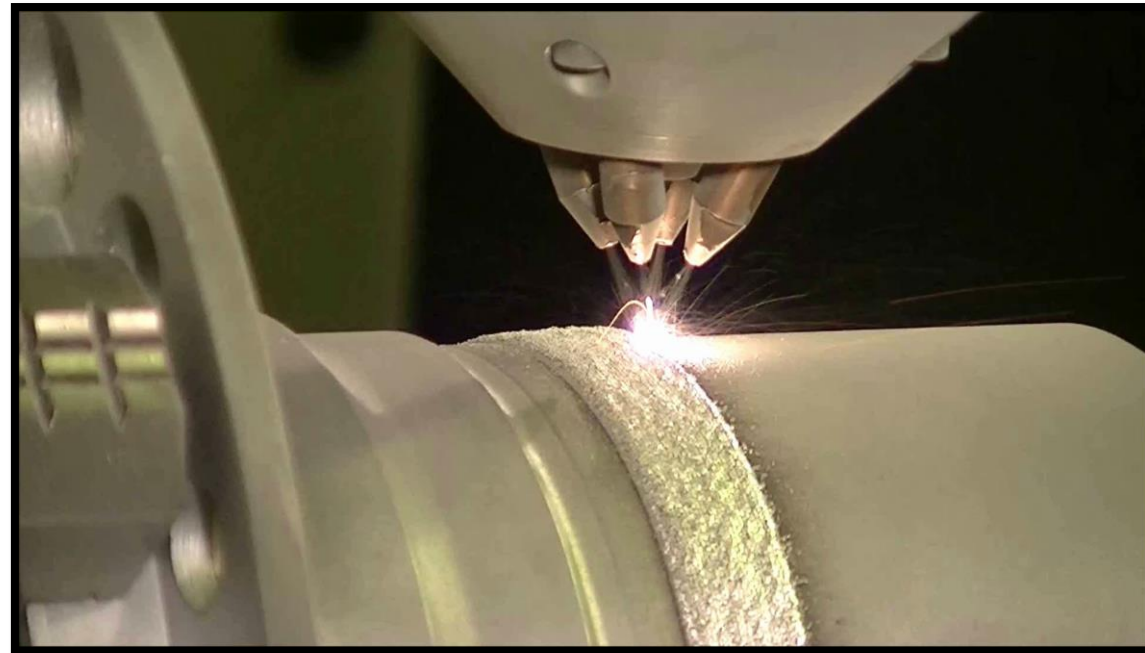
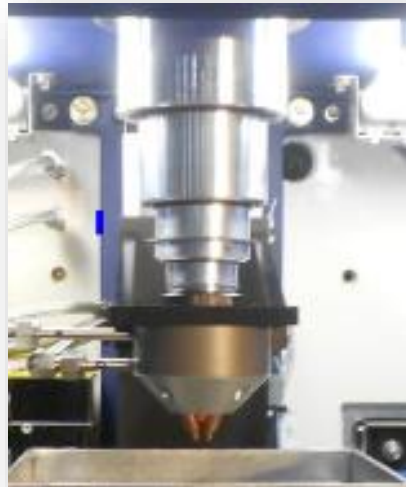


# LENS Deposition Head (LDH) Overview of Models

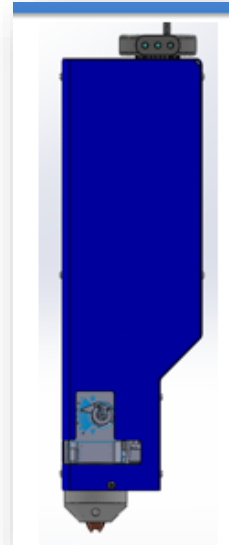


# LDH Models (not shown to scale)-

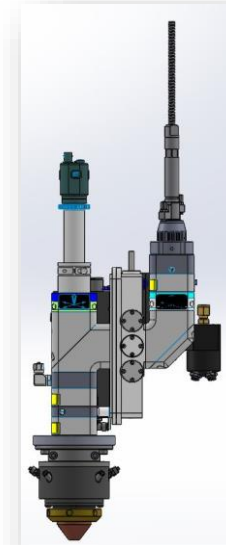
## LDH 1.0



## LDH 2.0



## LDH 3.X



All LDH models start from a general construct of components that deliver a laser beam to the work piece as a heat source for the purpose of metallurgically bonding blown metal powder in a free form 3D build, layer by layer, on an initial substrate. The process is known in additive manufacturing as the DED process.

# LDH Models

LDH models will differ according to configuration and options, such as:

1. Overall dimensions and form.
2. Allowable laser power range.
3. Laser fiber cable diameter.
4. Focus lens length.
5. Spot size range.
6. Cooling (air or water).
7. Single nozzle or nozzle interchangeability (4-tip or coax).
8. Shaping optics.
9. Visual and monitoring tools, such as laser alignment, melt pool sensor, and thermal imaging.

# LDH Models

Each LDH model will have its own specific design or configuration. However, the components that make up the core of each LDH will generally include the following:

1. Fiber optic connector (QBH type, also called HLC-8)- where the laser is transmitted from the laser source to the LDH.
2. Collimating lens- aligns the beam path.
3. Turning mirrors- channel the beam.
4. Focusing lens- focuses the laser beam to an optimal spot size at the work piece location.
5. Powder delivery system- manifold, tubes, and housing for mixing and delivery of metal powders. The powders are blown with argon gas.
6. Gas delivery system- Argon gas is used to deliver the metal powder and provide positive pressure via a center purge from the deposition nozzle to the work piece.
7. Water cooling system (when operating with higher laser powers).
8. Deposition nozzle (also called the LPN)- houses the powder delivery nozzles, shield gas nozzle, and water cooling channels (when operating with higher laser powers).

# LDH 1.0

# LDH 1.0 Base Features

The LDH 1.0 base features are summarized below.

LDH Model Information- LDH 1.0	
Features	LDH 1.0
Laser power range	up to 400W
Laser beam delivery- fiber cable diameter (um)	200
Collimator length (mm)	60
Focus lens length (mm)	200
Cooling system	air cooled
Deposition nozzle type(s)	4-tip nozzle
Spot size	400um (optimal)
Powder delivery	Argon blown
Gas delivery	Argon center purge, argon blown powder
Functional grading	2 metal powder feeders in LENS 150 system- capable to deliver up to 4 metal powders

# LDH 1.0 Options, Systems, and Applications

## Options

The LDH 1.0 is suitable for a 500 W laser and comes with a 4-tip deposition nozzle. Water cooling of the head is not required for this power range. There are no options available with the LDH 1.0.

## Systems

The LDH 1.0 is used in the CS 150 only.

## Applications

The LDH 1.0 is primarily suitable for the following applications:

1. New builds
2. Small add-ons
3. Small repairs or remanufacturing
4. Small corrosion and wear coatings
5. Functional grading (up to 4 metal powder types)



# LDH 2.0



# LDH 2.0 Base Features

The LDH 2.0 base features are summarized below.

LDH Model Information- LDH 2.0	
Features	LDH 2.0
Laser power range	up to 2kW
Laser beam delivery- fiber cable diameter (um)	200
Collimator length (mm)	60
Focus lens length (mm)	200
Cooling system	water cooling
Deposition nozzle type(s)	4-tip
Spot size	500um optimal
Powder delivery	Argon blown
Gas delivery	Argon center purge, argon blown powder
Functional grading	Up to 4 metal powders

# LDH 2.0 Options, Systems, and Applications

## Options

1. Laser power- 500W, 1kW, and 2kW laser power options are available.
2. Deposition nozzle- the LDH 2.0 is fitted with a 4-tip nozzle.
3. Water cooling- an LDH chiller (water cooling system) is used with the LDH for all laser powers 500 W and above.
4. Alignment software package- includes coaxial camera and SW package. This option makes it possible for the user to view coaxially the build area and align the deposition head to a desired location.
5. Melt pool sensor (MPS) software package- includes coaxial camera, SW package, and laptop. The coaxial camera reads the melt pool surface area and relays the information to the laptop. If the melt pool exceeds a designated surface area, the laser power is decreased. If the melt pool surface area decreases below a designated threshold, the laser power is increased. This is a closed loop function- laser power is increased or decreased automatically during a build.

*Note- a customer can purchase both the alignment SW package and the MPS SW package as options for a single system. However, though they may have both capabilities, they cannot run both simultaneous.*

# LDH 2.0 Options, Systems, and Applications (Cont'd)

## Systems

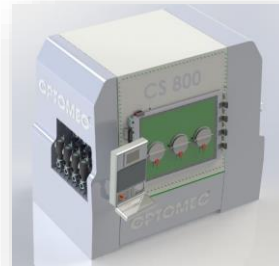
The LDH 2.0 is available for use with any of the following:

1. LENS 600
2. LENS 800
3. LENS 1500
4. LENS 500
5. LENS 860
6. LENS 1400
7. LPE

LENS 600



LENS 800



LENS 1500



LENS 500



LENS 860



LENS 1400



LPE



# LDH 2.0 Options, Systems, and Applications (Cont'd)

## Applications

The LDH 2.0 is primarily suitable for the following applications:

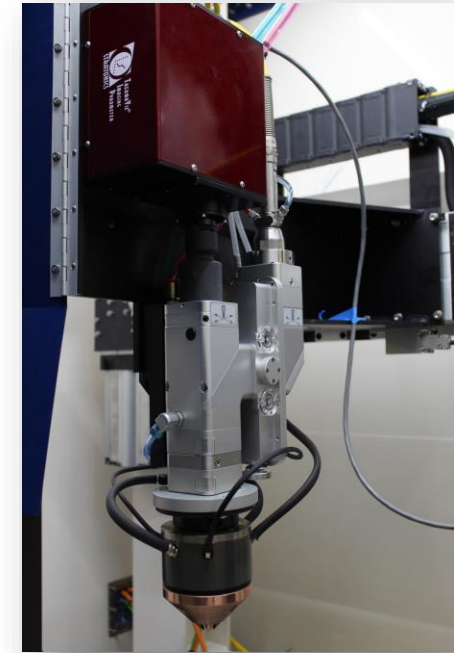
1. New builds
2. Add-ons
3. Repairs
4. Remanufacturing
5. Corrosion and wear coatings
6. Functional grading (up to 4 metal powder types)

# LDH 3.X

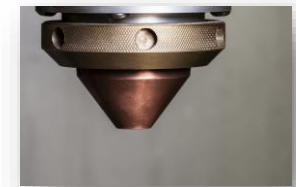
## ➤ LDH 3.X Quick Reference- What To Know

- Up to 3 kW power.
- Improved head chilling for higher powers.
- Shaping optics slide tray for 0.67, 2, and 3 mm focused spot sizes.
- Interchangeable nozzles- 4-tip (std) and coax nozzles.
- Compatible for all systems (except LENS 150).
- Laser power should be limited to 2 kW for LDH 3.X in LENS 500 and 600.
- Already being quoted on new systems and is the base LDH for all new system quotes.

### LDH 3.X



**4-tip nozzle**

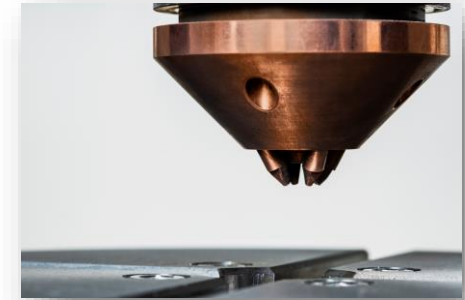


**coax nozzle**

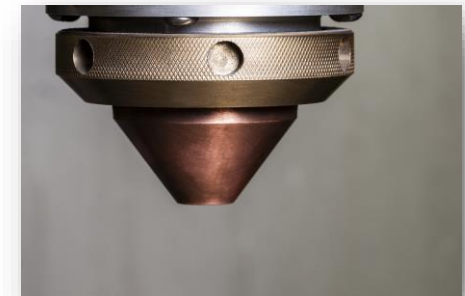
## ➤ 4-tip and Coax Nozzle Comparisons

- A general rule of thumb when choosing between the two nozzles:
  1. The 4-tip nozzle is generally used for lower laser powers and smaller builds. When processing, the 4-tip is able to get finer build quality in complex contours or thinner wall structures.
  2. The coax nozzle is generally used for higher laser powers and material deposition rates. When processing, the coax is able to convey more powder flow evenly to larger spot sizes or melt pools typical of higher powers. It is the preferred nozzle for laying more metal such as in coating or cladding operations.

**4-tip nozzle**



**coax nozzle**



# LDH 3.X Base Features

The LDH 3.X can achieve varying spot sizes through the use of shaping optics. The LDH 3.X base features are summarized below.

LDH Model Information- LDH 3.X	
Features	LDH 3.X
Laser power range	up to 3kW
Laser beam delivery- fiber cable diameter (um)	200
Collimator length (mm)	60
Focus lens length (mm)	200
Cooling system	water cooling for 1kW and above
Deposition nozzle type(s)	4-tip, coax, or high overhang
Spot size- focused (mm)	0.67
Spot size- shaping optic 1 (mm)	2
Spot size- shaping optic 2 (mm)	3
Powder delivery	Argon blown
Gas delivery	Argon center purge, argon blown powder
Functional grading	Up to 4 metal powders



# LDH 3.X Options, Systems, and Applications

## Options

1. Laser power- up to 3kW laser systems.
2. Deposition nozzle- The LDH 3.X can be fitted with a 4-tip or coax nozzle. The nozzle types are interchangeable.
3. Water cooling- an LDH chiller (water cooling system) is used with the LDH.
4. Alignment software package- includes coaxial camera and SW package. This option makes it possible for the user to view coaxially the build area and align the deposition head to a desired location.
5. Melt pool sensor (MPS) software package- includes coaxial camera, SW package, and laptop. The coaxial camera reads the melt pool surface area and relays the information to the laptop. If the melt pool exceeds a designated surface area, the laser power is decreased. If the melt pool surface area decreases below a designated threshold, the laser power is increased. This is a closed loop function- laser power is increased or decreased automatically during a build.
6. Thermal imager- a coaxial camera/imager that reads melt pool surface temperatures.
7. Shaping optics- two additional optics within the laser beam delivery system that create a discreetly different spot size by manipulation of the laser beam. The LDH 3.X will be able to achieve three discreet focused spot sizes by manually moving shaping optics in the beam path.

*Note- for the alignment and MPS SW packages, a customer can purchase both, however, though they may have both capabilities, they cannot run both simultaneous. In addition, if a customer chooses the option of the thermal imager, they may also get the MPS SW package, but not the alignment camera, and MPS and thermal imager cannot be operated simultaneously.*

# LDH 3.X Options, Systems, and Applications

## Interchangeable nozzles

1. The LDH 3.X is capable of switching out nozzle types

# LDH 3.X Options, Systems, and Applications (Cont'd)

## Systems

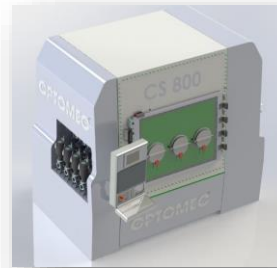
The LDH 3.X can be used with the following LENS systems:

1. LENS 600
2. LENS 800
3. LENS 1500
4. LENS 500
5. LENS 860
6. LENS 1400
7. LPE

LENS 600



LENS 800



LENS 1500



LENS 500



LENS 860



LENS 1400



LPE



Note- the LDH 3.X is suitable for LENS 600 and LENS 500 models for powers up to 2kW only. Thermal imager option not available with LDH 3.X for hybrid machine models.

# LDH 3.X Options, Systems, and Applications (Cont'd)

## Applications

The LDH 3.X configurations are suitable for applications as indicated below:

1. New builds
2. Add-ons
3. Repairs
4. Remanufacturing
5. Corrosion and wear coatings
6. Functional grading (up to 4 metal powder types)
7. Coatings requiring higher temperatures (i.e. coatings containing W carbides)
8. Cladding

*Note- higher laser power required for #s 7 and 8 above.*

# LDH Models Quick Reference

The following table can be used as a quick reference guide for the various LDH models.

<b>LDH Models- Quick Reference of General Information</b>			
<b>LDH Model</b>	<b>Laser Power</b>	<b>Spot Size</b>	<b>Nozzle Options</b>
<b>LDH 1.0</b>	Up to 400 W	Focused at 400 um	4-tip nozzle only
<b>LDH 2.0</b>	Up to 2 kW	Focused at 500 um	
<b>LDH 3.X</b>	Up to 3 kW	Standard focused 1 mm, with shaping optics for additional focused 2 and 3 mm	4-tip and coax (interchangeable)

# LDH Models and Options

LDH Models and Options			
	LDH 1.0	LDH 2.0	LDH 3.X
<b>Options</b>	<i>Note- Green indicates the feature is available for the model.</i>		
500W laser			
1kW laser			
2kW laser			
3kW laser			
4-tip nozzle			
coax nozzle			
Shaping optics			
2 powder feeders			
4 powder feeders			
Alignment SW package <sup>1</sup>			
MPS SW package <sup>1</sup>			
Thermal imager <sup>1,2</sup>			
<b>NOTES-</b>			
1. If the options are available, the following interaction rules apply: For the alignment and MPS SW packages, a customer can purchase both , however, though they may have both capabilities, they can not run both simultaneous (must be operated one at a time). With the addition of Thermaviz, only MPS and Thermaviz may be purchased for use, and again these can not be run simultaneously.			
2. Thermal imager option not available with LDH 3.X for hybrid machine models.			

# LDH Models and Systems Compatibility

Otpomec systems and suitable LDH models			
Systems	LDH 1.0	LDH 2.0	LDH 3.X
LENS 150			
LENS 600			(note 1)
LENS 800			
LENS 1500			
LENS 500			(note 1)
LENS 860			
LENS 1400			
LPE			
Notes-			
1. LDH 3.X is suitable for LENS 600 and LENS 500 models for powers up to 2kW only.			
2. Thermal imager option not available with LDH 3.X for hybrid machine models.			

# LDH Models and Suitable Applications

LDH models and their suitable applications			
Applications	LDH 1.0	LDH 2.0	LDH 3.X
New builds			
Add-ons			
Repairs			
Remanufacturing			
Corrosion and wear coatings			
Functional grading with up to 4 metal powders			
Coatings requiring higher temperatures			
Cladding (high speed/high deposition rate)			



**Thank You.**

