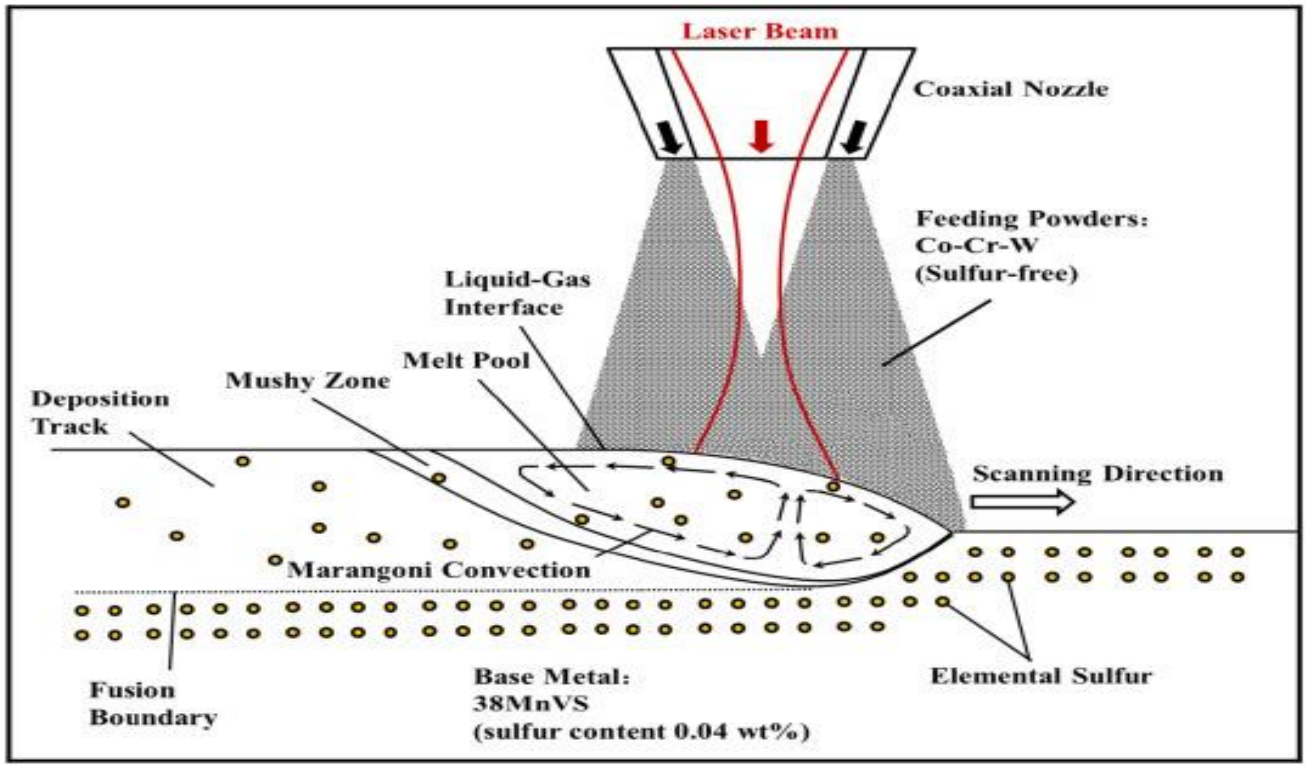
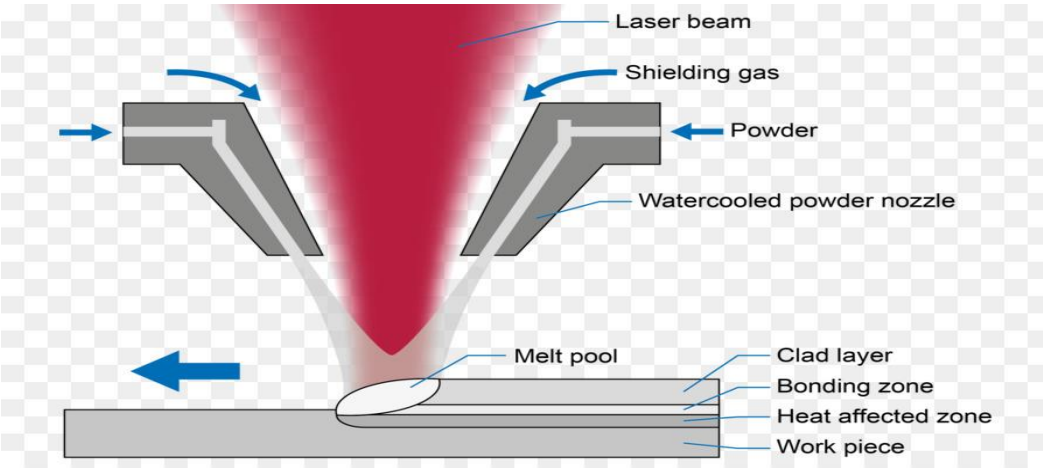
Laser Direct Metal Deposition

PG 1st Year-Second Semester

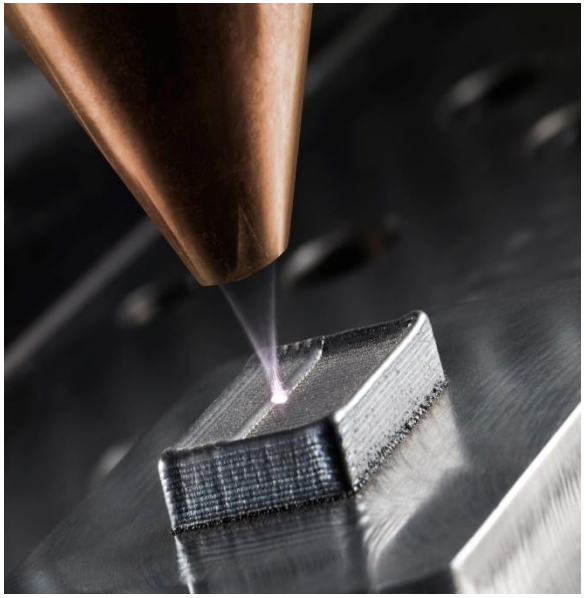
School of Laser Science and Engineering

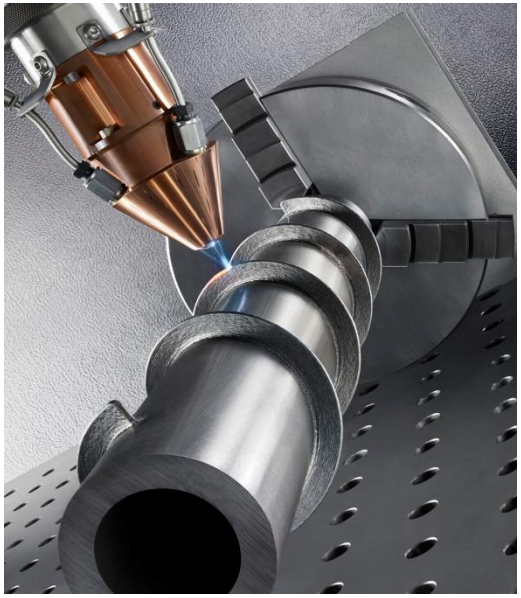
Laser Direct Metal Deposition





Laser Metal Depos.





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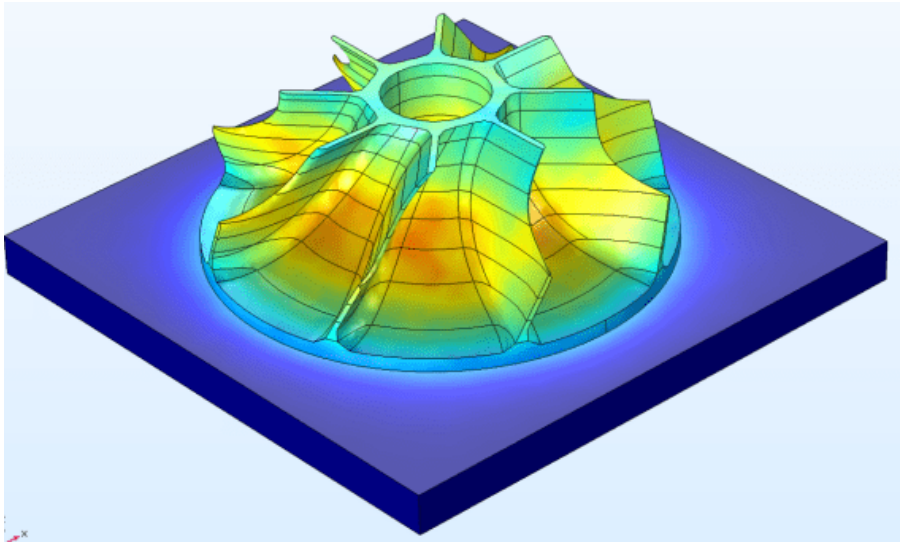
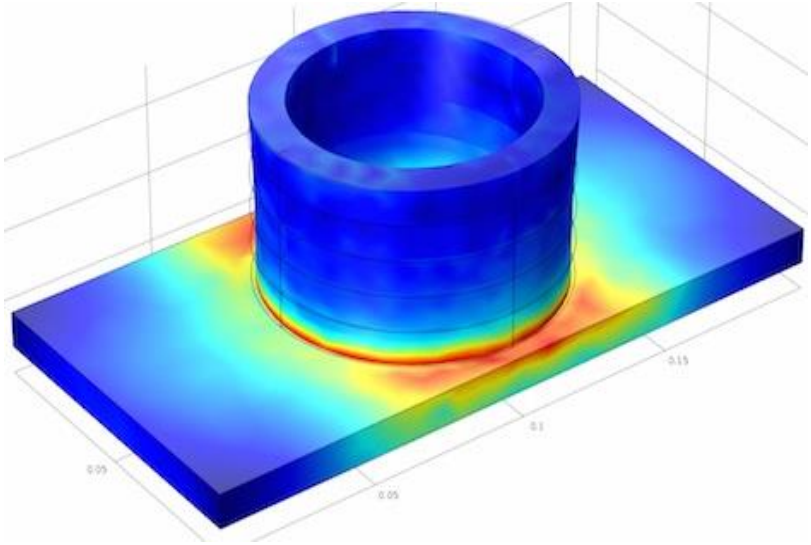
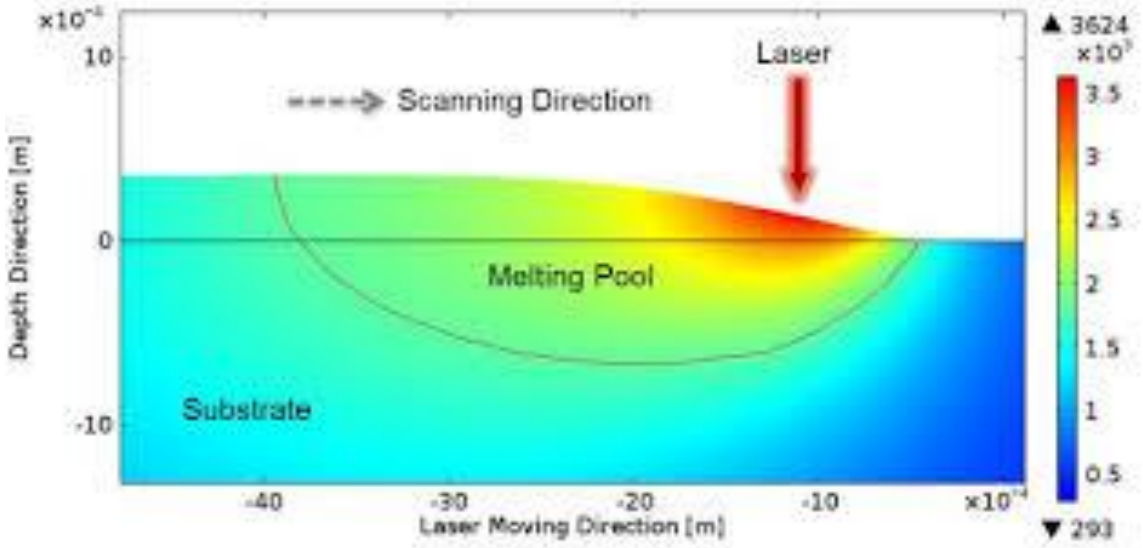
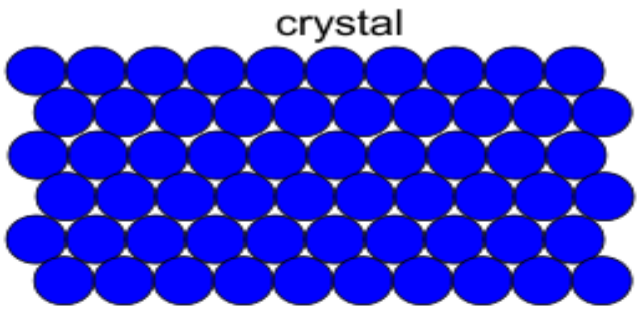


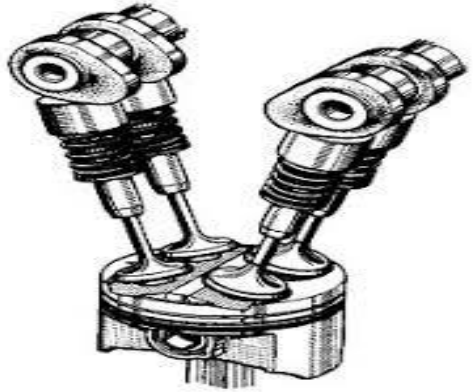


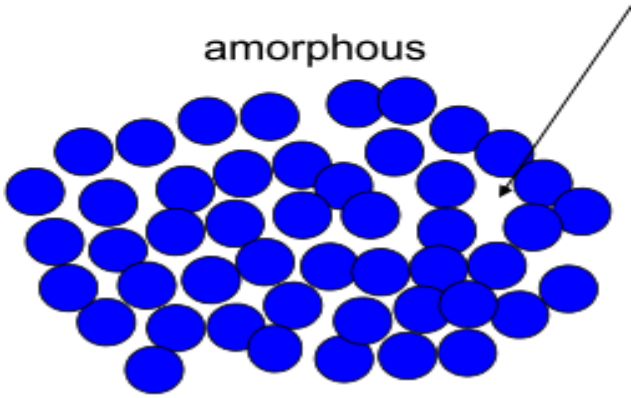


Laser Metal Depos.

- Laser deposition is a form of cladding, hardfacing, or coating technique for enhancing the corrosion and/or wear resistance of a part.
- This process involves using a laser beam to melt a very thin surface of a substrate. The molten substrate mixes with melted clad alloy, which is usually applied as powder to form a metallurgical bond.
- In the other cases of laser surface modification, the rapid solidification and/or quench rates associated with the process enable either amorphous or non-equilibrium crystalline phases to be formed.
- The amorphous phases enable material properties to be obtained which cannot be obtained under equilibrium cooling. Laser cladding applications include engine valve components, boiler firewall, and turbine blades.



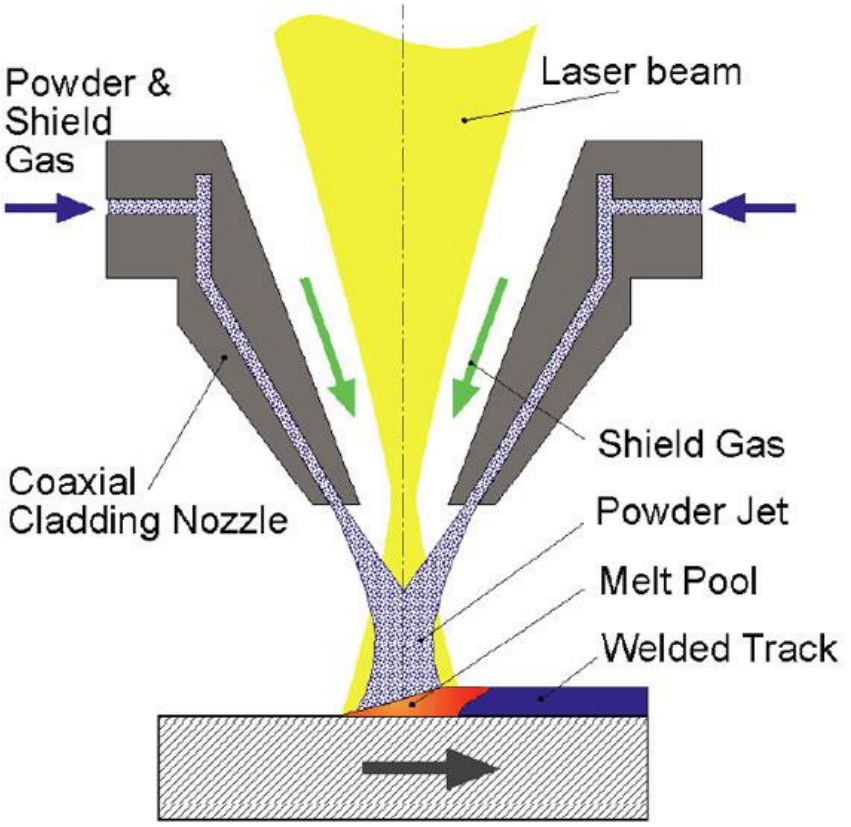




Laser Metal Depos.

- Potential problems that may arise during cladding include the following

1. Porosity
2. Thermal stresses which may cause cracking



Cracking due to following factors:

- Difference between the melting points of the clad layer and substrate.
- Different coefficients of thermal expansion of the clad layer and substrate.
- Volume changes associated with phase changes.

Laser Metal Depos.

- Typical processing parameters for cladding of a Mg–Al alloy

Parameters	Values	Units
Power	1–3	kW
Defocused beam diameter	3–5	mm
Power densities	1–100	kW/cm^2
Scanning velocities	1–60	mm/s
Powder feed rate	0.1–0.4	g/s
Clad layer thickness	0.1–2	mm
Feeder nozzle diameter	3	mm
Feeder nozzle orientation	30 with substrate	°
Shielding gas	Argon	–
Overlap between passes	50	%

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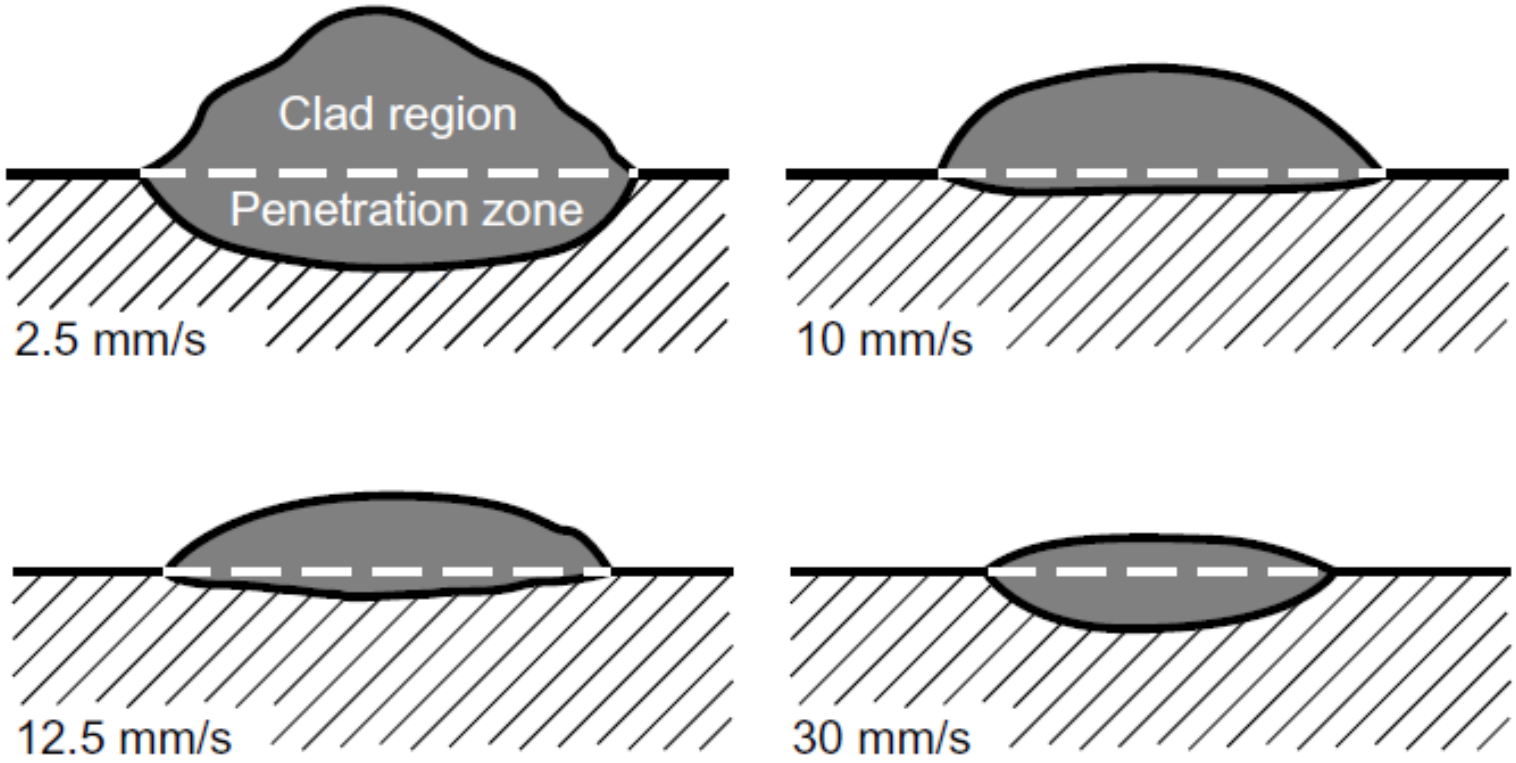
Scanning speed

The clad tracks that are formed in laser cladding tend to be discontinuous with a high height-to-width (aspect) ratio at relatively low speeds, becoming shallower with a reducing aspect ratio as speed increases. Thus, at very high speeds, about 30 mm/s, the cladding obtained is relatively thin, and the dilution increases accordingly.



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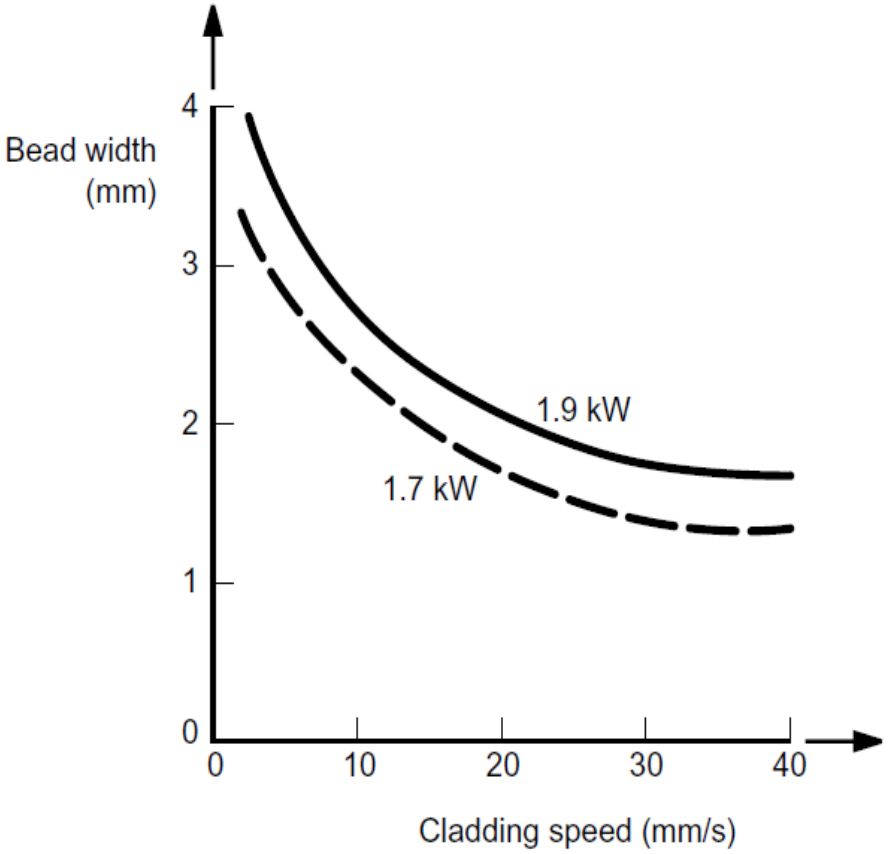
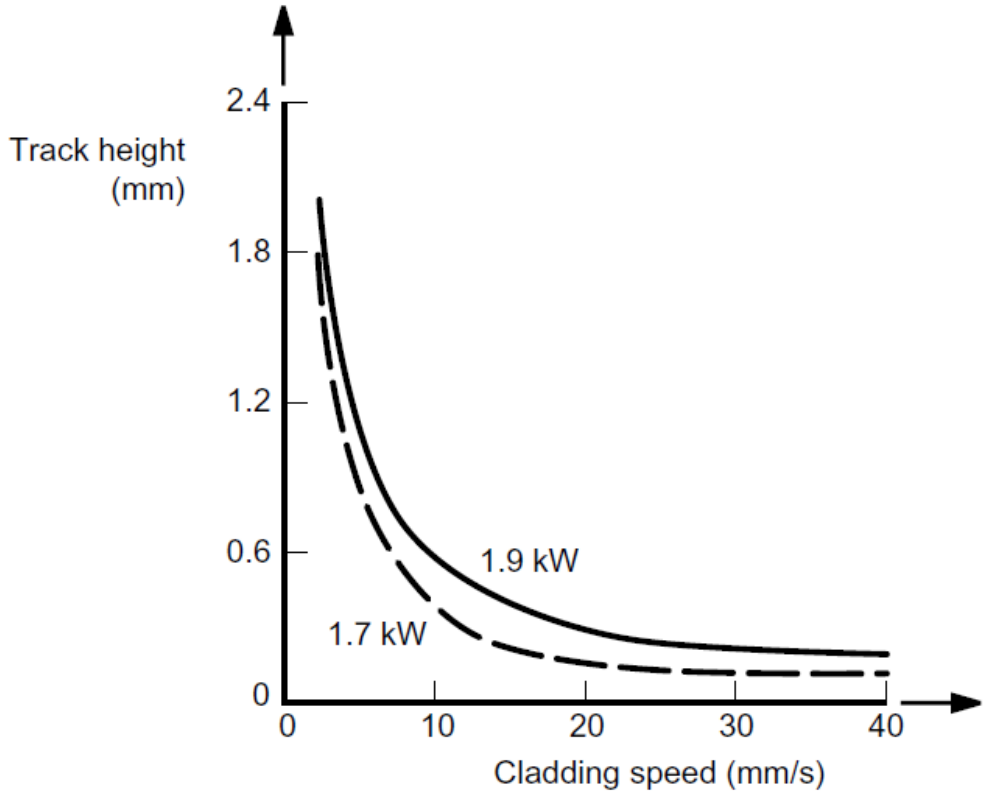


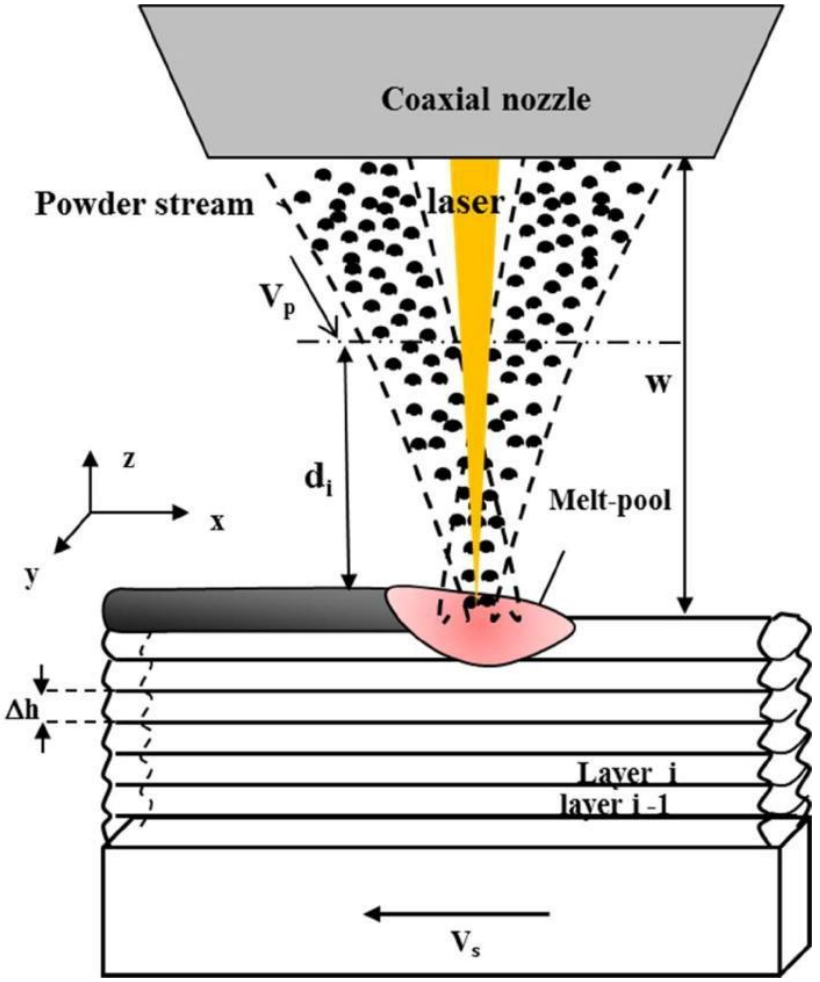


Laser Metal Depos.

Methods for Applying the Coating Material

The coating material may be applied in a number of ways.

1. **Preplaced loose powder bed.**
2. **Presprayed surfacing powder.**
3. **Prepositioned chip or rod.**
4. **Wire or ribbon feed.**
5. **Powder feed.**



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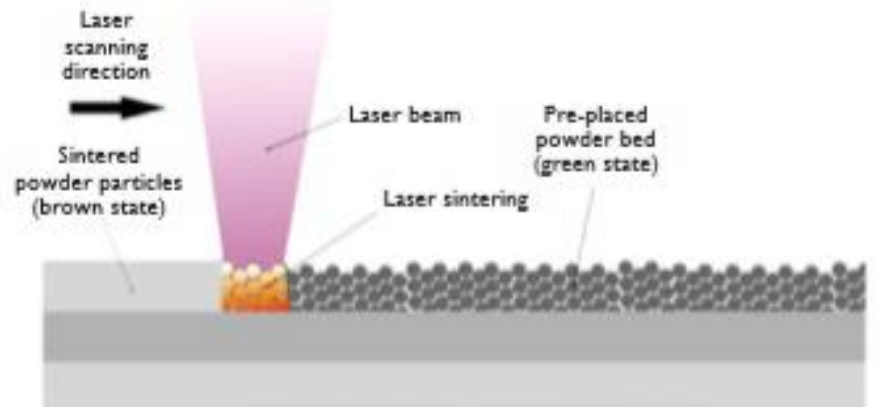

2. Presprayed surfacing powder.

3. Prepositioned chip or rod.

4. Wire or ribbon feed.

5. Powder feed.

- Complex geometries are difficult
- Shielding gas usage is difficult
- Control of the molten zone between the clad layer and substrate is difficult
- It requires a higher specific energy to melt

It has the **advantage** that it is very simple to use and is also relatively low cost.

Laser Metal Depos.

Methods for Applying the Coating Material

The coating material may be applied in a number of ways. **thermal or plasma spraying**

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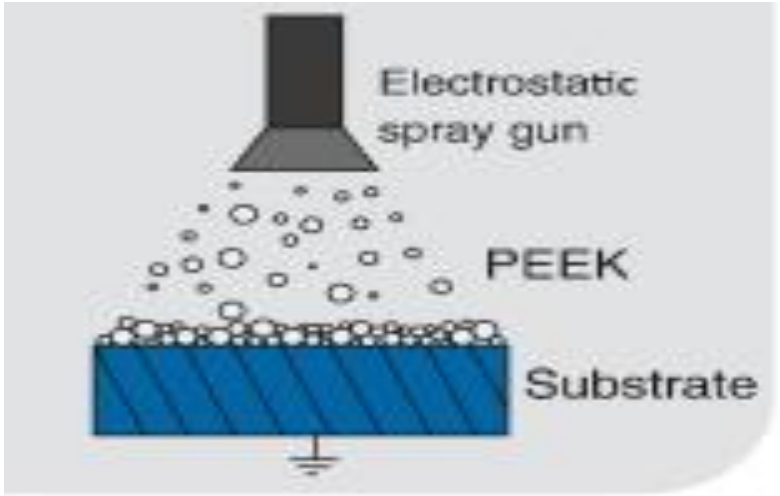

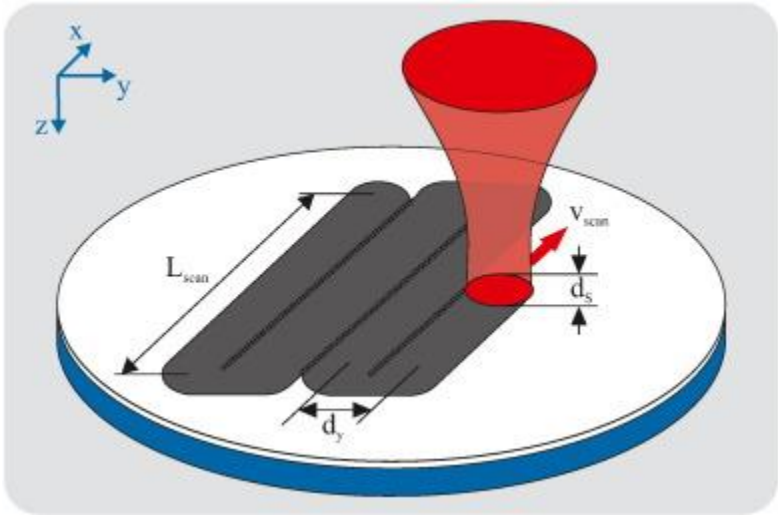

Additional processing step involved is a **drawback**

Laser Metal Depos.

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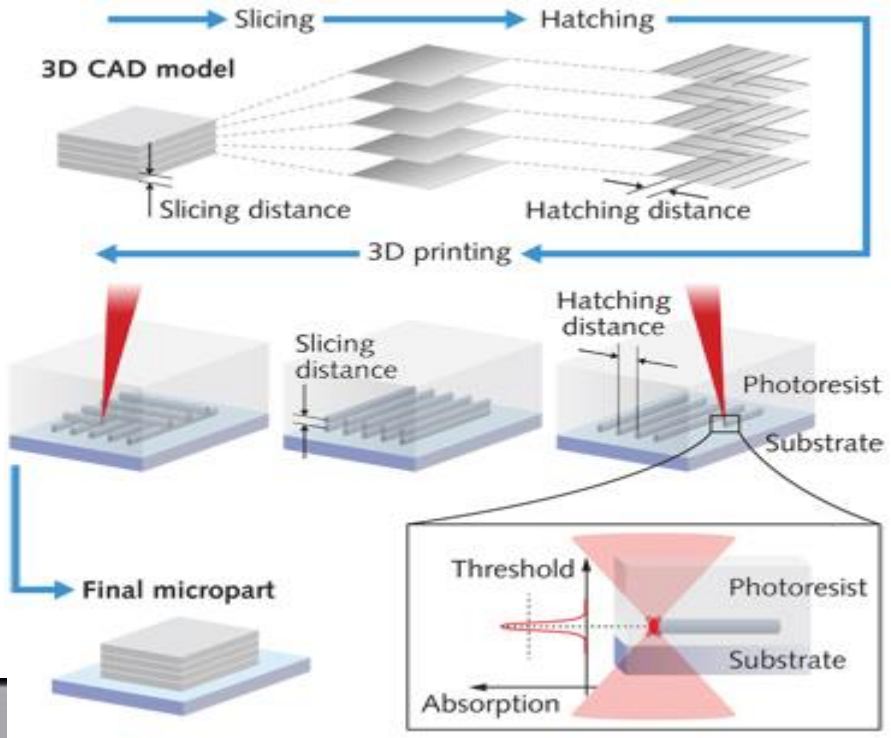

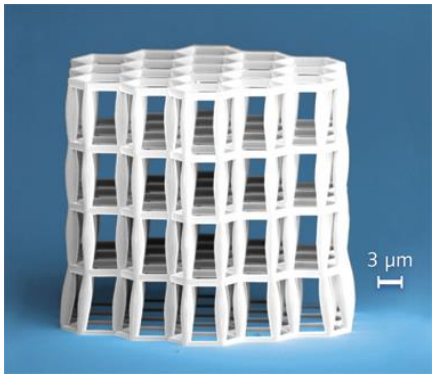

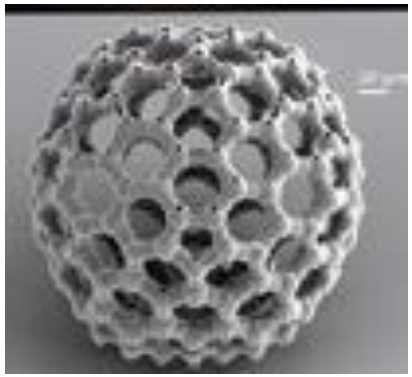

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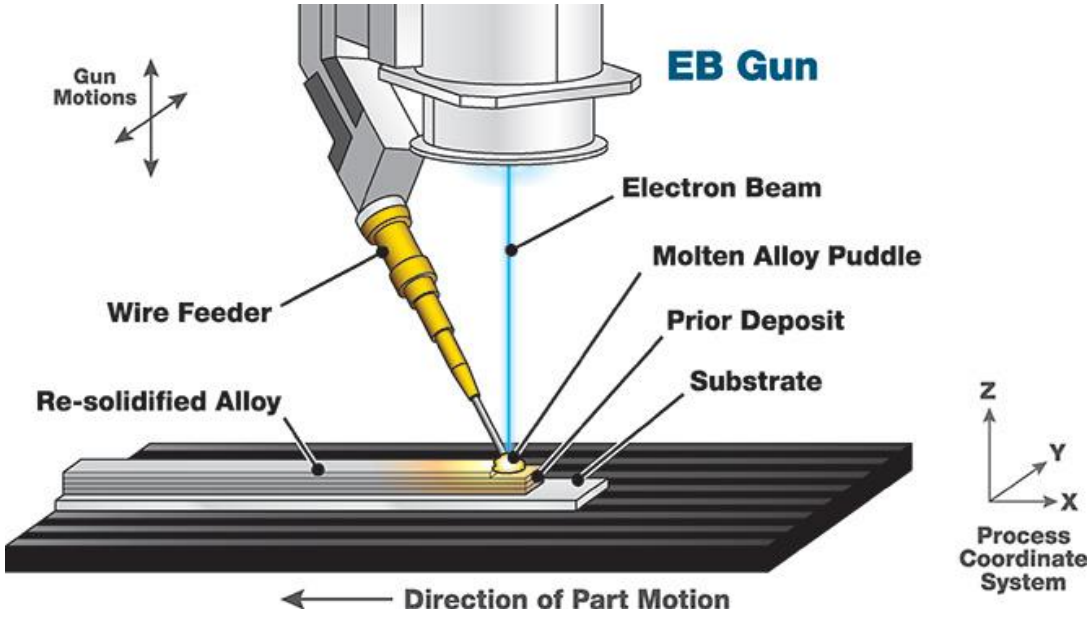

- ❑ Similar to arc or gas welding
- ❑ Complex shapes can be clad

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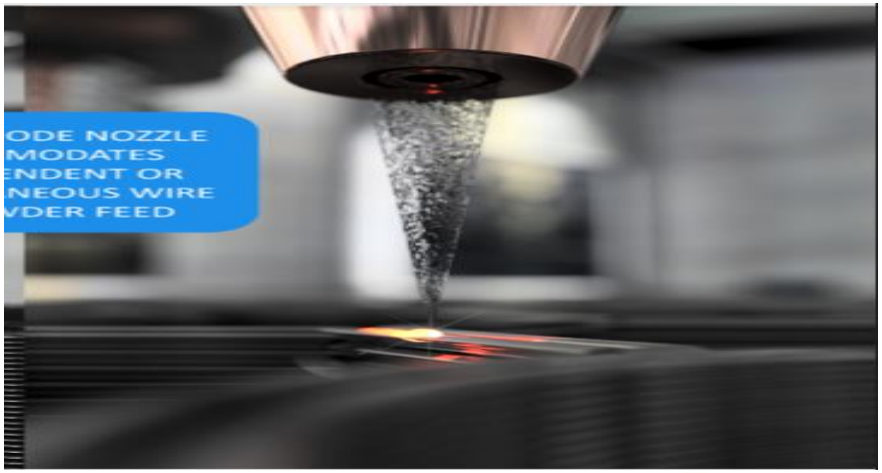

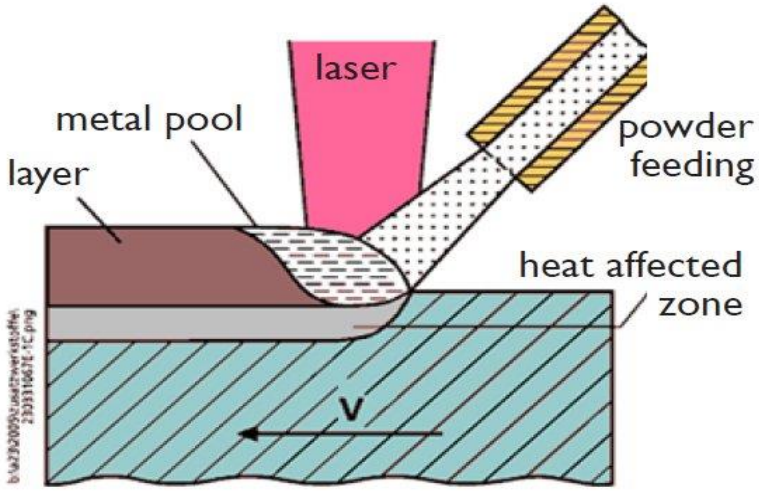

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- It involves continuously feeding the alloy powder through a nozzle that is positioned such that the powder feeds directly into the molten portion of the substrate.
- Different powder compositions can be fed in, enabling online variations in the alloy composition to be achieved.
- The powder is delivered directly in front of the molten zone.
- Using a pneumatic screw feed system with a small amount of argon gas (about 1 L/min) flowing in the tube to aid powder flow and directional placement.

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Control of the powder flow rate into the molten zone is determined by the following factors:

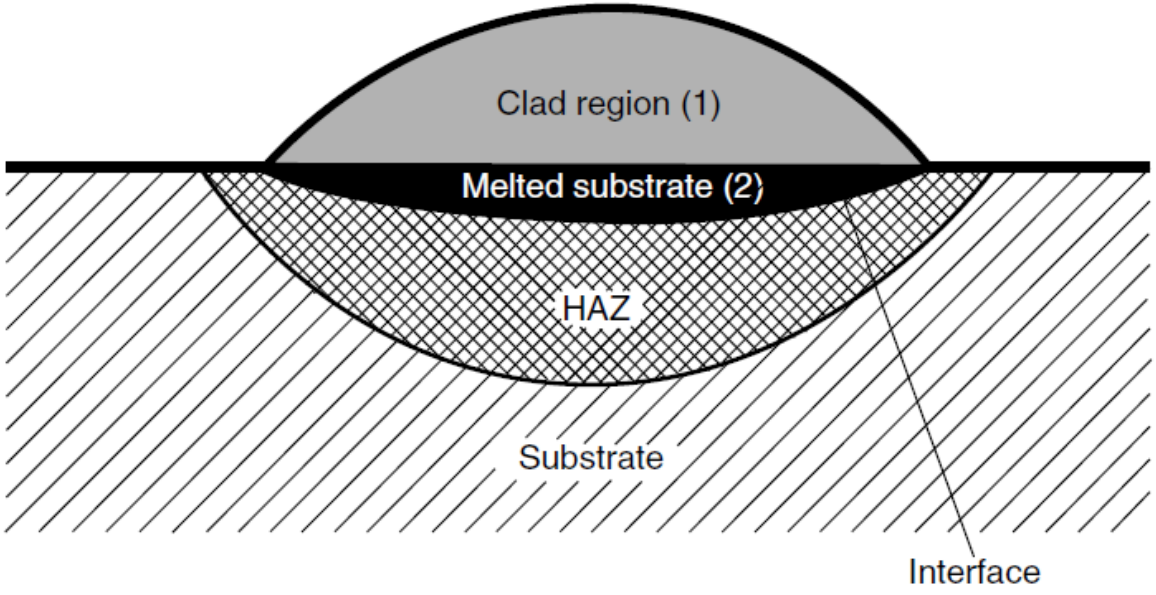
- ❑Material flow characteristics.
- ❑Powder preparation, for example, preheat.
- ❑Powder injection angle.
- ❑Shielding gas characteristics.

Since the cladding process involves addition of one or more materials to the substrate, this results in dilution or change in chemical composition of portions of the base metal.

Laser Metal Depos.

Dilution

- Integral metallurgical bond and low dilution of clad layer are required for laser cladding. During cladding, heat accumulates near the melt pool. So the dilution becomes larger and larger.

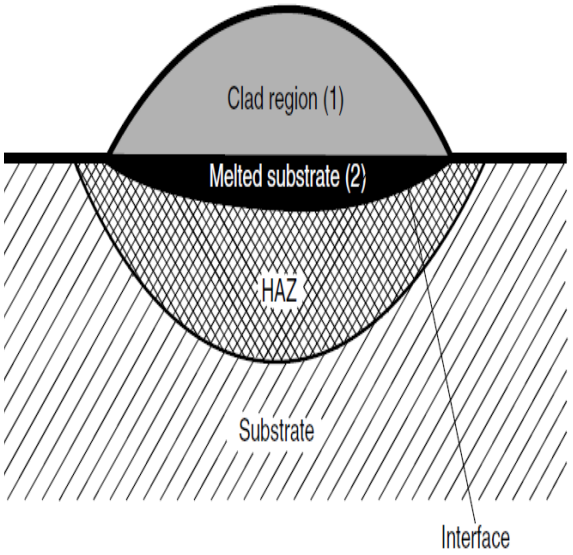


- Dilution of the clad material can be defined either as the ratio of the area of substrate melted to the total melted zone, or in terms of the chemical composition difference between the starting powder and the solidified clad layer.

Laser Metal Depos.

Dilution

$$\%\text{Area dilution} = \frac{\text{Melted substrate cross sectional area}}{\text{Clad region cross-sectional area} + \text{Melted substrate cross-sectional area}} = \frac{(2)}{(1)+(2)}$$



which is strictly applicable only to single track clads, and

$$\%\text{Chemical dilution} = \frac{C_{clad} - C_{powder}}{C_{powder}}$$

where C_{clad} is the elemental composition of the clad at a position near the substrate/clad interface and C_{powder} is the elemental composition of the starting powder.

If dilution is excessive, it can compromise the material properties of the clad and reduce the wear or corrosion performance of the clad layer.

Laser Metal Depos.

Advantages of Laser Cladding

- Potential of low dilution and limited heat effects on base metal, integral metallurgical bond, minimal warpage(bent or twist) and distortion of clad components, reduced cracking possibility, suitability for full automation, and possibility of developing coatings with non-equilibrium microstructures and superior physical properties.
- Low-heat input, and thus narrow heat-affected zone and reduced distortion.
- Reduced alloy material loss
- Minimal clad dilution of base metal (less than 2%) enables the special properties of the clad material to be maintained.
- Complete metallurgical bonding to the substrate, resulting in high-integrity coating.

Laser Metal Depos.

Disadvantages of Laser Cladding

- It is not the method of choice when the area to be hardened is relatively small .
- It is more expensive than comparative processes that use plasma arc or gas tungsten arc heat sources.