SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF AEROSPACE ENGINEERING

19ASZ401 – 3D PRINTING FOR SPACE COMPONENTS
IV YEAR VII SEM
UNIT-III Photo polymerization and Powder Bed Fusion Process
TOPIC: Powder Bed Fusion process parameters

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Process parameters in PBF

- **LBM**
  - Power of laser source
  - scan speed
  - hatch distance
  - laser tracks
  - thickness of powdered layer
- **EBM**
  - Electron beam power,
  - Current
  - diameter of focus
  - powder pre-heat temperature
  - layer thickness

Porosity in PBF parts

- Types of pores in PBF parts

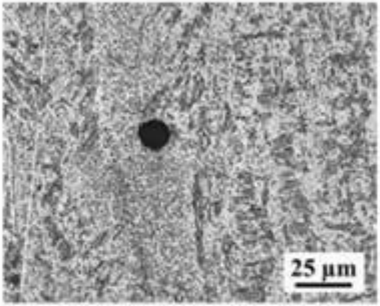


Fig.4 pore due to trapped gas in SLM processed TI-6Al-4V

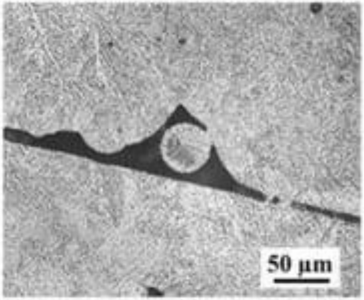
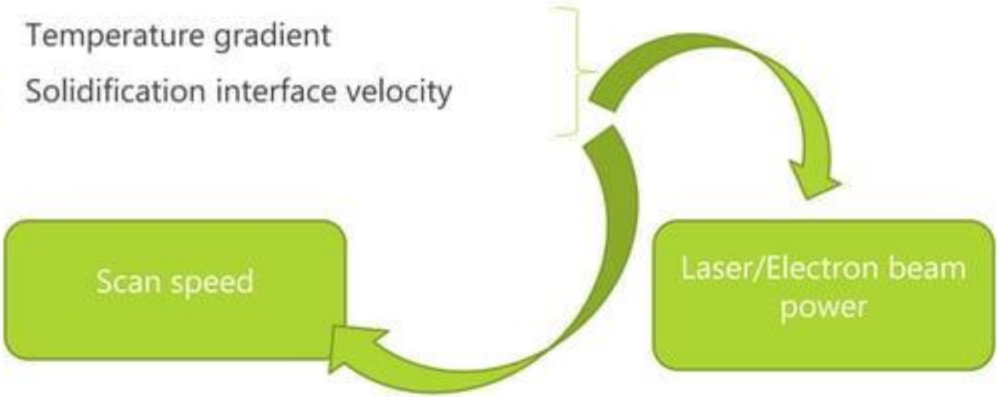


Fig.5 pore due to insufficient heating in SLM processed TI-6Al-4V

PBF Microstructure

- Factors affecting grain microstructure
  - Temperature gradient
  - Solidification interface velocity



Laser Scan Strategy in AM

- laser power
- Laser spot size
- scan speed,
- hatch distance

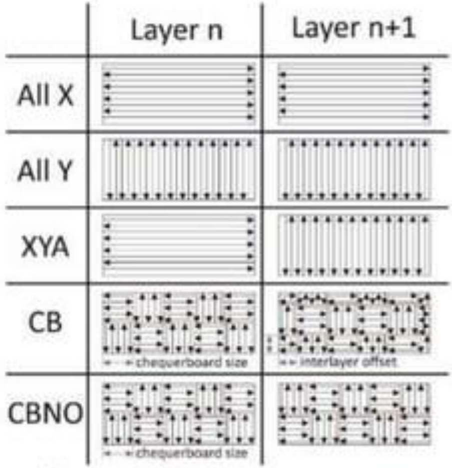


Fig.6 Schematic of laser scanning strategies used

Density variations with laser power and scanning velocity in SLM

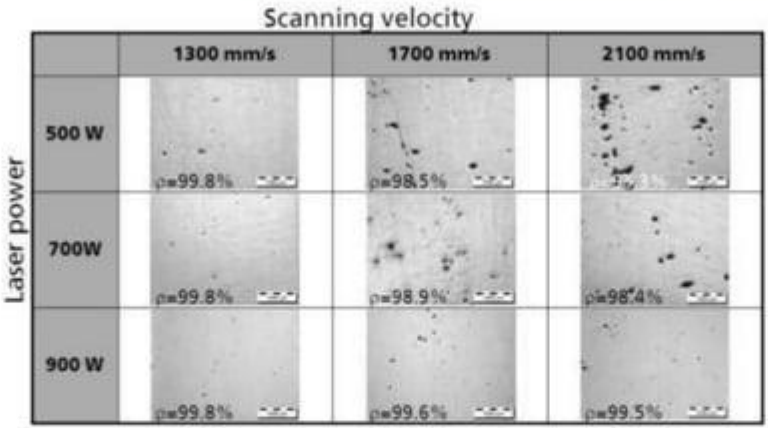


Fig.8 Densities by means of cross sections of SLM samples depending on scanning velocity and laser power

Effect of scanline spacing on Density in SLM

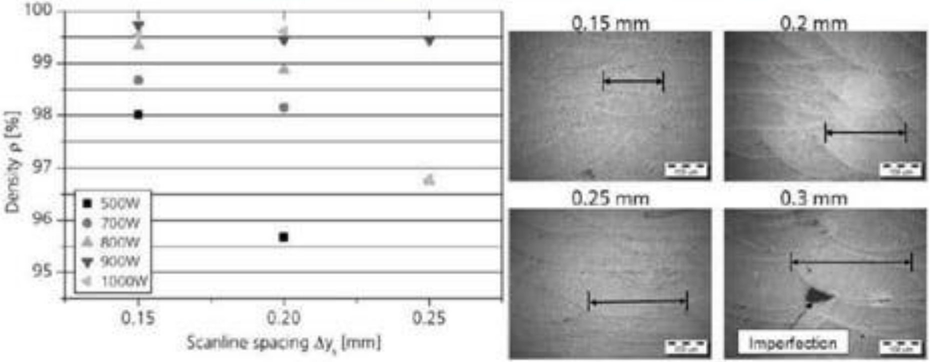


Fig.9 . Density depending on scanline spacing, P_L = 900 W, Vs = 1700 mm/s, Ds = 50 µm (left), Cross sections of SLM samples built with different scanline spacings (right)

Hardness variations with scanning velocity and scanline spacing

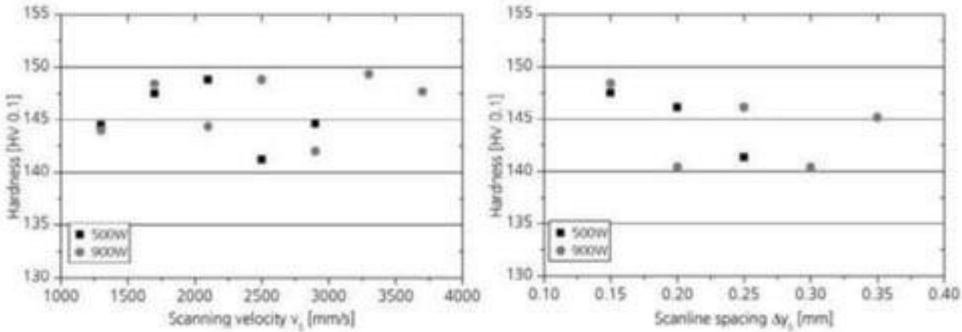


Fig.10 . Hardness depending on scanning velocity (left), Hardness depending on scanline spacing (right)

Multi-material PBF

- A critical requirement **in multiple material SLM** is **to deposit at least two discrete powder materials within one layer.**
- 316L **stainless steel**, In718 **nickel alloy** and Cu10Sn **copper alloy**
- combining powder-bed spreading, point-by-point multiple nozzles ultrasonic dry powder delivery, and point-by-point single layer powder removal to realize multiple material fusion within the same layer and across different layers

Multi-material PBF

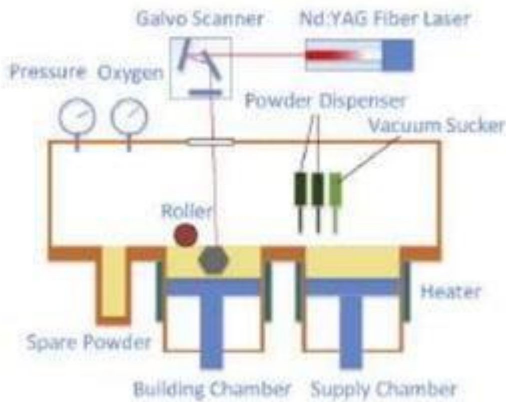


Fig.10 Schematic of multi-material PBF equipment

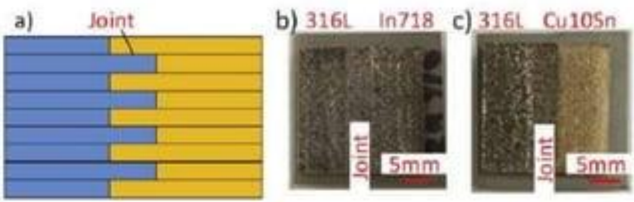


Fig.11 Multi-material PBF specimen

Materials in DED

- Titanium alloys
- Stainless steel
- Tool steels
- Aluminium alloys
- Refractory metals (tantalum, tungsten, niobium)
- Superalloys (Inconel, Hastelloy)
- Nickel
- Copper

Process parameters in laser DED

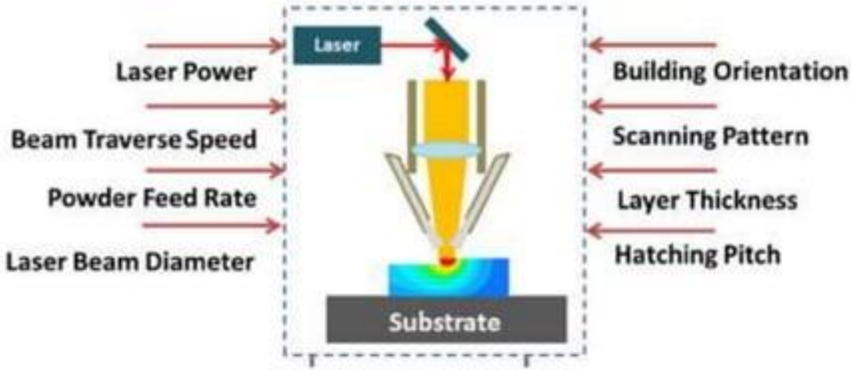
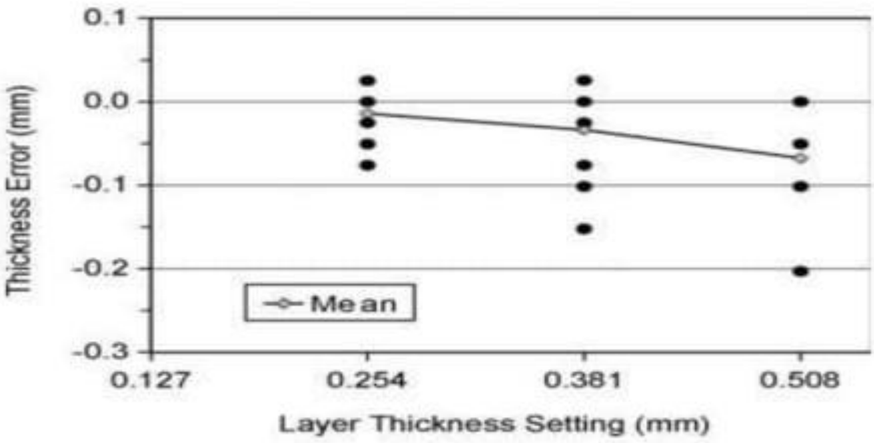
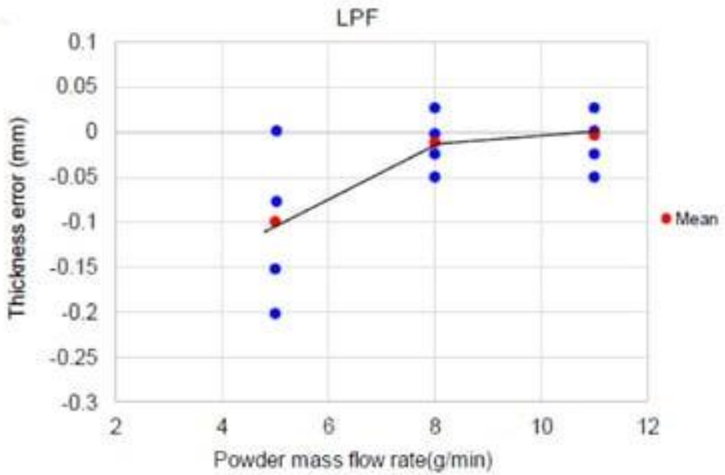


Fig.13 Process parameters in laser DED

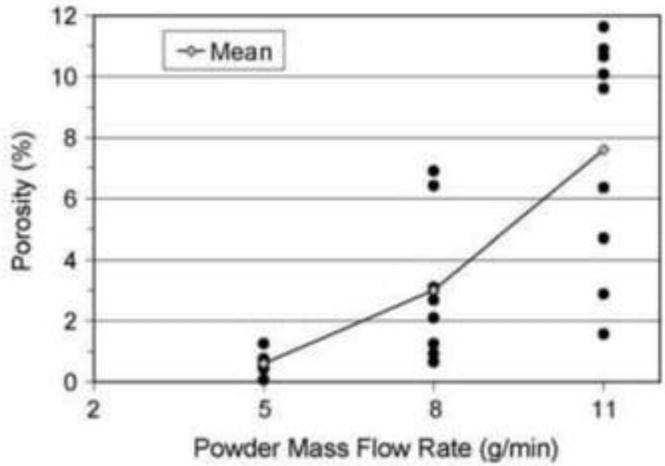
Effect of layer thickness on thickness error



Effect of powder mass flow rate on thickness error



Influence of powder mass flow rate on porosity



Comparison of DED and PBF

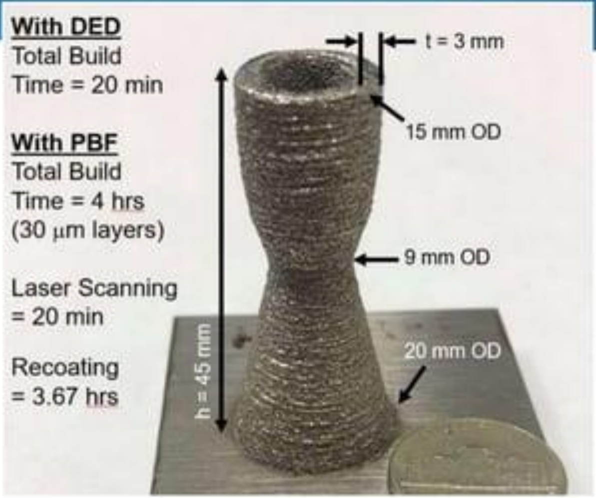


Fig.14 Build-time comparisons for laser-based DED and PBF for a small titanium nozzle. The material is Ti-6Al-4V.

Process parameters in binder jetting

- Drying time
- Printing saturation
- Powder characteristics
- Layer thickness
- Binder burnout and sintering
- Sintering additives
- Infiltration of nanoparticles into porous BJ printed parts

Post processing in binder jetting

- The main drawback of metal Binder Jetting parts are their mechanical properties, which are not suitable for high-end applications.
- **Reason** : printed parts basically consist of metal particles bound together with a **polymer adhesive**.

1. **Infiltration**
2. **Sintering**

Post processing in binder jetting

- **Infiltration**: After printing, the part is placed in a furnace, where the binder is burnt out leaving voids. At this point, the part is approximately 60% porous**. Bronze is then used to infiltrate the voids** via capillary action, resulting in parts with low porosity and good strength.
- **Sintering:** After printing is complete, the parts are placed in a high temperature furnace, where the **binder is burnt out** and the remaining metal particles are sintered (bonded) together, resulting in parts with very low porosity.

Advancements in binder jetting

- Binder jetting additive manufacturing with a particle-free **metal ink** as a binder precursor
- using **metal nanoparticles** ink as a binder to replace polymer adhesives
- **Metal-Organic-Decomposition (MOD) ink**
- MOD ink contains an organometallic compound formed by introducing ligands (complexing agents) to metal salts

Process Parameters in UAM

- Weld speed
- Sonotrode oscillation amplitude
- Weld pressure
- Anvil temperature
- Sonotrode topology

THANK YOU