

Optomec DED Systems Overview



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DED Overview

What is DED?- Basics of the Process

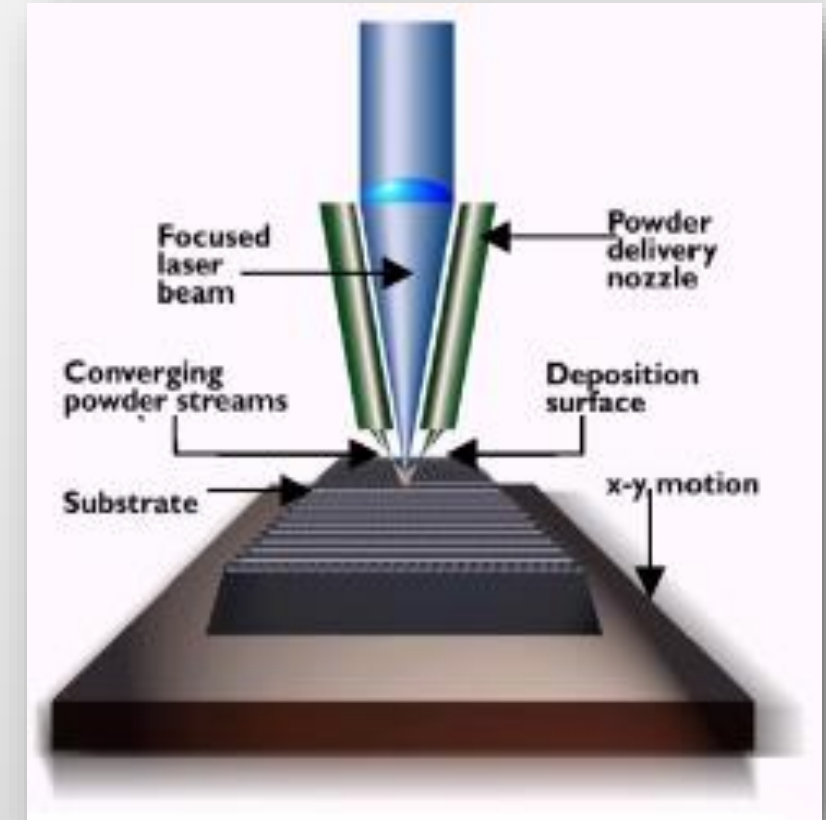
- **Directed Energy Deposition, an AM process**
- Other names include Optomec's laser engineered net shaping (LENS), laser metal deposition (LMD), direct metal deposition (DMD), and others-

A working definition of DED-

- **ISO/ASTM** definition- “an additive manufacturing process in which focused thermal energy is used to fuse materials by melting as they are being deposited.”
- For Optomec, the focused thermal energy is a laser and the material is metal powder.

Optomec and LENS-

In the 1990's, scientists invented the DED process at the Sandia National Lab in Albuquerque (hence our location). They called the process “laser engineered net shaping” (hence “LENS”)- Optomec entered a licensing agreement to commercialize the process and has been building LENS systems now for over 20 years.



The key components of the LENS technology include:

1. A laser for the heat source.
2. A powder feed system to deliver metal powder to the work piece.
3. A laser deposition head (LDH).



3 kW stand-alone laser.



500 W and 1 kW lasers are rack mounted. This side view of the LENS 860 shows a 1 kW laser (top right, above 2 chillers).



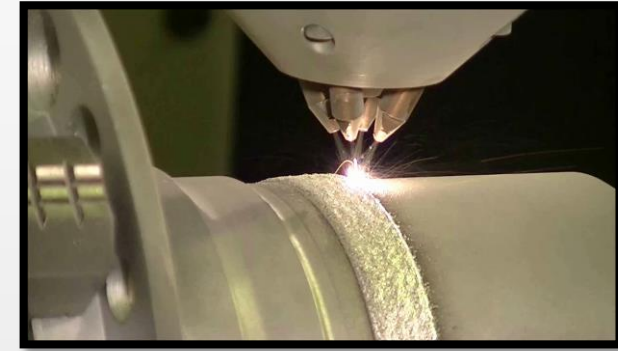
Side view of LENS 860 shows 2 powder feeders mounted to the side panel. A total of 4 powder feeders can be mounted.



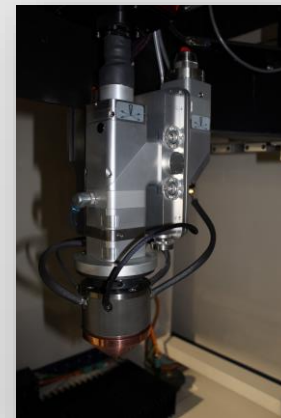
The CS 150 has a powder feeder cart with 2 mounted powder feeders. The system can run 2 carts (total of 4 powder feeders).

Laser Deposition Head Basics-

- a) Laser light enters the head, travels through a set of optics (collimator, turning mirrors, and focusing lens), and exits vertical down through the center of a copper nozzle at the bottom of the LDH to the work piece.
- b) The copper nozzle contains exit points for metal powder that is directed at the focused laser spot on the work piece.
- c) Argon, an inert gas, is used to blow the metal powder from the powder feed system through the LDH and to the work piece. It is also used to create a positive pressure at the center laser exit point to protect optics from fumes/particulates.



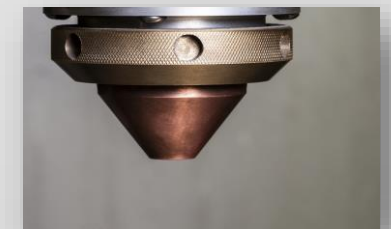
Close up of head printing with coaxial laser delivery (vertical down) and 4-tip copper nozzle metal powder delivery. Argon gas is used to blow the metal powder and also to create positive pressure from the laser exit point to protect head/optics from any fumes/particulates.



Laser deposition head



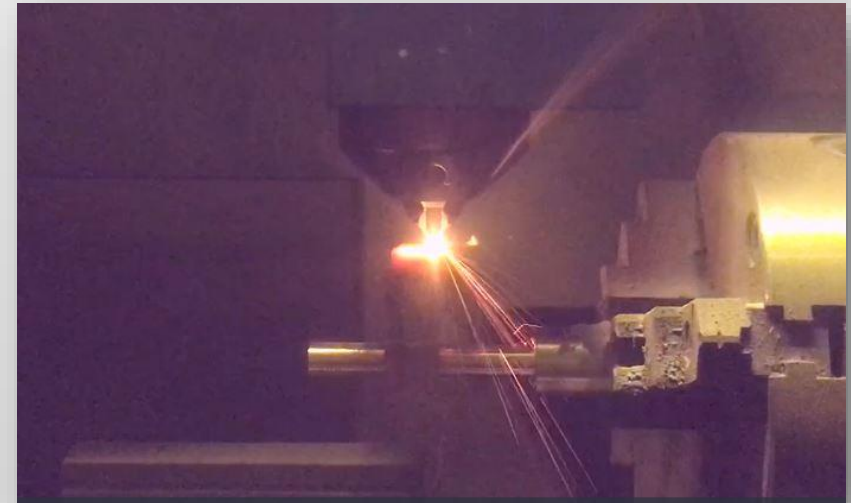
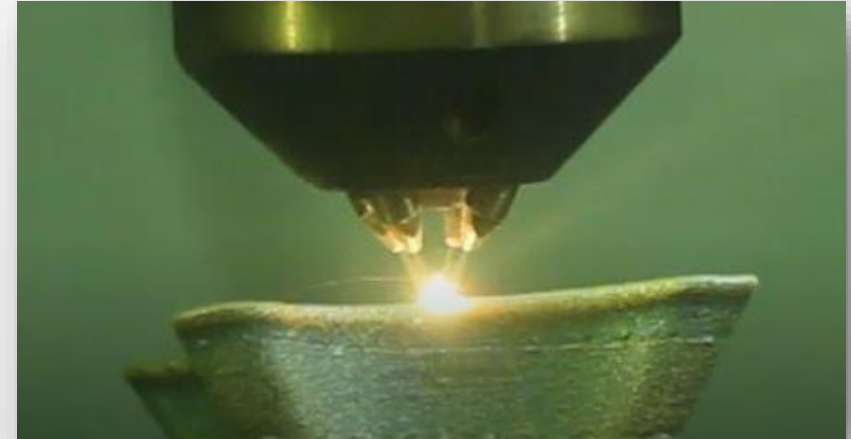
4-tip nozzle



coax nozzle

The DED Process

- The DED process is a metallurgically bonding process- not an adhesive or mechanical bonding process i.e. thermal/cold spray. Mechanical properties achieved are near wrought material properties.
- The process forms fully dense parts- the material (powder or wire) does not include plastics, composites, or any bond-assisting type materials- not a sintering process. Does not require post-processing to remove non-metallic or bonding agents.
- It allows free form building with multi-axis capabilities. It typically does not require support structures that later have to be removed.
- It allows for start/stops, in-situ adjustments to parameters with closed loop feedback capabilities.



The DED Process

- A wide range of materials can be processed, including reactive materials.
 - Steels
 - Tool steels
 - Stainless steels
 - Nickel base alloys
 - Co/wear resistant steels
 - Reactives- Ti, Al, Mg
- Metal powders can be blended during building to create new alloys, change chemistry during building/functionally grade, apply dissimilar metals or coatings for property enhancement.
- It can be combined with other processes in a system- additive and subtractive from one machine.
- SW/controller easy adoption- SW packages and G&M codes that a machinist is already familiar with.



Metal powders.



Functional grading- the bar was printed starting with carbon steel (magnetic) then transitioning layer by layer to stainless steel (non-magnetic).



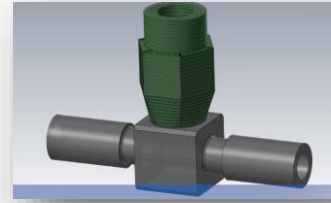
Hybrid capabilities- both machining (subtractive) and printing (additive) were done in the same machine.



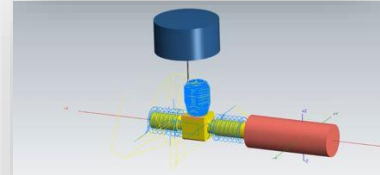
User friendly controller/HMI with familiar G&M code programming.

DED- “Art to Part”-

- CAD file
- Tool path generation
- Controller (G&M code)
- Building-
 - Motion control
 - Laser power
 - Powder feed
 - Scan rate
 - Inert gas (Argon)
 - Closed loop feedback controls



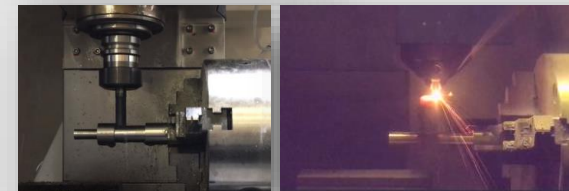
CAD drawing



Tool path generation



Controller/HMI



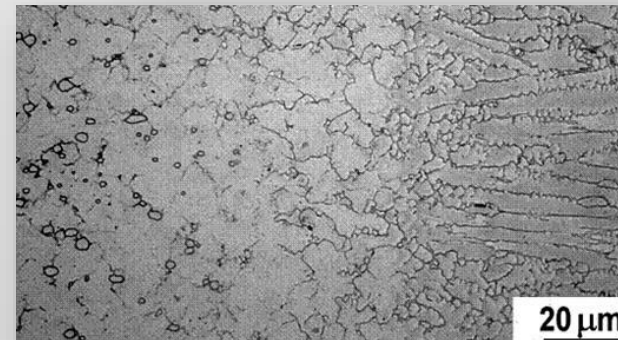
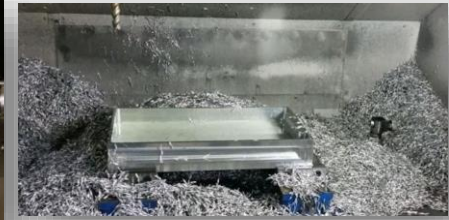
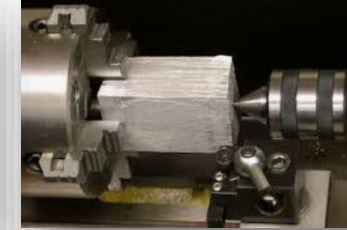
Processing



Completed part

What separates Optomech LENS DED from traditional manufacturing-

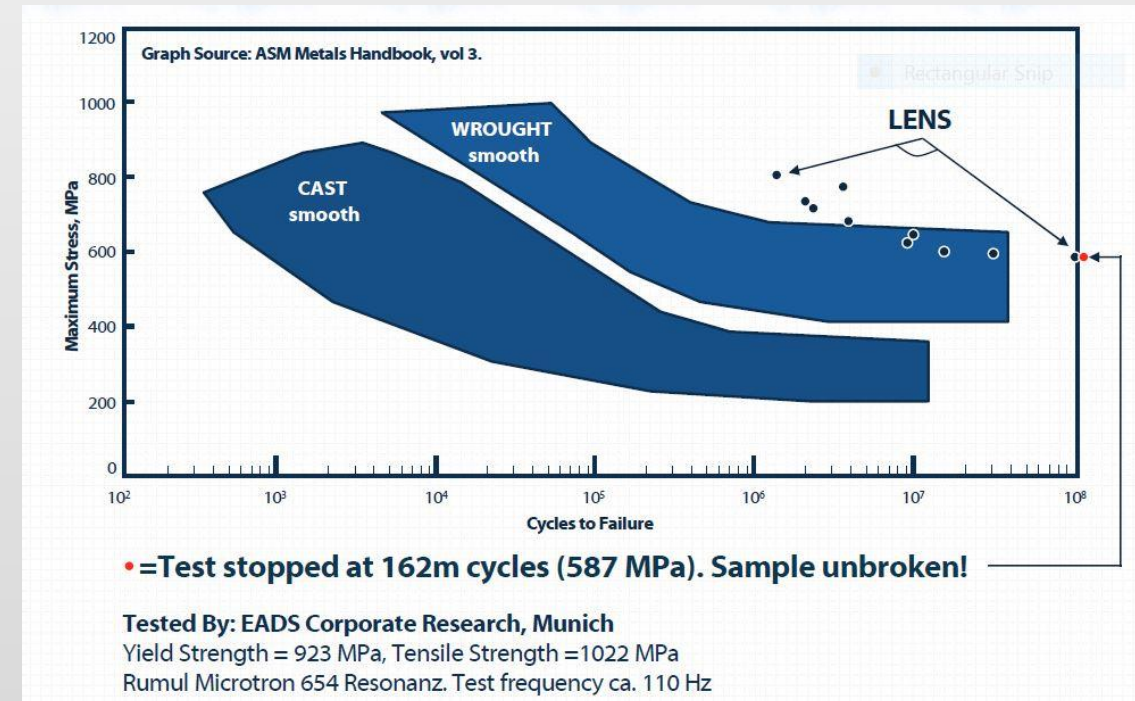
- Addition instead of removing.
- Design considerations.
- Removal of steps in build process.
- DED vs. traditional arc fusion welding processes:
 - **heat input**- lower, more precise heat input, fine grain structure, less base metal dilution, less residual stresses or distortion.
 - **travel speeds**- TIG- typical 9-14 IPM, laser welding typical 10 to 60+ IPM.
 - **HAZ**- much smaller heat affected zone, less detrimental effects to material/mechanical properties.
 - **near net shape**- little to no finishing requirements.



Material Properties-

- Typical mechanical properties (yield and tensile strength) are near wrought properties.
- Fine grain microstructure, HAZ on a micron scale, very little distortion of part.
- Excellent fatigue properties.

Material	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	El. (%)
LENS Ti 6-4	848	955	15
Wrought Ti 6-4 Typical	883	952	14
LENS 316 Stainless Steel	276	661	67
Wrought 316 Stainless Steel	289	578	50
LENS Ni Alloy 625	579	930	38
Wrought Ni Alloy 625	400	834	30



What separates DED from other AM processes:

- A metal AM process (vs. plastics, polymers, composites, etc.).
 - Laser heat source (vs. solid state extrusion, electron beam, etc.).
 - Metallurgical bond (vs. binding, sintering, adhesive, or mechanical means).
 - Powder fed, not powder bed.
- There are two main metal AM processes for building parts from metal powder using a laser heat source:

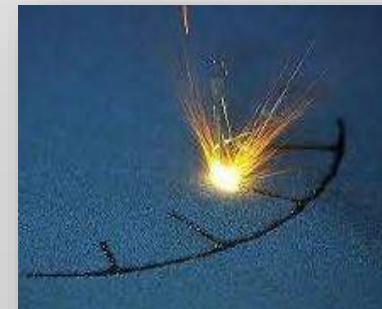
DED- Directed Energy Deposition

“Powder Fed”



PBF- Powder Bed Fusion

“Powder Bed”



Metal AM Processes- DED and PBF

DED

- Powder and focused laser energy are delivered simultaneously. Part is built up in free space.
- The part is visible during build- any powder not fused falls away from part/build area.
- For building larger features/ less complex shapes (when compared to PBF builds).

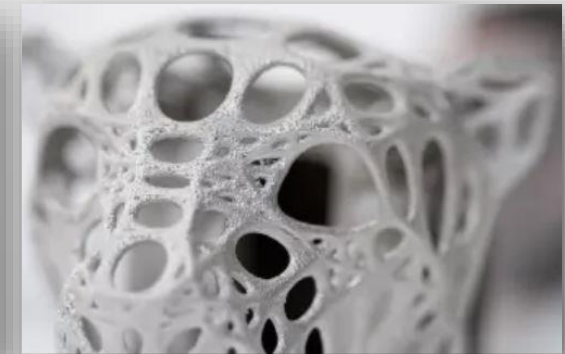
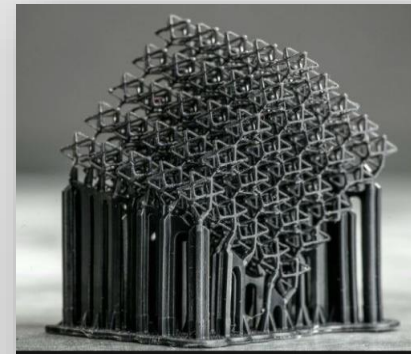
DED Builds



PBF

- Powder is laid out first, then selectively melted or sintered with a laser.
- Process is repeated layer by layer, and part is built up in a “powder cake”- the part is not visible during build.
- After post-processing, the excess powder is removed and the part revealed.
- For building smaller feature parts with more complex shapes/geometries.

PBF Builds



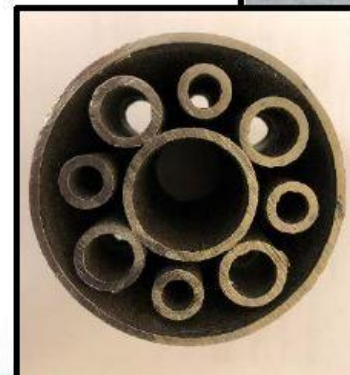
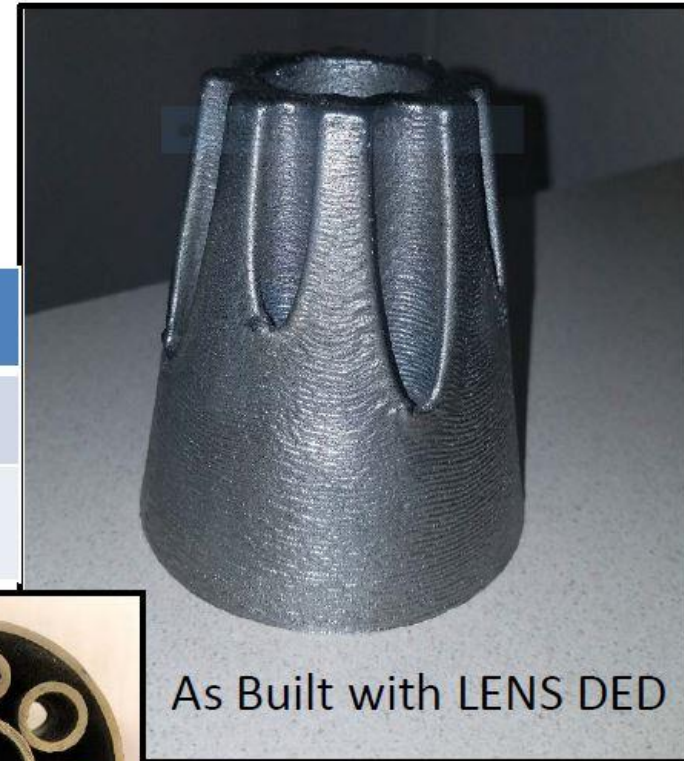
DED and PBF- Sample Build Comparison

Comparison of Powder AM Methods

- ▶ Part dimensions:(\varnothing x H) 100 mm x 200 mm,
- ▶ Wall thickness 2.5mm
- ▶ Material: Inconel 716

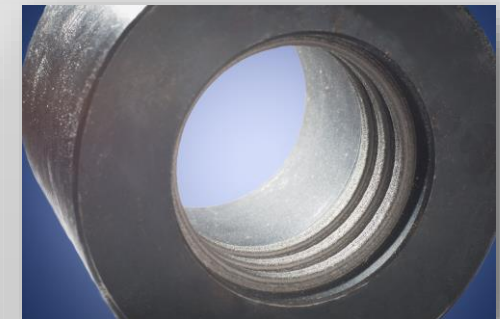
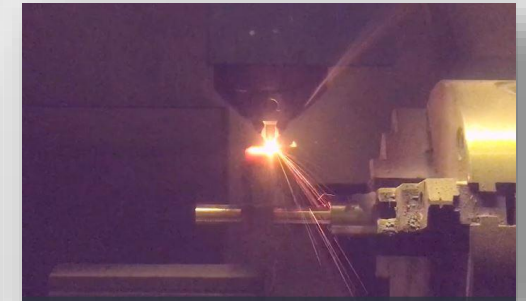
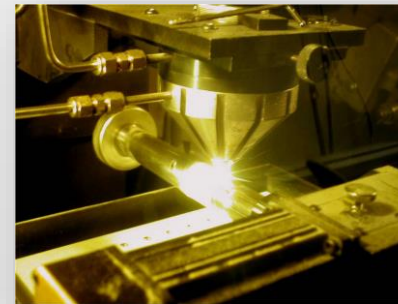
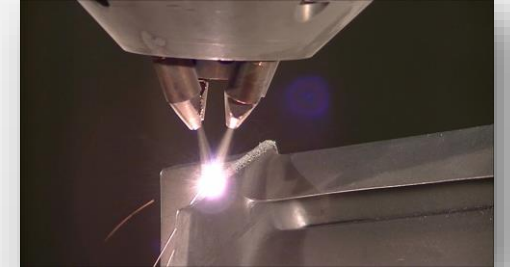
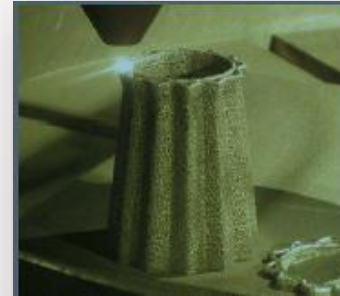
Metric	LENS DED*	PBF*
Build Time	10 hours	240 hours
Cost	\$3,400	\$16,800

* time/cost estimates provided by LENS & PBF service bureaus. Does not include post processing.



DED is well suited for a number of industry applications:

- Rapid mid-large size new builds
- ***Repairs***
- Rework
- Remanufacturing
- Feature addition/part modification
- Functional grading
- Coatings/property enhancements



LENS Systems (Visual)

Optomec LENS Classic Series



CS 150



CS 800



CS 600



CS 1500

Optomec LENS MTS Series and LENS Print Engine



MTS 500



MTS 860



LPE

System Key Points

➤ The LENS Classic Series- Key Points



CS 150

- All CS models are controlled atmosphere only.
- Except for CS 150, all base systems come with LDH 2.0 deposition head. The LDH 3.X is an upgrade.



CS 600

LDH 2.0

- Up to 2 kW laser power.
- One focused spot size- 0.6 mm.
- One fixed nozzle- 4-tip.

LDH 3.X

- Up to 3 kW laser power.
- Up to three focused spot sizes with variable optics (sold separately)- 0.6, 2, and 3 mm focused spot sizes.
- Interchangeable nozzles- the 4-tip comes standard, with optional coax nozzle (sold separately).



CS 800



CS 1500

- Models “grow” in footprint, build volume, laser power, and sophistication of software and controllers. See model section in this presentation for more in-depth details.

➤ The LENS Machine Tool Series- Key Points



MTS 500



MTS 860

- These are “hybrid” systems. Hybrid in this case means the system can perform both additive and subtractive functions.
- These systems start with a rugged CNC machine base and have LENS technology integrated into the system.
- These systems start as open atmosphere. Controlled atmosphere is an available upgrade.
- For the MTS 500, there is an additional peripheral pod that houses the laser, powder feeders, and chillers. With the MTS 860, all components are built into the machine except for 2 or 3 kW lasers, which would stand alone apart from the system.
- Like in the classic series, these models come standard with the LDH 2.0 deposition head. LDH 3.X is available as an upgrade.
- Models “grow” in footprint, build volume, laser power, and sophistication of software and controllers. See model section in this presentation for more in-depth details.

➤ The LENS Machine Tool Series- Key Points



MTS 500



MTS 860

- Touch probes are available for the hybrid versions of both these models.
- The touch probe kit for the MTS 500 HY is an IR (infrared) touch probe system.
- The touch probe kit for the MTS 860 HY is an RF (radio frequency) touch probe system.
- For both systems, the touch probe kit consists of:
 1. Touch probe with stylus- for part location in the coordinate planes.
 2. Tool setter- for offsetting tool distance in the coordinate planes.
 3. Tool holder- fits tool into the tool changer in the HY system.
 4. Receiver- receives coordinate information from touch probe.

➤ The LENS Print Engine (LPE)- Key Points



LPE

- The LENS print engine consists of a laser, powder feeder cart with 2 powder feeders, and a LENS deposition head (LDH 2.0).
- This unit is for OEMs or resellers/distributors ONLY. This offering is for OEMs that want to perform the integration of LENS technology onto an existing CNC machine.
- Optomech provides an Integration Guide document which clearly states the responsibilities concerning this system. The main point is for the OEM/reseller/distributor to understand that Optomech does not perform the integration- there is an open line of communication concerning some integration details i.e. post process information, however the OEM must perform all integration work.
- The OEM may purchase the LPE without a laser, in the case they already have a laser supplier.
- See detailed LPE options in the model section of this presentation.

System Quick Reference

-LENS CS Series Quick Reference-



CS 150- Excellent starter system. Very small footprint. Great for new alloy development, material testing, functional grading of materials, and simple builds/repairs. 2 to 4 powder feeders (2 carts capable) and 400 W laser. 3 axis only.



CS 600- Powerful and robust, industrial ready for small to large parts. Up to 2 kW laser power, up to 4 powder feeders, up to simultaneous 5 axis capable with MasterCAM/LENS plug in software and Siemens 840D controller.



CS 800- Same as above but for small to extra large parts and laser power up to 3 kW.



CS 1500- Industrial ready for very large part processing, repairing, coating, or cladding. Largest build volume.

-NOTE- all CS series models are controlled atmosphere only (std).-

-LENS MTS Series and LPE Quick Reference-



MTS 500- Smaller hybrid system (additive and subtractive capable with vertical milling system on CNC base. For small to mid-size parts. Up to 2 kW, 3+2 axis motion, Siemens 828 controller.



MTS 860- Largest hybrid system for mid to large size parts. Up to 3 kW, simultaneous 5 axis motion, Siemens 840D controller.



LENS Print Engine (LPE)- For OEMs who want to integrate LENS technology into an existing CNC machine- includes powder feed cart with 2 powder feeders, LENS deposition head (LDH 2.0), and either no laser (for OEMs owning lasers) or from 500 W to 2 kW lasers (3 kW when upgrading to the LDH 3.X head).

-NOTE- Base MTS series are open atmosphere systems (CA is an optional upgrade).-

Guide to System Selection

-Guide Concerning System Selection-

Before reviewing the systems to decide which system is right for you, here are some questions to ask to help narrow down the field:

- What size parts do I want to process? (build volume, system size)
- What materials do I want to process? (open or controlled atmosphere)
- How much power do I need? (laser power selection)
- How much room do I have in my facility? (System size/footprint)
- How sophisticated are my parts? (# axes and level of software required)
- Do I want to use multiple materials or blend materials? (# of powder feeders needed)
- Do I want to be able to change focused spot sizes? (LDH selection)
- Do I want to be able to change nozzle types? (LDH selection)
- Do I want to do additive and subtractive? (Hybrid systems)
- Do I want to monitor melt pool size/temperature and make in-situ adjustments? (sensors, monitoring and/or closed loop feedback/parameter adjustment capabilities)

System Base Features and Options Details

LENS CS Series

LENS CS 150



➤ LENS CS 150 Base System

- The CS 150 base system includes:

Base CS 150 System	
Laser	400 W rackmount laser
Fiber cable	200 um diameter feed fiber cable
Deposition head	LDH 1.0
Nozzle	4-tip only
Powder feeder	2 powder feeders mounted on a stand-alone cart
Software	Windows PC
Controller	Galil
Axes	3 axis system, X Y table, Z overhead
Work chamber	Controlled atmosphere only
Build volume	150 x 150 x 150 mm





➤ LENS CS 150 Options

Options for the CS 150 include:

Option	Description
2 nd powder feeder cart with 2 powder feeders.	Can be a total of four independent powder feeders (2 carts).
PartPrep tool path software.	Optomech's 2.5D tool path software.
Beam coupler unit with 10 m process fiber cable.	The laser for this unit is a rackmount unit with a 10 m hard wired "feed" fiber cable. To protect the unit and undetachable cable from back reflection damage, a beam coupler unit with a detachable 10 m process fiber cable can be added in the line so any back reflection damage stops at the bcu.
Material starter recipes.	See list of material starter recipes (separate slide at end of this presentation).

LENS CS 600



➤ LENS CS 600 Base System

- The CS 600 base system includes:

Base CS 600 System	
Laser	500 W rackmount laser
Fiber cable	200 um diameter feed fiber cable
Deposition head	LDH 2.0
Nozzle	4-tip only
Powder feeder	1 powder feeder on side panel
Software	None included
Controller	Siemens 840D
Axes	3 axis system, Y table, X Z overhead
Work chamber	Controlled atmosphere only
Build volume	600 x 400 x 400 mm





➤ LENS CS 600 Options

Options for the CS 600 include:

Option	Description
Upgrade to LDH 3.X	LDH 3.X head capabilities include operating at up to 3 kW (2 kW max for CS 600), advanced water cooling head chiller, variable optics to achieve focused spot sizes of 0.6, 2, and 3 mm diameters, and interchangeable nozzles (4-tip and coax available).
Addition of coax nozzle	With an upgrade to the LDH 3.X head, the coax nozzle can be purchased to interchange with the 4-tip nozzle.
2 and 3 mm focused optics	With an upgrade to the LDH 3.X head, 2 and 3 mm optics can be added in the optics train to achieve focused spot sizes of 0.6, 2, and 3 mm.
Upgrade to 1 or 2 kW laser	Increase laser power by upgrading to either a 1 or 2 kW laser. The 1 kW laser remains a rackmount unit with 10m feed fiber cable. The 2 kW laser is a stand-alone unit (will add to the overall system footprint) and contains a bcu in the unit, so this has a 10 m detachable process fiber cable included.



➤ LENS CS 600 Options (Cont'd)

Option	Description
4 th axis 180 mm rotary table	Removable A axis rotor bolted to 3 axis table to allow for 4 axis motion.
4 th /5 th axis 250 mm T/R trunnion	Non-removable trunnion for 4 th /5 th axis motion.
Additional powder feeders	The unit can hold up to 4 powder feeders on the side panel. The base unit comes with 1 powder feeder, so the number shown on the quote sheet should be only for additional powder feeders (i.e. if a total of 4 powder feeders are desired, enter "3" on the "additional powder feeders" line).
PartPrep tool path software.	Optomech's 2.5D tool path generation software.
MasterCAM/LENS Plugin software	Advanced software for up to simultaneous 5 axis additive operations. Includes post processor. 2 day LENS additive plugin training (performed at system install). Includes 1 year LENS additive plugin software maintenance.
Simultaneous 4 th /5 th axis motion package	An upgrade to the Siemens 840D and MC/LPI software for simultaneous 5 axis operation capability. Includes post processor and 1st year software maintenance.



➤ LENS CS 600 Options (Cont'd)

Option	Description
Melt pool sensor with closed loop controls	Vision system with closed loop feedback to control melt pool size during build. This effectively helps with final microstructure and layer control.
Thermal imaging pyrometer/calibration system	Thermal measurement system giving temperature readings of melt pool during processing. The calibration system is required with this option.
Beam coupler unit with 10 m process fiber cable.	The 500 W laser for this unit is a rackmount unit with a 10 m hard wired “feed” fiber cable. To protect the unit and undetachable cable from back reflection damage, a beam coupler unit with a detachable 10 m process fiber cable can be added in the line so any back reflection damage stops at the bcu. NOTE- this is not needed for 2 kW stand-alone laser.
Material starter recipes.	See list of material starter recipes (separate slide at end of this presentation).
Remote electronic handwheel	Effective for manually jogging laser into position.

LENS CS 800



➤ LENS CS 800 Base System

- The CS 800 base system includes:

Base CS 800 System	
Laser	500 W rackmount laser
Fiber cable	200 um diameter feed fiber cable
Deposition head	LDH 2.0
Nozzle	4-tip only
Powder feeder	1 powder feeder on side panel
Software	None included
Controller	Siemens 840D
Axes	3 axis system, Y table, X Z overhead
Work chamber	Controlled atmosphere only
Build volume	800 x 600 x 600 mm





➤ LENS CS 800 Options

Options for the CS 800 include:

Option	Description
Upgrade to LDH 3.X	LDH 3.X head capabilities include operating at up to 3 kW, advanced water cooling head chiller, variable optics to achieve focused spot sizes of 0.6, 2, and 3 mm diameters, and interchangeable nozzles (4-tip and coax available).
Addition of coax nozzle	With an upgrade to the LDH 3.X head, the coax nozzle can be purchased to interchange with the 4-tip nozzle.
2 and 3 mm focused optics	With an upgrade to the LDH 3.X head, 2 and 3 mm optics can be added in the optics train to achieve focused spot sizes of 0.6, 2, and 3 mm.
Upgrade to 1, 2, or 3 kW laser	Increase laser power by upgrading to either a 1, 2, or 3 kW laser. The 1 kW laser remains a rackmount unit with 10m feed fiber cable. The 2 and 3 kW lasers are stand-alone units (will add to the overall system footprint) and contain an internal bcu so this has a 10 m detachable process fiber cable included.



➤ LENS CS 800 Options (Cont'd)

Option	Description
4 th axis 180 mm rotary table	Removable A axis rotor bolted to 3 axis table to allow for 4 axis motion.
4 th /5 th axis 250 mm T/R trunnion	Non-removable trunnion for 4 th /5 th axis motion.
Additional powder feeders	The unit can hold up to 4 powder feeders on the side panel. The base unit comes with 1 powder feeder, so the number shown on the quote sheet should be only for additional powder feeders (i.e. if a total of 4 powder feeders are desired, enter “3” on the “additional powder feeders” line).
PartPrep tool path software.	Optomech’s 2.5D tool path software.
MasterCAM/LENS Plugin software	Advanced software for up to simultaneous 5 axis additive operations. Includes post processor. 2 day LENS additive plugin training (performed at system install). Includes 1 year LENS additive plugin software maintenance.
Simultaneous 4 th /5 th axis motion package	An upgrade to the Siemens 840D and MC/LPI software for simultaneous 5 axis operation capability. Includes post processor and 1st year software maintenance.



➤ LENS CS 800 Options (Cont'd)

Option	Description
Melt pool sensor with closed loop controls	Vision system with closed loop feedback to control melt pool size during build. This effectively helps with final microstructure and layer control.
Thermal imaging pyrometer/calibration system	Thermal measurement system giving temperature readings of melt pool during processing. The calibration system is required with this option.
Beam coupler unit with 10 m process fiber cable.	The 500 W laser for this unit is a rackmount unit with a 10 m hard wired “feed” fiber cable. To protect the unit and undetachable cable from back reflection damage, a beam coupler unit with a detachable 10 m process fiber cable can be added in the line so any back reflection damage stops at the bcu. NOTE- this is not needed for 2 or 3 kW stand-alone lasers.
Material starter recipes.	See list of material starter recipes (separate slide at end of this presentation).
Remote electronic handwheel	Effective for manually jogging laser into position.

LENS CS 1500



➤ LENS CS 1500 Base System

- The CS 1500 base system includes:

Base CS 1500 System	
Laser	2 kW laser (stand-alone)
Fiber cable	200 um diameter process fiber cable
Deposition head	LDH 2.0
Nozzle	4-tip only
Powder feeder	1 powder feeder on side panel
Software	None included
Controller	Siemens 840D
Axes	5 axis system, X Y Z overhead, A C trunnion
Work chamber	Controlled atmosphere only
Build volume	1500 x 1000 x 1000 mm



➤ LENS CS 1500 Options

Options for the CS 1500 include:



Option	Description
Upgrade to LDH 3.X	LDH 3.X head capabilities include operating at up to 3 kW, advanced water cooling head chiller, variable optics to achieve focused spot sizes of 0.6, 2, and 3 mm diameters, and interchangeable nozzles (4-tip and coax available).
Addition of coax nozzle	With an upgrade to the LDH 3.X head, the coax nozzle can be purchased to interchange with the 4-tip nozzle.
2 and 3 mm focused optics	With an upgrade to the LDH 3.X head, 2 and 3 mm optics can be added in the optics train to achieve focused spot sizes of 0.6, 2, and 3 mm.
Upgrade to 3 kW laser	Increase laser power by upgrading to a 3 kW laser. Lasers are stand-alone units (will add to the overall system footprint) and contain an internal bcu so this has a 10 m detachable process fiber cable included.

➤ LENS CS 1500 Options (Cont'd)



Option	Description
Additional powder feeders	The unit can hold up to 4 powder feeders on the side panel. The base unit comes with 1 powder feeder, so the number shown on the quote sheet should be only for additional powder feeders (i.e. if a total of 4 powder feeders are desired, enter “3” on the “additional powder feeders” line).
MasterCAM/LENS Plugin software	Advanced software for up to simultaneous 5 axis additive operations. Includes post processor. 2 day LENS additive plugin training (performed at system install). Includes 1 year LENS additive plugin software maintenance.
Simultaneous 4 th /5 th axis motion package	An upgrade to the Siemens 840D and MC/LPI software for simultaneous 5 axis operation capability. Includes post processor and 1st year software maintenance.

➤ LENS CS 1500 Options (Cont'd)



Option	Description
Melt pool sensor with closed loop controls	Vision system with closed loop feedback to control melt pool size during build. This effectively helps with final microstructure and layer control.
Thermal imaging pyrometer/calibration system	Thermal measurement system giving temperature readings of melt pool during processing. The calibration system is required with this option.
Material starter recipes.	See list of material starter recipes (separate slide at end of this presentation).
Remote electronic handwheel	Effective for manually jogging laser into position.

LENS MTS Series

LENS MTS 500



➤ LENS MTS 500 Base System

- The MTS 500 base system includes:

Base MTS 500 System	
Laser	500 W rackmount laser (on peripheral pod)
Fiber cable	200 um diameter feed fiber cable
Deposition head	LDH 2.0
Nozzle	4-tip only
Powder feeder	1 powder feeder on peripheral pod
Software	None included
Controller	Siemens 828
Axes	3 axis system, X Y table, Z overhead
Work chamber	Open atmosphere
Build volume	350 x 325 x 500 mm additive, 500 x 325 x 500 subtractive (3 axis)

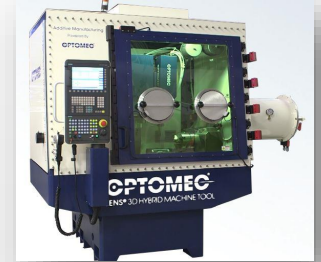




➤ LENS MTS 500 Options

Options for the MTS 500 include:

Option	Description
Controlled atmosphere upgrade	This option will include the dri train, pump, O2 sensors, HMI for O2/pressure readout, and gas recirculation components. O2 levels down to 40 ppm or lower.
Upgrade to LDH 3.X	LDH 3.X head capabilities include operating at up to 3 kW (2 kW max for MTS 500), advanced water cooling head chiller, variable optics to achieve focused spot sizes of 0.6, 2, and 3 mm diameters, and interchangeable nozzles (4-tip and coax available).
Addition of coax nozzle	With an upgrade to the LDH 3.X head, the coax nozzle can be purchased to interchange with the 4-tip nozzle.
2 and 3 mm focused optics	With an upgrade to the LDH 3.X head, 2 and 3 mm optics can be added in the optics train to achieve focused spot sizes of 0.6, 2, and 3 mm.
Upgrade to 1 or 2 kW laser	Increase laser power by upgrading to either a 1 or 2 kW laser. The 1 kW laser remains a rackmount unit with 10m feed fiber cable. The 2 kW laser is a stand-alone unit (will add to the overall system footprint) and contain an internal bcu so this has a 10 m detachable process fiber cable included.



➤ LENS MTS 500 Options (Cont'd)

Option	Description
4 th axis 120 mm rotary table	Removable A axis rotor bolted to 3 axis table to allow for 4 axis motion.
4 th /5 th axis 120 mm T/R trunnion	Non-removable trunnion for 4 th /5 th axis motion.
Additional powder feeders	The peripheral can hold up to 4 powder feeders. The base unit comes with 1 powder feeder, so the number shown on the quote sheet should be only for additional powder feeders (i.e. if a total of 4 powder feeders are desired, enter "3" on the "additional powder feeders" line).
MasterCAM/LENS Plugin software	Advanced software for up to 3+2 axis additive operations. Includes post processor. 2 day LENS additive plugin training (performed at system install). Includes 1 year LENS additive plugin software maintenance.



➤ LENS MTS 500 Options (Cont'd)

Option	Description
Melt pool sensor with closed loop controls	Vision system with closed loop feedback to control melt pool size during build. This effectively helps with final microstructure and layer control.
Beam coupler unit with 10 m process fiber cable.	The 500 W laser for this unit is a rackmount unit with a 10 m hard wired “feed” fiber cable. To protect the unit and undetachable cable from back reflection damage, a beam coupler unit with a detachable 10 m process fiber cable can be added in the line so any back reflection damage stops at the bcu. NOTE- this is not needed for 2 or 3 kW stand-alone lasers.
Wireless IR touch probe	Touch probe kit includes infrared transmitter/receiver with part probe/stylus, tool setter, and tool holder.
Material starter recipes.	See list of material starter recipes (separate slide at end of this presentation).
Remote electronic handwheel	Effective for manually jogging laser into position.
Sandvik #40 V flange taper tool kit	8 CAT 40 V flange taper tools to load into the machine tool changer.

LENS MTS 860



➤ LENS MTS 860 Base System

- The MTS 860 base system includes:

Base MTS 860 System	
Laser	500 W rackmount laser on system side panel
Fiber cable	200 um diameter feed fiber cable
Deposition head	LDH 2.0
Nozzle	4-tip only
Powder feeder	1 powder feeder on system side panel
Software	None included
Controller	Siemens 840D
Axes	3 axis system, X Y table, Z overhead
Work chamber	Open atmosphere
Build volume	600 x 600 x 610 mm additive, 860 x 600 x 610 subtractive (3 axis)



➤ LENS MTS 860 Options

Options for the MTS 860 include:



Option	Description
Controlled atmosphere upgrade	This option will include the dri train, pump, O2 sensors, HMI for O2/pressure readout, and gas recirculation components. O2 levels down to 40 ppm or lower.
Upgrade to LDH 3.X	LDH 3.X head capabilities include operating at up to 3 kW, advanced water cooling head chiller, variable optics to achieve focused spot sizes of 0.6, 2, and 3 mm diameters, and interchangeable nozzles (4-tip and coax available).
Addition of coax nozzle	With an upgrade to the LDH 3.X head, the coax nozzle can be purchased to interchange with the 4-tip nozzle.
2 and 3 mm focused optics	With an upgrade to the LDH 3.X head, 2 and 3 mm optics can be added in the optics train to achieve focused spot sizes of 0.6, 2, and 3 mm.
Upgrade to 1, 2, or 3 kW laser	Increase laser power by upgrading to either a 1, 2, or 3 kW laser. The 1 kW laser remains a rackmount unit with 10m feed fiber cable. The 2 and 3 kW lasers are stand-alone units (will add to the overall system footprint) and contain an internal bcu so this has a 10 m detachable process fiber cable included.

➤ LENS MTS 860 Options (Cont'd)



Option	Description
4 th axis 170 mm rotary table	Removable A axis rotor bolted to 3 axis table to allow for 4 axis motion.
4 th /5 th axis 170 mm T/R trunnion	Removable trunnion for 4 th /5 th axis motion.
4 th /5 th axis 250 mm T/R trunnion	Non-removable larger trunnion for 4 th /5 th axis motion.
Additional powder feeders	The side panel can hold up to 4 powder feeders. The base unit comes with 1 powder feeder, so the number shown on the quote sheet should be only for additional powder feeders (i.e. if a total of 4 powder feeders are desired, enter “3” on the “additional powder feeders” line).
MasterCAM/LENS Plugin software	Advanced software for up to simultaneous 5 axis additive operations. Includes post processor. 2 day LENS additive plugin training (performed at system install). Includes 1 year LENS additive plugin software maintenance.
Simultaneous 4 th /5 th axis motion package	An upgrade applied to the Siemens 840D and MC/LPI software for simultaneous 5 axis operation capability. Includes post processor and 1st year software maintenance.



➤ LENS MTS 860 Options (Cont'd)

Option	Description
Melt pool sensor with closed loop controls	Vision system with closed loop feedback to control melt pool size during build. This effectively helps with final microstructure and layer control.
Beam coupler unit with 10 m process fiber cable.	The 500 W laser for this unit is a rackmount unit with a 10 m hard wired “feed” fiber cable. To protect the unit and undetachable cable from back reflection damage, a beam coupler unit with a detachable 10 m process fiber cable can be added in the line so any back reflection damage stops at the bcu. NOTE- this is not needed for 2 or 3 kW stand-alone lasers.
Wireless RF touch probe	Touch probe kit includes radio frequency transmitter/receiver with part probe/stylus, tool setter, and tool holder.
Material starter recipes.	See list of material starter recipes (separate slide at end of this presentation).
Remote electronic handwheel	Effective for manually jogging laser into position.
Sandvik #40 V flange taper tool kit	8 CAT 40 V flange taper tools to load into the machine tool changer.

LENS Print Engine

LENS Print Engine (LPE)



➤ LENS Print Engine Base System

- The LPE base system includes:

Base LPE System	
Deposition head	LDH 2.0 with a focused spot size of 0.6 mm
Fiber cable	200 um diameter feed fiber cable with 500 W/1 kW laser, 200 um diameter process fiber cable with 2 kW laser
Nozzle	4-tip only
Powder feeder	Powder feeder cart with 2 powder feeders
NOTE:	The base LPE system does not come with a laser as some OEMs already have a laser supplier. If the OEM requires a laser, options are from 500 W through 2 kW (3 kW when upgrading to LDH 3.X).

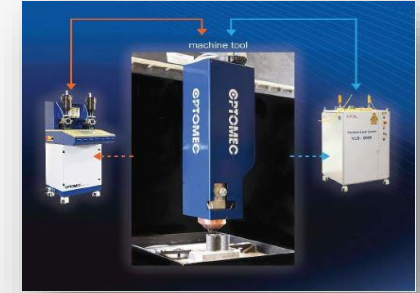


➤ LENS Print Engine Options

Options for the LPE include:

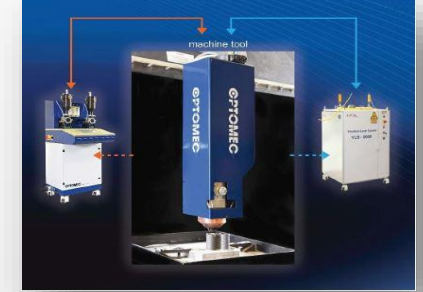


Option	Description
Laser option	Laser options include 500 W, 1 kW, and 2 kW with LDH 2.0, and up to 3 kW with LDH 3.X upgrade. The 500 W and 1 kW are rackmount lasers. Higher powers are stand-alone unites. These options include an LDH chiller, laser chiller for 1 kW or higher, a 10 m, 200 um diameter undetachable feed fiber cable for 500 W and 1 kW, and 10 m, 200 um detachable process fiber cable for 2 and 3 kW. All fiber cables have a QBH terminus to connect to the LDH.
Upgrade to LDH 3.X	LDH 3.X head capabilities include operating at up to 3 kW, advanced water cooling head chiller, variable optics to achieve focused spot sizes of 0.6, 2, and 3 mm diameters, and interchangeable nozzles (4-tip and coax available).
Addition of coax nozzle	With an upgrade to the LDH 3.X head, the coax nozzle can be purchased to interchange with the 4-tip nozzle.
2 and 3 mm focused optics	With an upgrade to the LDH 3.X head, 2 and 3 mm optics can be added in the optics train to achieve focused spot sizes of 0.6, 2, and 3 mm.



➤ LENS Print Engine Options (Cont'd)

Option	Description
Beam coupler unit with 10 m process fiber cable.	The 500 W and 1 kW lasers are rackmount units with a 10 m hard wired “feed” fiber cable. To protect the unit and undetachable cable from back reflection damage, a beam coupler unit with a detachable 10 m process fiber cable can be added in the line so any back reflection damage stops at the bcu. NOTE- this is not needed for 2 or 3 kW stand-alone lasers.
Powder feed hoppers	Additional hoppers can be purchased to use for storage of powders or for quick connection to powder feeders when another hopper runs low/out of powder.
Pneumatic slide	A pneumatic slide plate for mounting LDH to side of existing CNC spindle.
LDH chiller	This option is available when the OEM supplies the laser and the laser power is 1 kW or above- a chiller for the head will be required.
Second powder feed cart	Additional powder feed cart with two integrated powder feeders.
Single powder feed panel with one powder feeder	For OEMs who want a powder feeder that can be mounted to the side of an existing CNC system. NOTE- this requires integration by OEM.



➤ LENS Print Engine Options (Cont'd)

Option	Description
Alignment software package	Includes camera, software, and DAQ card. Provides visual of deposition area for alignment prior to laser run.
Melt pool sensor with closed loop controls	Vision system with closed loop feedback to control melt pool size during build. This effectively helps with final microstructure and layer control.
PartPrep	Optomech's 2.5D tool path generation software.
MasterCAM/LENS Plugin software	Advanced software for up to simultaneous 5 axis additive operations. Includes post processor. 2 day LENS additive plugin training (performed at system install). Includes 1 year LENS additive plugin software maintenance.
Material starter recipes.	See list of material starter recipes (separate slide at end of this presentation).

LENS Systems- Service Options Details

➤ LENS Systems- Service Options

Service options for all systems include:

Service Option	Description
Installation start-up package (required)	This installation package is required, and includes shipment from factory to USA airport (international) or customer dock (national), insurance during shipping, installation and set-up (includes travel and living expenses for tech(s) present during installation), and basic operator training after set-up. A syllabus can be provided outlining the training. Installation includes connection of cables, hoses, etc. It does not include any integration of the system.
Annual remote service contract	This includes unlimited remote hardware and software assistance, remote application assistance, field change order updates, access to Optocare Prime, one material starter recipe, and 10% discount on spare parts.
Annual full-service contract	Includes remote service plus one onsite preventive maintenance visit (tech travel and living expenses included)
Applications development workshop	Generally occurring 30-60 days after install, this includes advanced training with a senior Optomec tech. A syllabus can be provided outlining training details.

➤ LENS Systems- Service Options (Cont'd)

Service Option	Description
Standalone preventive maintenance	This includes an Optomec technician coming onsite to change out hoses, filters, nozzles, etc. and check system components (laser, powder feeder, optics, etc.) for optimal functionality and health of system.
LENS onsite customer support services per day	For when a customer requires an Optomec technician to be onsite for trouble shooting or support. Price does not include travel and living expenses- this is added to the per day price after work is complete.
Extended Warranty	For extending the system warranty beyond one year for a specified period of time.

Material Starter Recipes



➤ LENS Material Starter Recipes List-

Recipe Description	Material	Mesh Size	Manufacture	System	Nozzle Assembly	Head
Inconel Alloy, Large Volume	IN 718	44-149 µm	Carpenter	Open Atmosphere	4-tip	125mm (LDH2.0)
Inconel Alloy, Small Volume	IN 718	44-149 µm	Carpenter	Open Atmosphere	4-tip	125mm (LDH2.0)
Inconel Alloy, Thin Wall, Single Wall no hatch	IN718	44-149 µm	Carpenter	Open Atmosphere	4-tip	125mm (LDH2.0)
Stainless Steel, Large Volume	420LC	44-149 µm	Carpenter	Open Atmosphere	4-tip	125mm (LDH2.0)
Stainless Steel, Small Volume	420LC	44-149 µm	Carpenter	Open Atmosphere	4-tip	125mm (LDH2.0)
Stainless Steel, Thin Wall, Single Wall no hatch	420LC	44-149 µm	Carpenter	Open Atmosphere	4-tip	125mm (LDH2.0)
Ti-6Al-4V, Large Volume	Ti-6Al-4V	50-100 µm	GKN Hoeganaes	Controlled Atmosphere	4-tip	K-type
Ti-6Al-4V, Small Volume	Ti-6Al-4V	50-100 µm	GKN Hoeganaes	Controlled Atmosphere	4-tip	K-type
Ti-6Al-4V, Thin Wall, Single Wall no hatch	Ti-6Al-4V	50-100 µm	GKN Hoeganaes	Controlled Atmosphere	4-tip	K-type

AVAILABLE ON OPTOCARE FOR CUSTOMERS WITH A SERVICE CONTRACT



Thank You