Model 61
- 190 kV
- Resolution between 25 – 120 µm
- 220 mm maximum diameter
- 5 kg weight capacity

- Nikon XT H 225 ST
- 225 kV
- Detector: 2,880 x 2,880 pixels, pixel size 150 µm
- 265 mm maximum diameter
- 50 kg weight capacity

LIFT HIGH-BAY

Extrusion Press

VENDOR

Danieli Breda

MATERIALS

Aluminum and
Magnesium alloys

An **Extrusion Press** is a thermo-mechanical processing machine which forces metal through a die, using elevated temperature and high pressure to form a piece with a uniform cross section along its length. For manufacturing lightweight components, high-temperature metallic billets (aluminum or magnesium, for example) are forced through a die to create an elongated product with a cross-sectional shape determined by the die shape.

The elongated material, now in the shape of the die, can be straightened, cut into desired lengths and/or reshaped using additional thermomechanical, additive, or subtractive processes. A common example of an extruded product is the aluminum perimeter of window screens.

APPLICATIONS

Industries and applications supported by an extrusion press include: **aerospace, automotive, renewable energy, telecommunications, electronics, mass transit, construction, and others.**

SPECIFICATIONS

- Produces up to 50” long sections
- Uses 1,344 U.S. tons of force
- Furnace preheats 80lb. billets at 900˚F

Capacity	12MN/1344 Tons
Nominal Pressure	250 Bar/3336 PSI
Extrusion Speed	16mm/s,0.63"/s
Exit hold width	200mm/7.9"
Exit slotted width	300mm/11.8"
Container (Ø)	157mm/6.18"
Container Length	830mm/32.67"
Extrusion Length	up to 50'

Billet Specifications

Billet (Ø)	152.4mm/6” +0mm/-2mm/0.08”
Billet Max Length	800mm/31.5”
Billet Furnace Temperature	530C/986F
Quench	n/a

Die Stack Dimension Ø355 x 355 ; 13.98” x 13.98”

LIFT HIGH-BAY

Hot Isostatic Processing

VENDOR

American Presses Inc.

MATERIALS

Common Materials are super alloys, titanium and aluminum alloys, high strength steels (HSS), and stainless steels

Hot isostatic pressing (HIP) is a manufacturing process used to eliminate internal microporosity in metal castings and other materials. Enables the solidification, sintering, and densification of metal, polymer, ceramic and composite powders in the solid state. This method, coupled with powder metallurgy allows for the formation of components from metals (such as refractory metals) that are otherwise inaccessible with other techniques, and results in superior material and mechanical properties.

The HIP process subjects a component to both elevated temperature and isostatic (or equal) gas pressure in a high-pressure containment vessel. The chamber is heated, and argon gas is pumped into the cell until the desired pressure and temperature are achieved. The pressure is applied to the material from all directions.

APPLICATIONS

Primary applications are the **consolidation of powder metals and ceramic composites.** Hot isostatic pressing is also used as part of a **sintering (powder metallurgy) process and for fabrication of metal matrix composites.**

SPECIFICATIONS

- 30,000 psi of working pressure
- Interior: 10” diameter x 30” length
- Hot zone: 6” diameter x 12” length
- Rapid cooling
- Furnace 1400 C molybdenum two zone furnace with a 150mm diameter x 30mm long hot zone

Vessel Type ASME Section VIII
Div 2 code stamped pressure vessel, National Board registered.
SA-723 steel.

Hydro
Test and stamped.

Cooling
Treated closed loop cooling system with reservoir, pump & heat exchanger.
Connects to customer coolant at 15 gpm.

LIFT HIGH-BAY

Forming Press

VENDOR

Interlaken Technology (ITC)

MATERIALS

Various metals

Forming Presses are often used for processing or reshaping material of various forms by thermomechanical deformation (a.k.a. upsetting). The workpiece and/or tool are often (but not always) held at elevated temperature, and pressure is applied by the press to deform the material into a predetermined geometry.

Advanced forming presses like those at LIFT also serve as sophisticated test systems, allowing one to characterize material properties over a range of temperatures and pressures. For example, the limitations of a material for stamping can be determined by generating a forming limit diagram via controlled experiments. Further, these data can be used to calibrate and refine Integrated Computational Materials Engineering Models (ICME), which serve as the core of any contemporary advanced manufacturing effort.

This ITC ServoPress line consists of two double-acting, servo-controlled hydraulic presses designed for laboratory and production use. The systems control, monitor, and record process parameters such as clamp force, clamp position, punch force, and punch position, affording a data stream that directly couples to the virtual and theoretical world.

SPECIFICATIONS

- Heated tooling currently capable of up to 1,200°F
- Double action forming
- FB35”xSS35”x24” Daylight
- Hydraulic power supply
- Complete system
- Super ServoPress 300 Ton (2670kN), 230 Ton (2046kN) punch
- 609mm stroke on clamp and punch
- 36” (800mm) between the columns, front to back and side to side, 24” (600m) daylight

LIFT HIGH-BAY

Plasmatreat Cell

VENDOR

Plasmatreat

MATERIALS

Plastics, metals, and glass to cardboard, textiles and composites.

Plasma pretreatment, or **Plasmatreat**, is the key enabling technology for microfine cleaning, surface activation and plasma coating of nearly all kinds of materials – from metals, carbon fiber, plastics and glass, to cardboard, textiles and composites.

When materials are subjected to atmospheric plasma, their surface chemistry and topology are altered at atomic and microscopic levels. The treated surfaces are activated toward accepting surface amendments such as insulating/ protective coatings and structural adhesives.

Often, the insulating and protective coatings are deposited via plasma coating technology, which is also provided by Plasmatreat. Together, plasma treatment and plasma coating increases the chemical and environmental stability of materials, as well as the strength of connections formed through the application of structural adhesives.

In the manufacturing industry, this principle is used for selective modification of material characteristics to increase in the adhesiveness and wettability of surfaces.

APPLICATIONS

Aerospace, automotive, energy, defense, and shipbuilding

SPECIFICATIONS

- Robot: R1000A, 2.23m reach, 80Kg, 6 axis
- Operating power: 1kW at 480V AC
- Large Working Area: 6’x5’

LIFT HIGH-BAY

Laser Beam Powder Bed Fusion

VENDOR

EOS

MATERIALS

Most metals, tooling and set up dependent

The award-winning EOS M 290 employs Direct Metal Laser Solidification (DMLS™) technology. This powder-bed based form of 3D printing ensures maximum part density and exceptional quality.

With the most extensive materials portfolio on the market and a powerful 400-watt fiber laser beam for superior detail resolution, the EOS M 290 is ideal for producing highly complex components in a repeatable, production-ready manner for a broad range of applications.

EOS is the world's leading technology provider for additive manufacturing solutions with metals and plastics through 3D printers, materials and software.

SPECIFICATIONS

- Building volume: 250 x 250 x 325 mm (9.85 x 9.85 x 12.8 in) (height incl. build plate)
- Laser type: Yb fiber laser; 400 W
- Precision optics: F-theta lens; high-speed scanner
- Scanning speed: Up to 7.0 m/s (23 ft./sec)
- Focus diameter: 100 µm (0.004 in)
- Power supply: 32 A / 400 V
- Power consumption: Max. 8.5 kW / average 2.4 kW / with platform heating up to 3.2 kW
- Inert gas supply: 7,000 hPa; 20 m^3/h (102 psi; 706 ft^3/h)
- Weight: Approx. 1,250 kg (2,756 lb)

LIFT HIGH-BAY

Machine Shop

VENDOR

Knuth and FANUC

MATERIALS

Most metals and other materials

A **machine shop** is an area for cutting, shaping, drilling, finishing, and other metal processing. The LIFT machine shop is a fully-outfitted machine shop, including a FANUC Robodrill CNC mill, in addition to machines which can cut, drill, grind, bend, and form metal into more finished products.

SPECIFICATIONS

- **Vertical Drill Press**
  Multifunctional machine used on small- and medium- sized work pieces for drilling, spot facing, reaming, taping, and milling.
- **KMT 1353 Motorized swing beam shear**
  The machine designed for cutting steel and plate shape plastic parts.
- **3 in 1 Sheet metal working machine**
  For cutting, folding, and roll bending or metal.
- **Lathe**
  Precision lathe with constant cutting speed.
- **Wire-Electric Discharge Machine**
  High-speed machining process utilizing a thin wire to cut difficult-to-machine materials with precision.
- **Disc and Combination Disc/Belt Sanders**
  For shaping and finishing materials.
- **5 Ton Arbor Press**
  For press-fitting and pulling bearings, aligning, bending, and broaching.
- **Surface Grinder**
  High precision and cost-effective machining/grinding of steel, cast iron, and nonferrous metals.
- **Hydraulic Workshop Press**
  Designed for beams, profiles, pivots, shaft bending and straightening; bearings, bushings, the assembly and disassembly of pivots; stamping, punching, forming.
- **Multipurpose Milling Machine**
  Used to process plane surfaces, oblique plane at any angle, mill key slots and grooves, and to drill, ream and bore holes.
- **Vertical Metal Band Saw**
  Can be used to cut out complex shapes and angles.

LIFT HIGH-BAY

Linear Friction Welder

VENDOR

MTI

MATERIALS

Variety of metals

Linear Friction Welding, is a solid-state process in which one part moved in a linear motion at high speed is pressed against another part held stationary. The resulting friction heats the parts, causing them to forge together.

The LF35-75 is a 35 ton oscillating 75 ton forge capacity (150,000 lbs. down to 10,000 lbs.) universal machine capable of solid state welding a variety of materials, sizes, and geometries.

ADVANTAGES

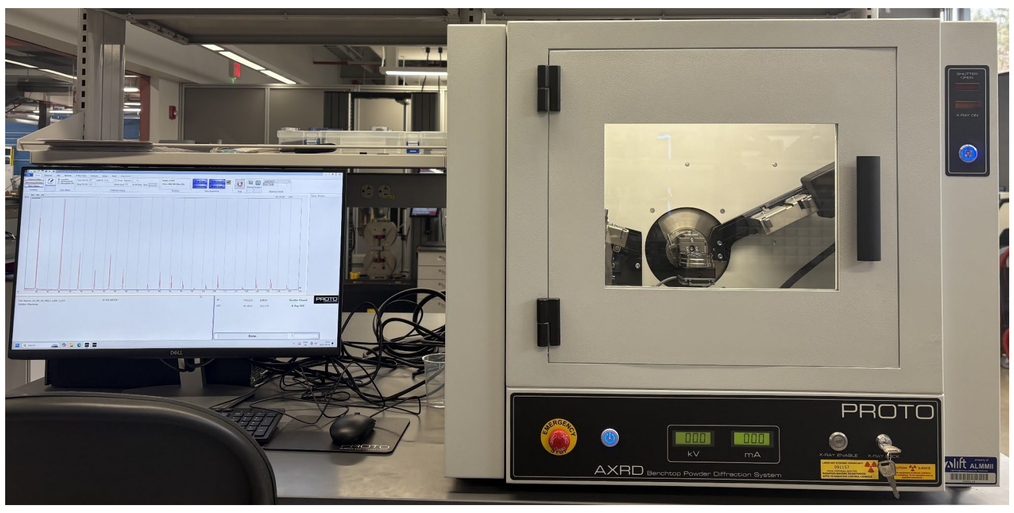
- Superior Joint Quality
- Energy Efficient
- Ecologically Friendly
- Eliminates Block Machining with “Near Net Shape” Joining
- Forged-quality welds for complex geometries of nearly any metal type
- Quick welding process meets the demands of any supply chain
- Minimal joint preparation reduces prep time and speeds up productions
- Defect-free welding decreases waste
- Scalable welding sizes for any magnitude of applications

SPECIFICATIONS

- Equipment Dimensions: 22' x 8' x 14'
- Weight: 122,000 lbs (61 metric tons)
- Forge Force: 7.5t U.S., 6.8 metric tons to 75t US, 68.05 metric tons
- Oscillation Process: Oscillation, frequency and amplitude are customized to each friction welding application
- 30 to 1 stationary to moving mass ratio

LIFT HIGH-BAY

Materials Lab



VENDOR

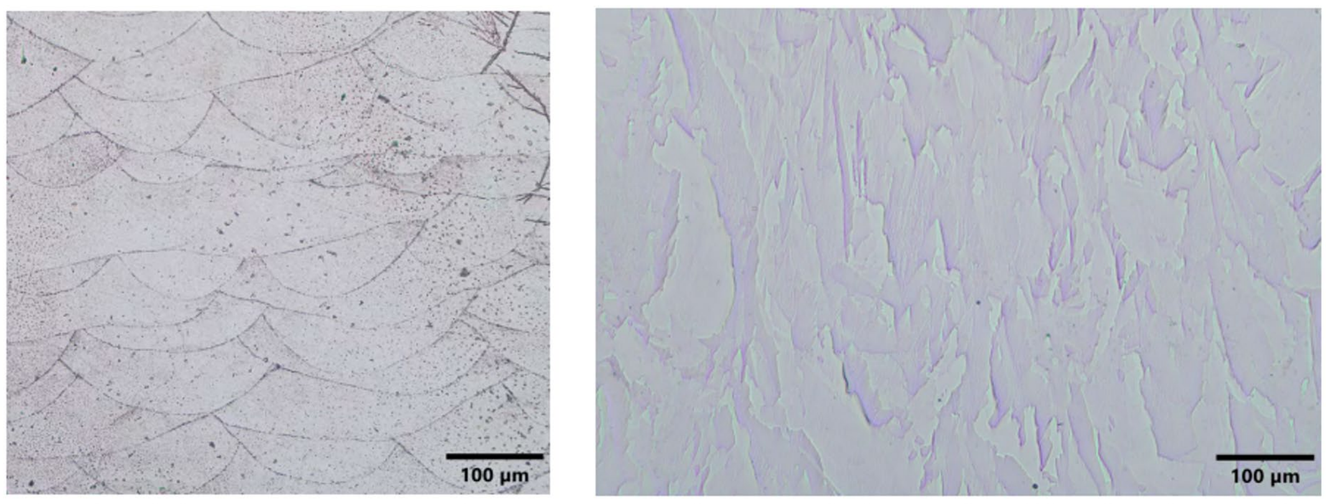
Various

MATERIALS

Variety of metals

Using the equipment in LIFT's **materials lab,** we are able to cut the metal specimens apart, mount them in media, polish them to a mirror finish, and chemically erode (or etch) their surface to show their microstructure.

Our optical and scanning electron microscopes were used to collect the images you see here. LIFT also uses its hardness testers and tensile frame to understand the mechanical properties of our materials.



Both of these images are the same metal, a nickel alloy called IN718 or Inconel 718. They were built at the same exact time in our laser beam powder bed fusion machine. However, they underwent different heat treatments after being built.

SPECIFICATIONS

- Zeiss EVO MA10 SEM with Oxford Energy Dispersive Spectrometer (EDS)
- Keyence VHX7000 digital microscope
- Keyence VR6000 optical profilometer
- Olympus GX41 Inverted Metallurgical Microscope
- Olympus SZ61 Stereoscopic Microscope
- Instron 5982 Series Universal Pull Testing System, 100 kN capacity
- Trillion Aramis 12M DIC
- LECO AMH Automatic Micro/Macro-Indentation Hardness Testing System
- LECO LR300TD Rockwell Hardness Tester
- Keyence VL-700 Optical CMM
- Hexagon Global Performance CMM
- Columbia Marking Tools Eco-Mark Laser Engraving
- EXUM Massbox Mass Spectrometer
- KEP Setaram Themys multi-test system (TGA, DTA, TG-DTA, TMA, DSC, TG-DSC, atmosphere control)
- LECO MSX255 Benchtop Sectioning
- LECO VC-50 Diamond Saw
- LECO MX400/MX500 hot mounting presses
- Struers CitoVac for cold mounting
- Struers Tegramin-30 polishing unit
- Struers Lavamin
- Pace Technologies Vibratory Polisher
- Microtrac SYNC particle analyzer
- Micromeritics AccuPyc II 1345 pycnometer
- Proto AXRD Benchtop Powder X-ray Diffractometer, Co source

LIFT HIGH-BAY

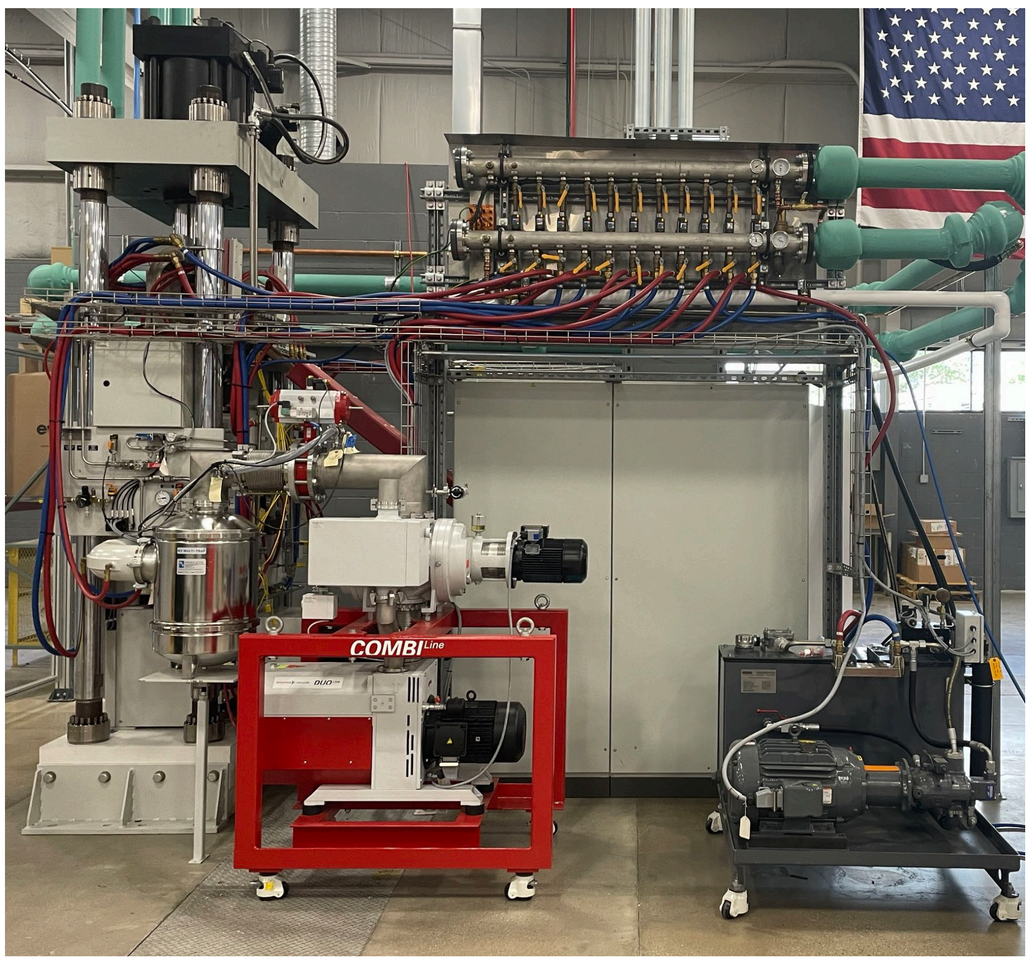
Direct Current Sintering

VENDOR

Thermal Technology

MATERIALS

Metallic, ceramic, and composite powders, including combinations and mixtures of the above



Direct Current Sintering (DCS), also known as Spark Plasma Sintering (SPS) or Field Assisted Sintering (FAST), employs low-voltage and high-current flow of electricity combined with a controlled pressing force to densify powdered or partially-dense materials into solid or more-condensed parts.

With the DCS-200 from Thermal Technology LLC, up to 50,000 amps can be conducted through tooling and sample (if using a conductive sample material) in concert with up to 2000 kN of pressing force to heat and densify material in an inert gas environment, or at vacuum levels down to 1.75e-2 torr. A variety of thermocouples and an optical pyrometer are used to monitor tooling and other machine reference temperatures for process data collection and automated control of applied current, while force and press displacement are also logged as pre-programmed machine sequences are executed.

Graphite tooling stacks of dies and punches typically produce cylindrical specimens, but complex geometries can be achieved with specialized tooling or process considerations like post-additive-process sintering. The Joule heating effect allows the tooling and sample to be heated at rapid rates with no external heating elements, resulting in faster processing times and lower sintering temperatures when compared with traditional hot pressing. With proper process parameter selection, loose powdered material can be densified to 99+% of full density.

SPECIFICATIONS

- Part size: 4” to 10” OD cylindrical samples of varying thickness up to 3”, other shapes and sizes possible with tooling and process development
- Compatible materials: Metallic, ceramic, and composite powders, and combinations thereof
- Heating rates in excess of 100°C/minute depending on tooling and material
- Maximum applied current: 50,000 Amps
- Maximum pressing force: 2,000 kN
- Process execution in inert gas (Argon) or vacuum environment down to 1.75e-2 torr

LIFT HIGH-BAY

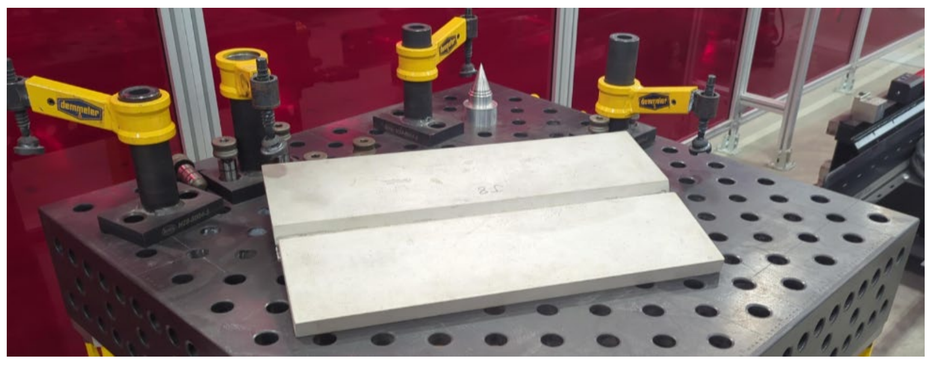
Flexible Joining System

VENDOR

Comau

MATERIALS

Steel, Aluminum Alloys, and Titanium Alloys



The Flexible Joining System can be used for many joining needs in the metalworking process, including wire-feed welding and spot welding, as well as fixturing, positioning, and alignment of components and assemblies.

ADVANTAGES

Joining needs include arc welding, spot welding, adhesive bonding, mechanical joining, surface treatment – cleaning or coating, and alignment and fixturing of components for joining.

SPECIFICATIONS

- 24.5’ x 50’ cell
- 10’ x 40’ work zone for tooling: small assemblies, large assemblies such as heavy truck frames, large plates for ships (both sides being welded simultaneously), Arc welding, Spot welding, Adhesive (bonding) Joining, Mechanical Joining, Surface Treatment, wide access doors, overhead crane access
- Arc and spot welding
- Bonding
- Mechanical Joining
- Component positioning and alignment

- **Robot 1**
  Smart 5 NJ 370 – 3.0
  Payload 370 kg – Reach 3.0m
- **Robot 3**
  Smart5 NJ 16-3.10
  Payload 16kg – Reach 3.10m

- **20 ft. Comau Rail System**
- **1 Weld gun**
  Multi-purpose tooling system
  Aluminum and steel capability

MEDC
MICHIGAN ECONOMIC DEVELOPMENT CORPORATION

LIFT HIGH-BAY

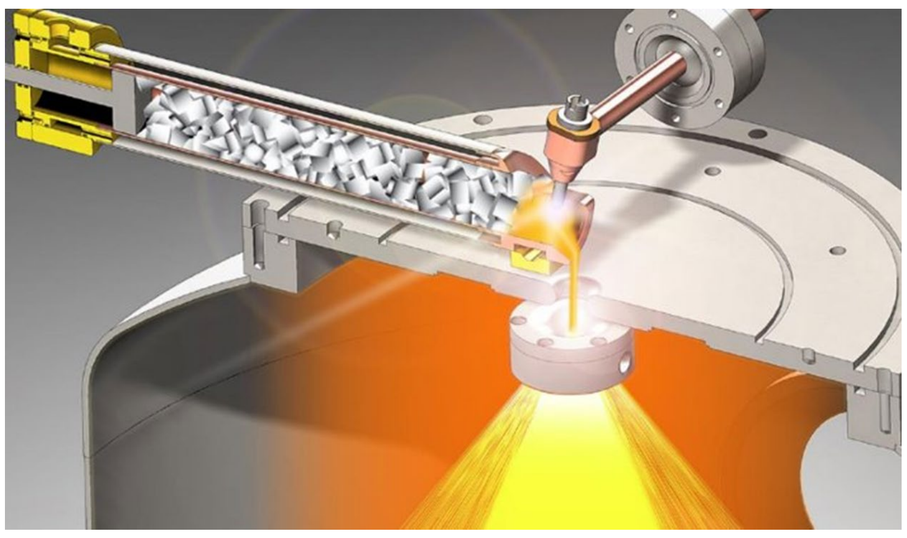
Powder Production and Processing

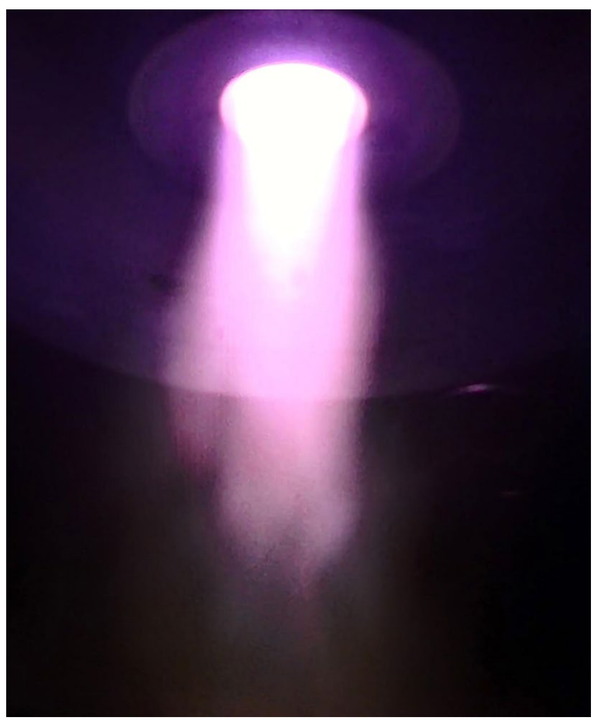
VENDOR

Arcast, Union Process, Elcan

MATERIALS

Broad capabilities including Al, Fe, Ti, and refractory metals





LIFT's **Advanced Metallics Production and Processing Center** (AMPP) includes a full suite of metal powder production and processing equipment with the aim of producing development quantities of various novel metal alloys.

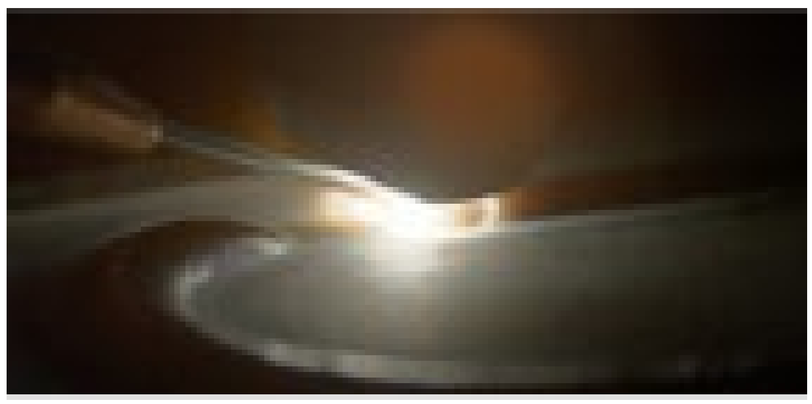
Our Arcast inert gas atomizer has the ability to produce metal powders including aluminum, steel, titanium, and refractory metals. Our Arcast spheroidizer allows for shape optimization of metal powders for additive applications. We also have an attrition mill for mechanical alloying & a vibratory sieve for precision particle size sorting.

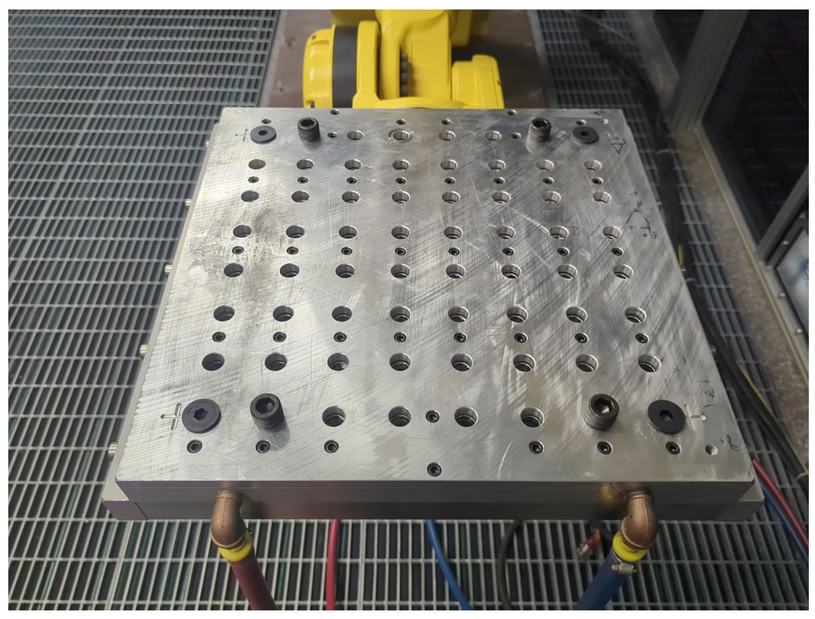
SPECIFICATIONS

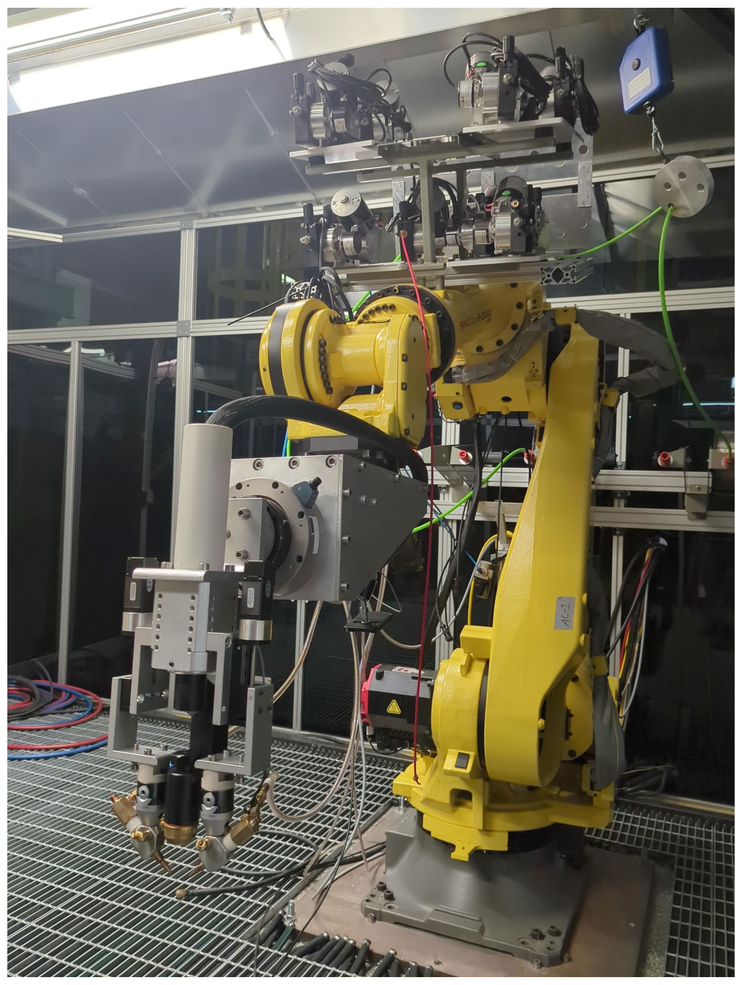
- Arcast Atomizer tube feed mode capable of producing metal powders of pre-alloyed materials such as Ti and refractory metals
- Arcast Atomizer close coupled mode capable of producing 25 L batches of metal powder using vacuum induction melting
- Arcast Spheroidizer capable of producing spherical shaped powders from irregular feedstock in 1L batches
- Union Process attrition mill for mechanical alloying of metal powders in up to 30 kg batch sizes
- Elcan Hi-Sifter vibratory sieve for efficient & precise powder screening and classification at a variety of sizes

LIFT HIGH-BAY

Plasma Arc Weld Directed Energy Deposition







VENDOR

Camarc, InfraTec, Xiris, Beckhoff, Miller, Fanuc

MATERIALS

Steel alloys, Refractory metals, and Titanium alloys

LIFT's **Plasma Arc Weld Directed Energy Deposition** system is a multi-axis wire Additive Manufacturing cell. Utilizing a plasma energy source for cleaner and more consistent deposition, at rates that exceed traditional WAAM deposition by a magnitude of 3-10 (material dependent). Unique to LIFT's system is the capability of online alloying with direct control of product chemistry. The cell is designed in a manner to produce complex geometries in a gravity neutral alignment, alleviating the need to use support structures. Additionally active build cooling is integrated into the system drastically reducing system downtime due to interpass temperature restrictions.

SPECIFICATIONS

- 16’ x 21’ cell
- Twin Hot-Wire system
- Eight wire alloying system
- Full cell “High-Speed” Argon purge system
- Active build plate cooling
- Continuous rotation, allowing spiral builds

Fully integrated suite including:

- Xiris Weld-Vision Camera with acoustic sensor
- InfraTec IR Camera
- Robot position
- Environmental sensors including cell O_2 content
- Shield gas consumption
- Wire-feed speed
- Robot Travel speed
- Plasma monitoring including Arc Voltage and Amperage

LIFT HIGH-BAY

Wire Production

VENDOR

Fenn, Mercer

MATERIALS

Variety of metals including Al, Steel, Ni, and refractory metals

LIFT has worked with Fenn to design and install metal **wire production** capabilities to produce development quantity batches of novel alloy wires for both traditional welding & additive processes. Rods are fed through a rotary swager either hot or cold to reduce the cross-sectional area of the material. Once the material is down to a suitable diameter, the bullblock wire draw pulls the material through a die to reduce the wire to suitable weld wire diameters. Material can be stress relieved throughout the process utilizing our vacuum heat treat furnace.

SPECIFICATIONS

- Fenn Rotary Swager capable of up to 1.75” diameter rods and 220 ksi max tensile strength. Hot & cold swaging capable.
- Fenn 30H Bullblock with 25,000 lbs max pull force & 30” diameter coil. Warm & cold drawing capable. Wet or dry lubricant capable.
- Wire sizes range from from 0.575” down to 0.024”
- Mercer Technologies Vacuum Furnace with a 48” diameter hot zone and up to 2400 F. 2 Bar argon quench.
- Ambrell Eko Heat & easy Heat induction sets for hot swaging & warm drawing

LIFT HIGH-BAY

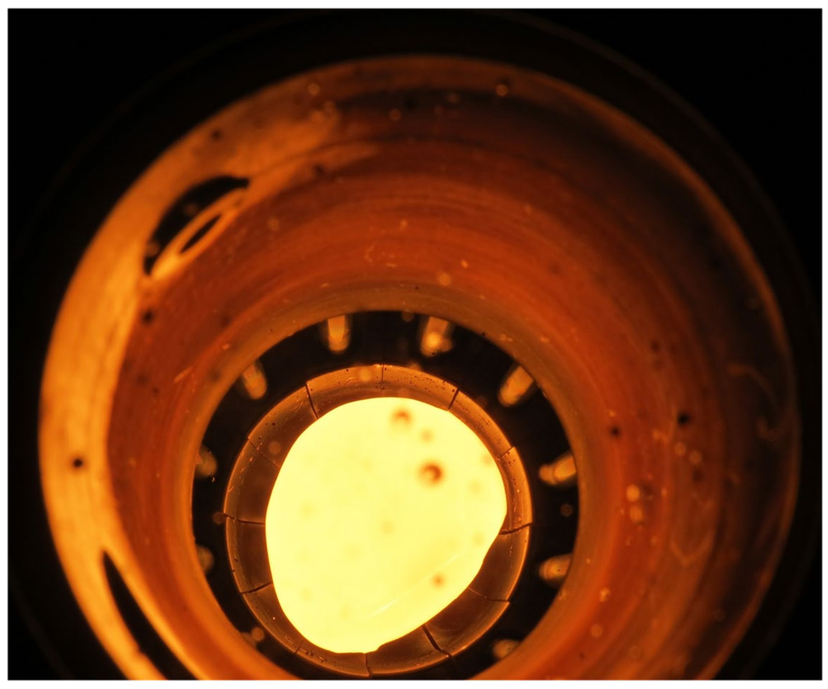
Induction Melting

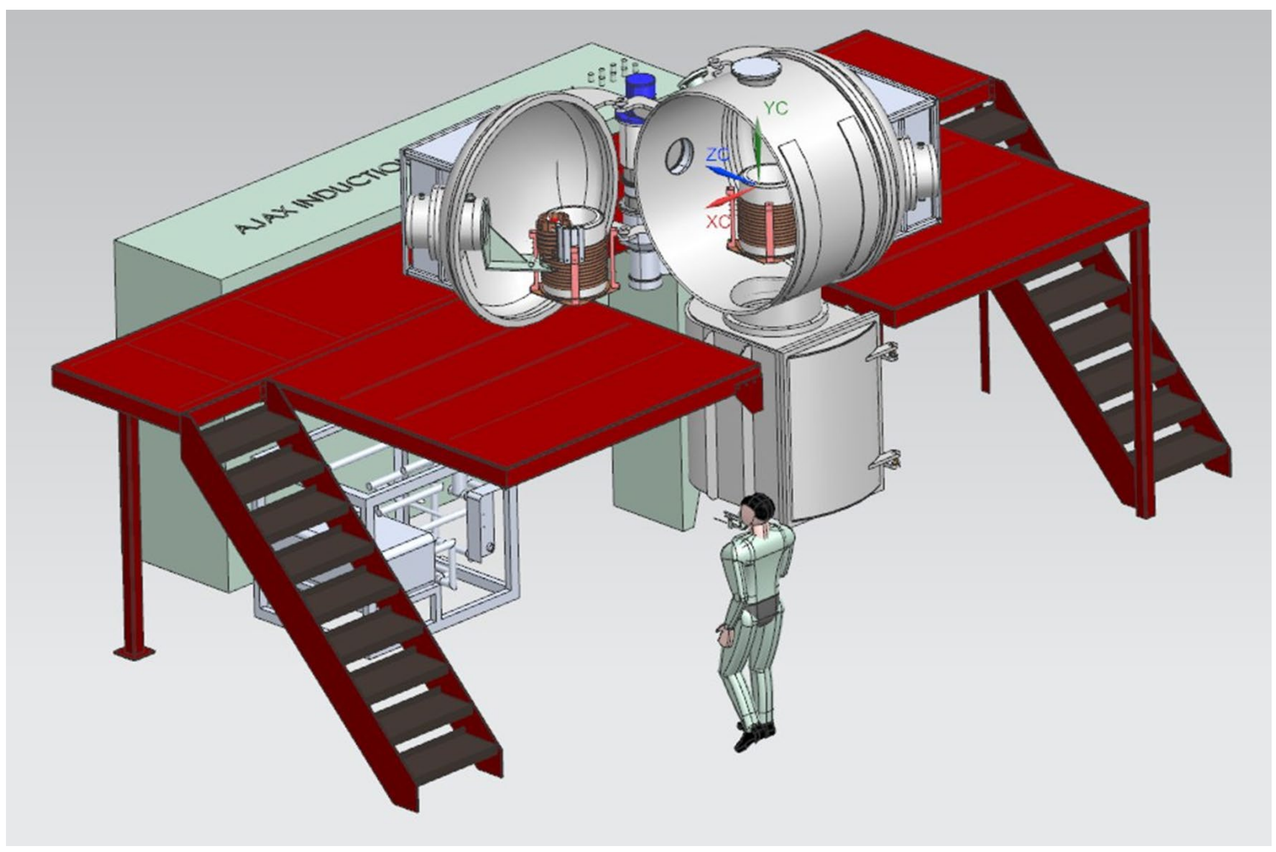
VENDOR

Arcast, Pillar

MATERIALS

Any metals up to 2200C melting





Induction melting uses electromagnetic induction to heat and melt metal efficiently. A coil generates a magnetic field, inducing currents in the metal, causing it to melt. This method is fast, precise, and energy-efficient, making it ideal for industrial metal processing. It can be done under a vacuum or in open air depending on the requirements for the material.

LIFT has partnered with Arcast on a dual-stage vacuum induction furnace capable of melting all metals up to 2200C with options for hot crucible or cold crucible skull melting. The system allows for casting of rods and billets for use in wire production, atomizing, or extrusion.

LIFT also has capabilities for open air induction melting for non-reactive metals like steel and aluminum.

SPECIFICATIONS

- Arcast Vacuum induction furnace capable up to 2200 C
- 28L hot crucible, Twin 5L cold crucible semi-levitation skull melting for reactive materials
- 500 kW power supply with dynamic switching to allow for dual crucible melting capabilities
- Casting system with molds for 1.75” or 6” diameter x 30” long rods
- Pillar MK50 open air induction
- Box furnace capable of 100 lbs of steel
- Dual lift-swing furnace capable of 40 lbs of aluminum per crucible

LIFT HIGH-BAY

Fuel Cell Manufacturing Pilot Line Development

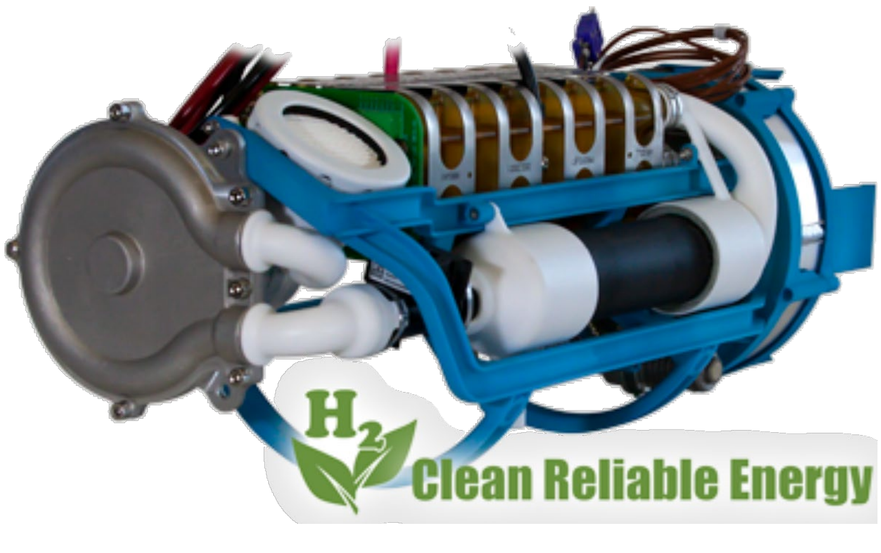
Overview

LIFT has proposed that the U.S. Naval Research Laboratory:

1. Fund the development of a manufacturing line, including design & development, commissioning, and pilot production of fuel cell plates in the U.S. at LIFT or another facility
2. Support low-volume production via subcontract while the manufacturing line is under development.

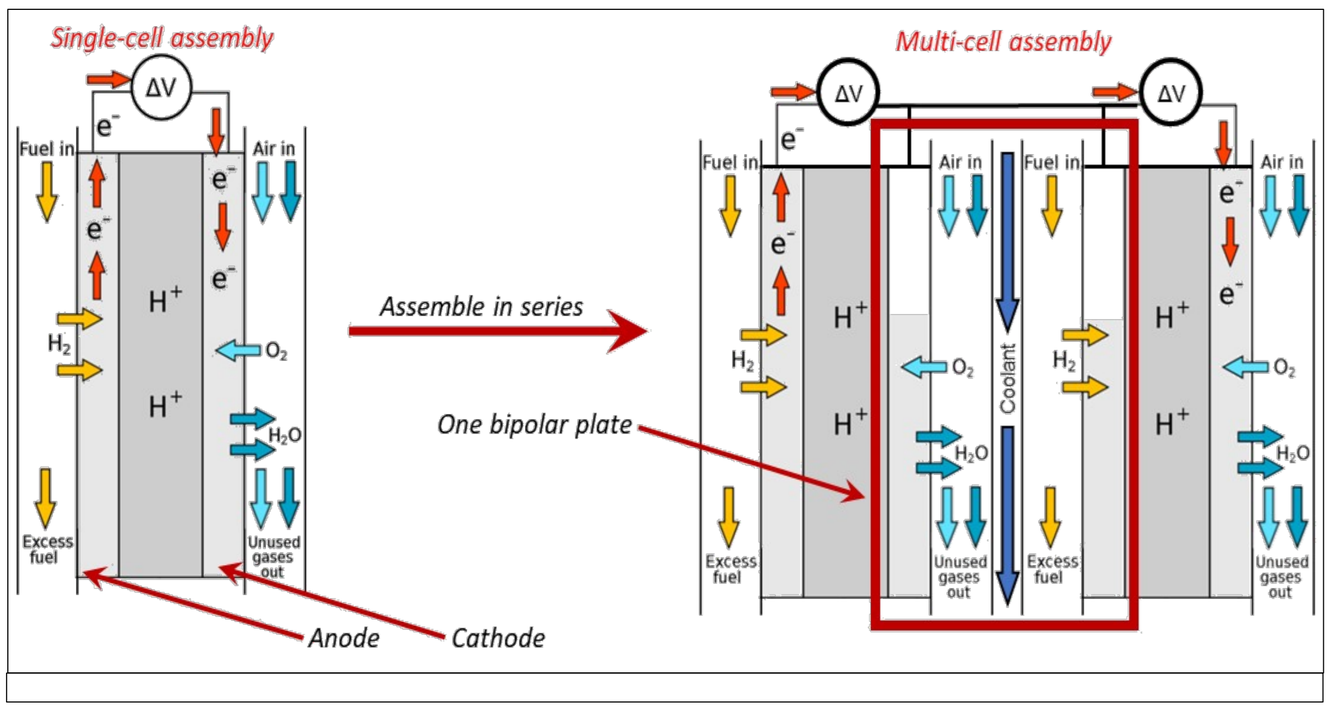
Why?

Historically NWUAV contracted Borit NV to manufacture their mid-sized proton exchange membrane (PEM) fuel cells, executing all manufacturing operations, including engineering, materials procurement, hydroforming, laser cutting and welding, sealant application, and quality control. Borit also offered the manufacturing line as a solution, until they were acquired by a Chinese entity. The acquisition also complicated the ethics of working with Borit, so another manufacturer is needed.



Complete fuel cell powerplant, including cell stack, air & coolant systems, controls, & skeleton frame.

Theory and operation of a hydrogen fuel cell (left), and series configuration (right)



- Each cell is composed of two sheets of foil (75µm gauge), welded together. Prescribed high-level manufacturing operations follow:

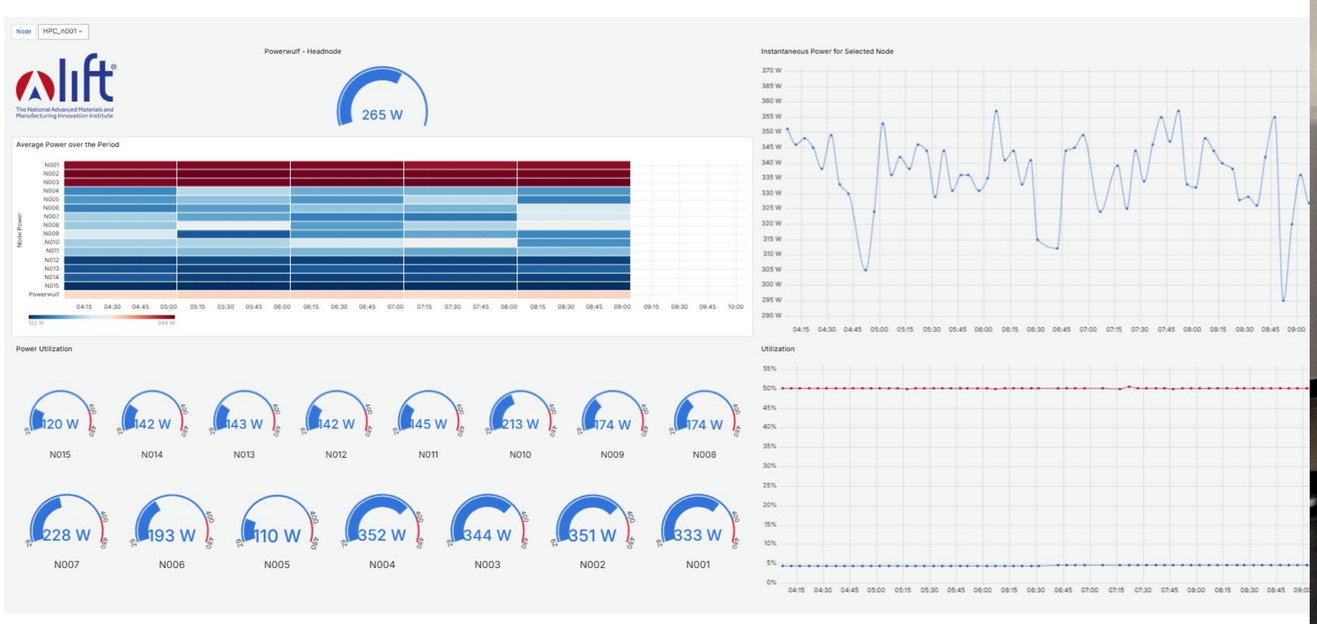
1. Precision die-forming
2. Laser cutting
3. Geometric inspection
4. Laser marking
5. Micro-laser welding
6. Robotic application of sealant
7. Heat curling of sealant
8. Pressure-decay leak testing

LIFT HIGH-BAY

Mission Control & IoT

Vision

- Secure intranet for remote machine operation
- Source of truth for machine data
- Enable digital twin model creation and validation
- Secure workspace for confidential data (CUI/ITAR)
- Demonstrate the potential for IoT ICME, and advanced manufacturing



Scope

- Objective: Implement Industry 4.0 best practices for manufacturing, streamlining connections between LIFT digital & physical initiatives, while bringing key learnings to the LIFT industrial base.
- Purpose: Enable advanced analytics and data collection in a fast and secure manner
- Benefits for LIFT: Enhanced data collection, operational efficiency, and technology demonstration