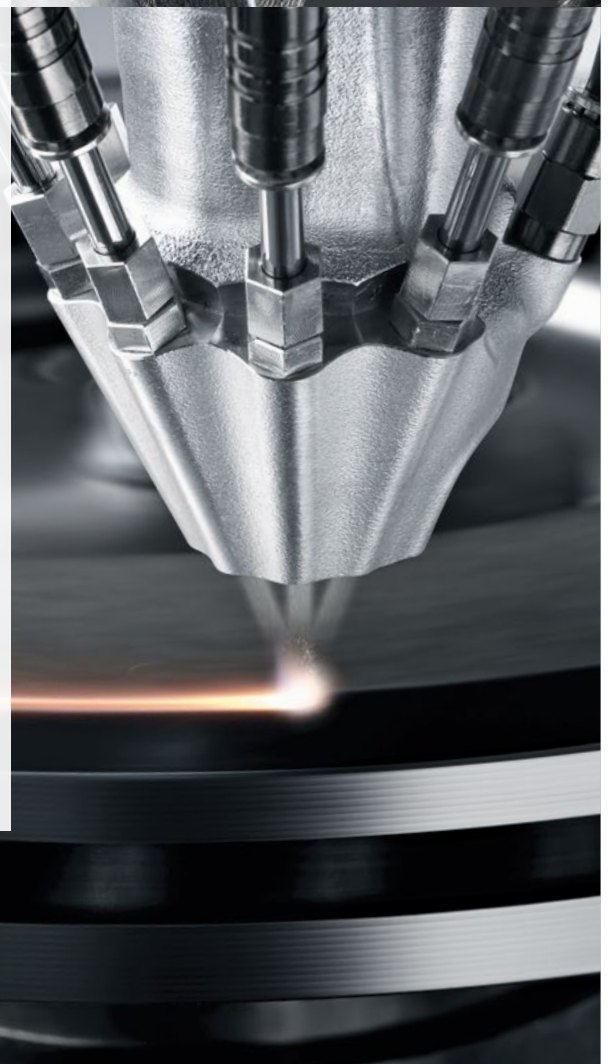


Laser metal deposition and
high-speed laser metal deposition

Tapping new potential



Simple principle – broad application

In laser metal deposition, laser light melts powder to form preprogrammed geometries in the desired alloys and coatings. The technique can be used for repairs, additive manufacturing, coatings, and gap filling during welding. It is a simple principle with broad application – no wonder, then, that it has become popular in a variety of industries.

Aerospace

Repair costly and complex components such as blades and housings.



Energy and heavy industry

Coat components for turbomachines, gas and steam turbines, shafts, work rolls and working shafts to protect them against wear and corrosion or to repair them.



Automotive

Provide components with localized reinforcement and achieve a better welding seal (for instance in electric motors), even when there are gaps to be bridged.



Research and development

Develop new alloys and material combinations, and produce 3D prototypes and components using additive techniques.



Mining and chemicals

Improve the surface of drills and hydraulic components to protect them against abrasion and corrosion; coat shafts and pipes to increase their resistance to corrosion.



Consumer goods

Take advantage of wear protection and 3D-printed structures to improve electric and thermal conductivity.



Tool- and mold-making

Repair tools and avoid the expense of having to replace them. Coating gives them additional protection against wear and therefore increases service life.



Medicine

Coat prostheses and medical tools with additional, biocompatible materials.



Contract manufacturers

Finish surfaces and modify or manufacture components with additive techniques. Laser metal deposition is the perfect complement to other laser-based surface-finishing techniques.



What is laser metal deposition?

Laser metal deposition (LMD) is an additive manufacturing process for metals. This is the most common designation for this process, but it is also known as direct metal deposition (DMD) and laser-direct energy deposition (L-DED).

The principle is simple: A laser beam creates a weld pool on the surface of a component, to which an additive material is then added. A laser fuses this material with the component surface. This creates a metallurgical bond between the component and the coating or between existing coatings. The

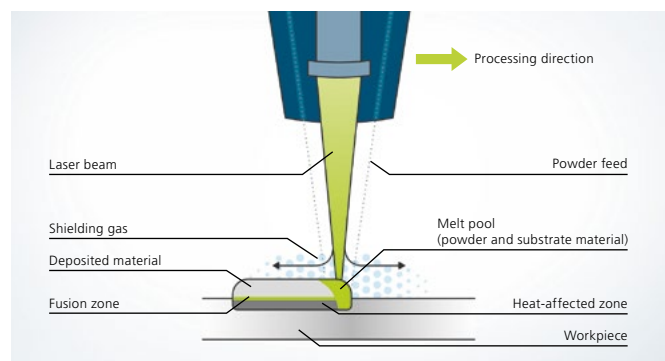
metal powder is deposited layer by layer on the base material, where it fuses with the substrate without forming any pores or cracks. Using this method, it is possible to apply successive metal coatings of either the same or even a different material.

Both laser metal deposition (LMD) and high-speed laser metal deposition (HS-LMD) can be used with most alloys. The table below lists a selection of suitable alloys.

Which materials can you use?

Standard workpiece materials*	Potential coating materials*
Tool steels/hardened steels/tempering steels	Tool steels/corrosion-resistant steels
Cast iron	Nickel alloys
Construction steel/cast steel	Cobalt alloys
Nickel alloys	Titanium alloys
Titanium alloys	Tungsten/titanium carbides
Aluminum	Aluminum
Copper	Copper

* Further materials are possible on request.



LMD can be used both for large structures and for finely detailed ones – offering a good build-up rate in both instances.

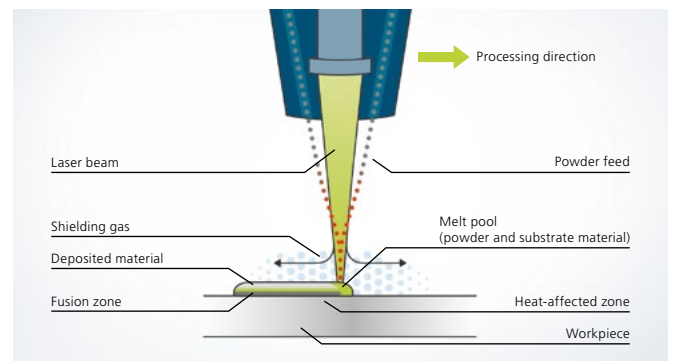
What is high-speed laser metal deposition?

Laser metal deposition is perfect for either repair jobs or additive manufacturing. Large volumes of material can be applied at a high rate. When coating large components with thin layers of material, it is often much faster and more efficient to use high-speed laser metal deposition (HS-LMD). In contrast to LMD, where feed rates are limited to a few meters per minute, HS-LMD achieves a feed rate of > 100 m/min. Thanks to the use of special nozzles, the additive material already becomes molten before touching the substrate's surface. A laser then fuses this material with the component surface.

This creates a metallurgical bond between the component and the coating or between existing coatings. The metal powder is deposited layer by layer on the base material and fuses with it. In this way, it is possible to apply successive metal coatings of either the same or even a different material.

Process variables and results	LMD	HS-LMD*	Factor
Process speed	0.5–4 m/min	> 100 m/min	50
Surface rate	1–100 cm ² /min	$> 1,000$ cm ² /min	10–1,000
Heat-affected zone*	500–1,000 μ m	< 10 –50 μ m	20–100
Available thickness	≥ 500 μ m	50–500 μ m	1–10
Surface roughness (R_z)	100–200 μ m	10–20 μ m	10

* In the case of rotationally symmetrical components, heat transfer can be reduced to such a degree that even base materials normally unsuitable for welding can be repaired. As a result, hybrid combinations of materials become an option.



Watch HS-LMD in action and full color in our latest video: www.trumpf.info/xwb7sj



Using HS-LMD, it is possible to achieve surface rates of $> 1,000$ cm²/min at, for example, coating thicknesses of 100 μ m.

A versatile technique: Laser metal deposition

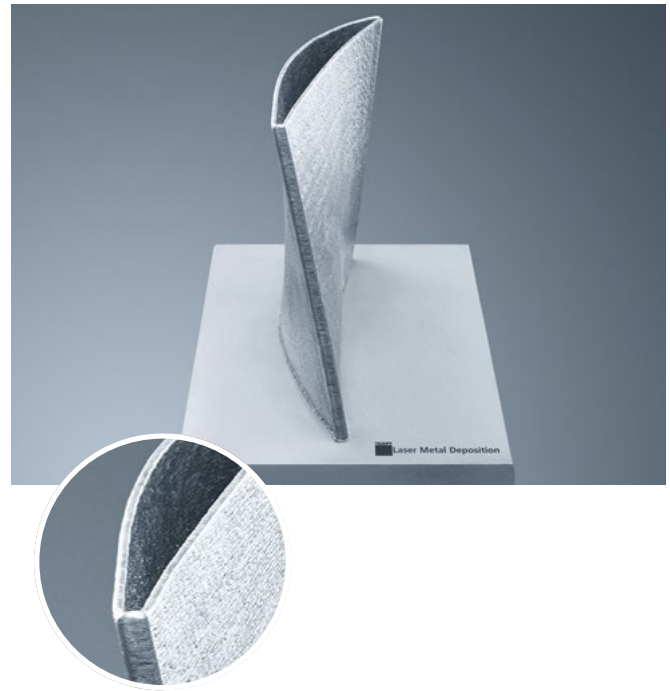
Laser metal deposition offers a fully industry-ready alternative to disposing of valuable components. Using this technique, you can repair parts, functionalize and finish surfaces, alter geometries without the need for machining, and manufacture 3D structures and components that just wouldn't be possible using other methods.



Repair, repurpose, reuse

Repairs

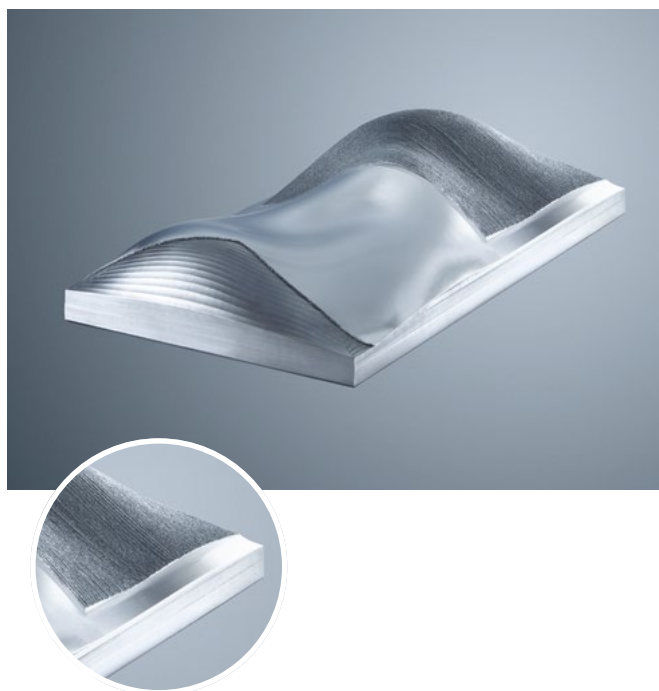
Are you looking for more added value? Use LMD to repair expensive components and tools with ease. LMD can repair both minor and major damage quickly and almost without a trace – ensuring that your component or tool is soon back in action. You can also use the technique to make design changes – saving a huge amount of time, energy, and materials, especially when it comes to expensive metals such as nickel or titanium. Typical applications include turbine blades, pistons, valves, shafts, and tools of all kinds.



Freedom of form

Additive manufacturing

Additive manufacturing using LMD provides considerable design freedom, even in the case of delicate and highly complex geometries. Create components from scratch or add 3D structures to base shapes. An example of this is the fan blade shown in the above illustration. It was developed in the EU project AMAZE. Getting started with LMD is easy: as one of TRUMPF's industrial additive technologies, LMD is a fully industry-ready technique that draws on tried-and-tested lasers and machines. Experience the speed and cost benefits for yourself – not to mention the extensive design possibilities. Combine different materials into sandwich structures, use specific alloys or create your own.



A long life

Coating

Upgrade your tools with a coating to protect against wear or corrosion. LMD coatings toughen your components and make them resistant to saltwater, chemicals, or weathering according to your needs. LMD allows for a wide range of material combinations and coating structures. Save on production costs, for instance, by using cheap materials for the component itself and then providing it with a high-quality coating.



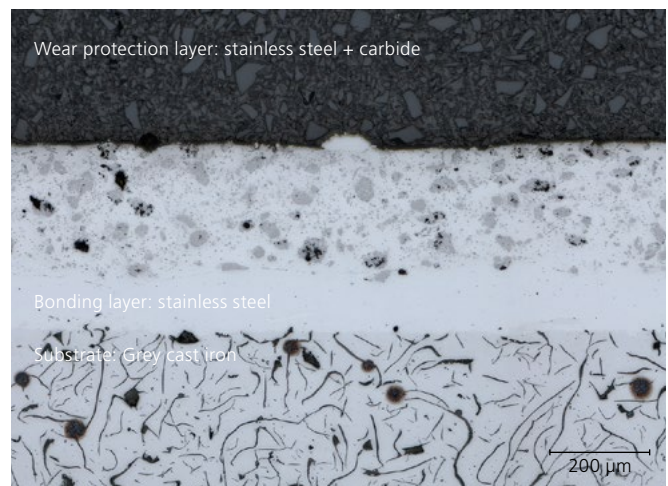
Goodbye cracks

Joining

LMD can also be used in joining – for instance, to fill gaps of several millimeters. This results in close, homogenous seams, without the need for any post-processing. Because the powder deposition is coaxial, the LMD joining process is three-dimensional and direction-independent, making your process chain especially flexible. LMD is suitable for joining a range of materials, such as steel and cast aluminum, for instance in battery, electric motor, and powertrain components.

High-speed laser metal deposition

As a method for coating large, rotationally symmetrical components, high-speed laser metal deposition (HS-LMD) is a technically feasible and also economical alternative to other surface-finishing processes such as thermal spraying or electroplating.



Cross section of a brake disc coated with HS-LMD with carbides embedded in a stainless steel matrix (here: TiCFeCr).

Layer for layer

Difficult-to-weld materials

The drawback with conventional processes (LMD and other welding methods) are the brittle phases that result from the deposition of material on flake graphite cast iron. HS-LMD applies thin coatings to a substrate by means of a metallurgical bond. Here, there is no restriction on the thickness of coating or the number of materials used. Materials can be modified or even functionally graded from layer to layer – without having to interrupt or retool the process. Each coating layer is produced virtually without pores or cracks.

No more cracks

Coatings free of pores and cracks

The deposition of cermets, a mixture of ceramics in metal matrixes, offers high protection against corrosion and abrasion. With conventional LMD and other welding techniques, the deposition of material on flake graphite cast iron is often associated with cracking due to brittle phases that result from carbon in the ferrous matrix. HS-LMD significantly reduces the thermal load, thereby hindering the formation of brittle phases.



Attractive alternative

Protection against wear

Thanks to high powder efficiency and fast processing speeds, components can be welded very productively and to a high quality. The coatings applied by HS-LMD are metallurgically bonded. The thickness of each coating can be individually set. Using this method, highly wear-resistant coating layers can be applied to a valve seat, for example, with processing times of only a few seconds per part. HS-LMD is a technically feasible and also economical alternative to conventional methods used to spray or weld wear-protection coatings onto components in large-scale production. Compared to other coating methods, it saves considerable time, effort and material costs, as well as delivering a higher quality of coating.



Prolonging life even further

Corrosion protection

In the case of large hydraulic components, it is often necessary to take elaborate precautions to protect them against corrosion by liquids or gases. The same is true of large shafts used to drive industrial machinery or processes. Technically, it is often highly complex and therefore very expensive to machine such large components. Here, too, HS-LMD offers a technically feasible and also economical alternative to thermal spraying or electroplating. Using this method, it is possible to coat component surfaces very productively at a rate of up to 5 m²/h at a coating thickness of approx. 100 µm. Moreover, HS-LMD can be used not only to provide corrosion protection but also to apply functional coatings that enhance slip and friction properties.

Get started

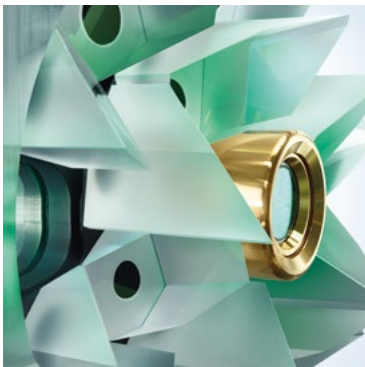
Benefit from tried-and-tested laser beam sources and machines for LMD, all from a single source. We put together a turnkey system tailored to your exact activities and batch sizes – so you can get started right away.

Application consulting



What do you want to solve with LMD? Special application advisors and fully equipped application laboratories support you in choosing materials, defining parameters, and configuring your system. You can also take advantage of our training events.

TruDisk



Because of their beam quality, the TruDisk disk lasers are ideal for delicate tasks. Put your trust in a broad portfolio of the world's most powerful fiber-guided disk lasers.

TruLaser Cell 3000

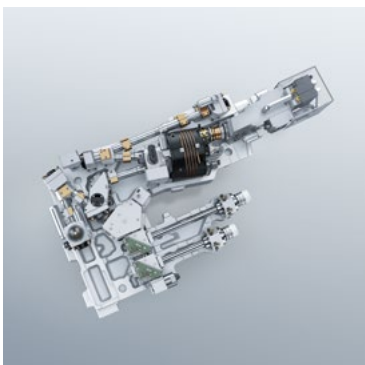


From prototype to full-scale production: with this 3-in-1 machine, you can process small and medium-sized components extremely efficiently. The machine is equipped for laser metal deposition (LMD) as well as laser cutting and welding in 2D and 3D. Process adapters make it particularly easy to switch between techniques.



www.trumpf.com/s/trulaser-cell-3000

TruDisk green



When paired with a laser operating in the green wavelength, LMD offers an efficient as well as high-quality and highly productive method of welding copper and other highly reflective materials, regardless of the nature of the material surface.

TruLaser Cell 7000



Similarly compact and modular in design, the "big sister" to the TruLaser 3000 provides more performance and more processing space for larger components. Switching between LMD and laser cutting and welding is quick and easy.



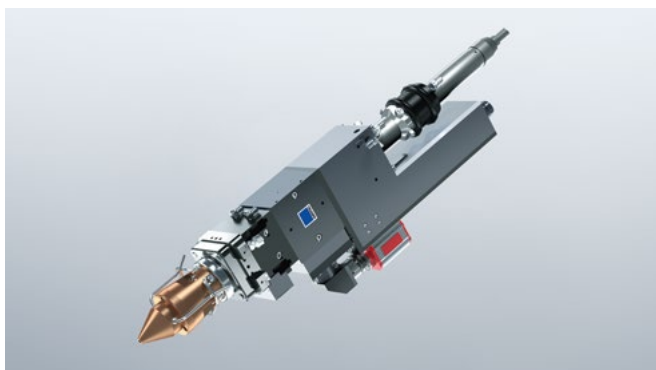
www.trumpf.com/s/trulaser-cell-7040

Integrate LMD yourself

Get the best equipment for LMD for your own system – the ideal solution for OEMs and integrators. DepositionLine comprises a traveling powder conveyor, the powder conveyor line, and the processing optics complete with powder nozzle. We are also happy to fit the powder conveyor with up to four independent containers. Depending on the application, you can operate the system using a TruDisk or a TruDiode laser.



For more information on a comprehensive solution tailored to your precise needs: www.trumpf.com/s/depositionline



BEO D 70 is a tried-and-tested optical system that features programmable motor-driven focusing and a digital camera for even greater process safety. The powder nozzles have been developed specifically for the technique, and allow for optimal distribution of the powder flow.



A vibration-disc feeder takes the powder-gas mixture out of the containers and supplies it to the nozzle. It is capable of handling even tiny amounts of powder and the finest grains.

We are there for you

From application consulting and training events to the prompt delivery of replacement parts, TRUMPF offers a range of tailored services that cover the entire life cycle of your laser or laser system. This allows you to use your laser or laser system to the full and manufacture even more productively. Make use of our worldwide training centers, for instance, or arrange an individual training session at your own location. With a suitable service agreement, you maximize the availability of your laser or laser system – select a package tailored to your wishes out of our comprehensive Services portfolio.



Application
consulting

Maintenance

Trouble-
shooting

Spare parts

Feature
enhancements

