

COMMON DEFECTS, AND POST PROCESSING

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CONTENTS

- Defects in AM Printed Parts
- Need of Post Processing
- Need for Surface Finishing
- Common Post Processing for MAM



COMMON DEFECTS

1. Elongated, non-spherical pores

2. Gas Pores

3. Unfused powder

4. Balling effect

5. Cracking

6. Warping

7. Delamination

8. Swelling

Laser Power ↓ or Feed rate ↑



→ Laser + layer thickness

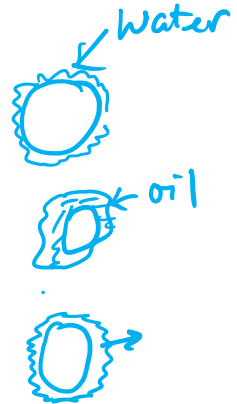
- 1. Surface tension
- 2. Viscosity
- 3. Thermal gradient etc



COMMON DEFECTS

1. ELONGATED, NON-SPHERICAL PORES

- Processed induced defect
- Due to an inefficient melting regime
 - Too little energy input with respect to hatching distance or layer thickness
 - Spatter and fumes ejection (too much energy input)



2. GAS PORES ↩

- Due to powder surface chemistry modification
- Due to trapped gas in particles that are released during melting and locked in during solidification.

AI → ML → DL → Pores → Cause for Pores



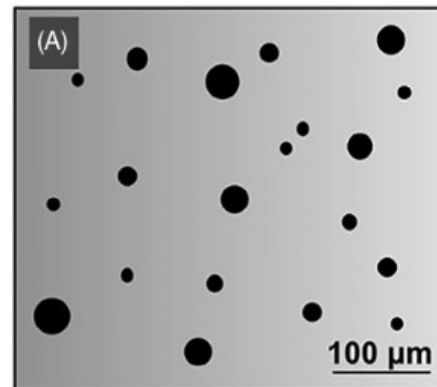
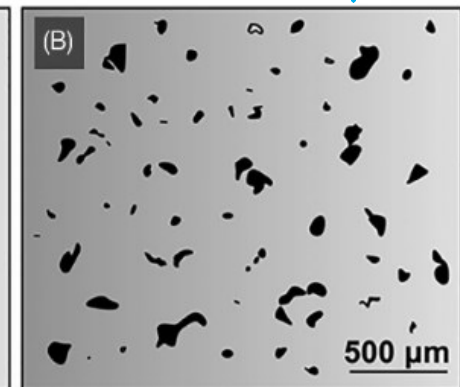
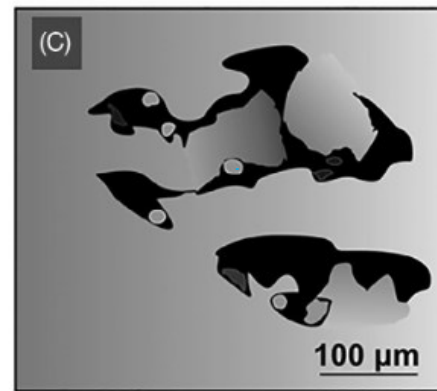
COMMON DEFECTS

POROSITY

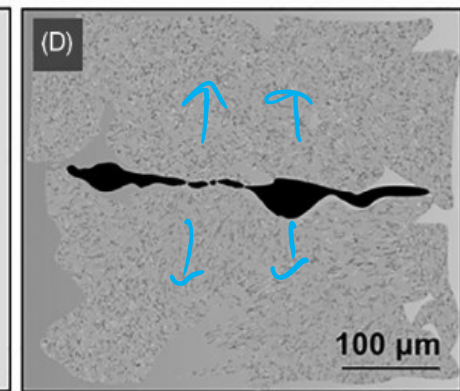
- A. Entrapped gas porosity
- B. Incomplete melting induced porosity
- C. Lack of fusion with unmelted particles inside large irregular pores
- D. Cracks

gas

incomplete melting



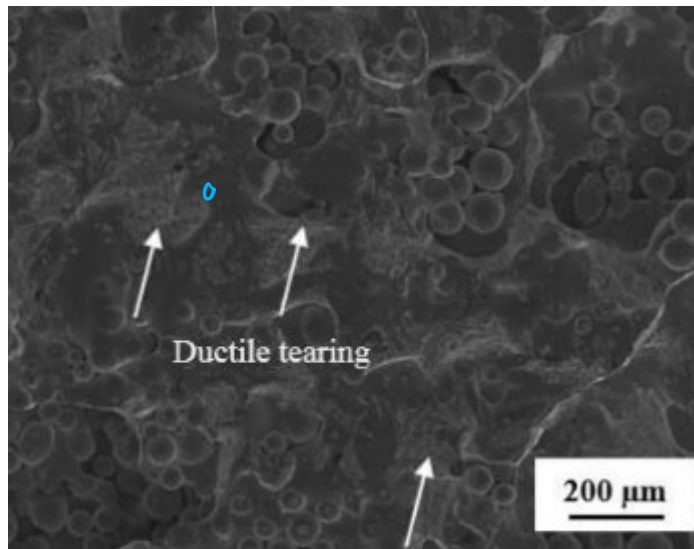
lack of fusion!



COMMON DEFECTS

3. UNFUSED POWDER

- Processed induced defect
- Due to insufficient melting or overlap between successive layers or adjacent melted tracks



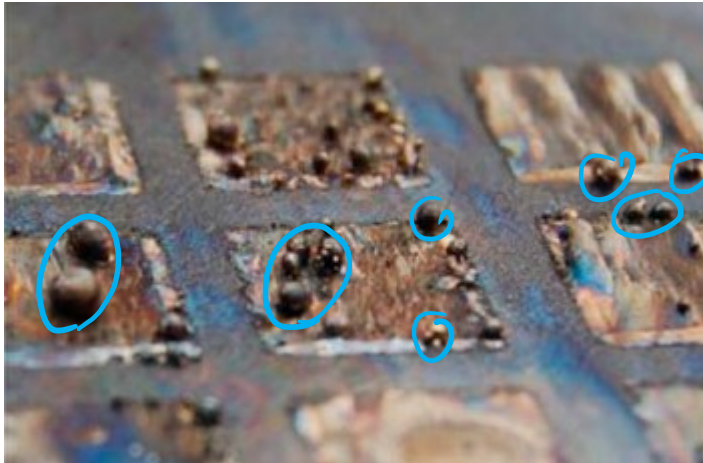
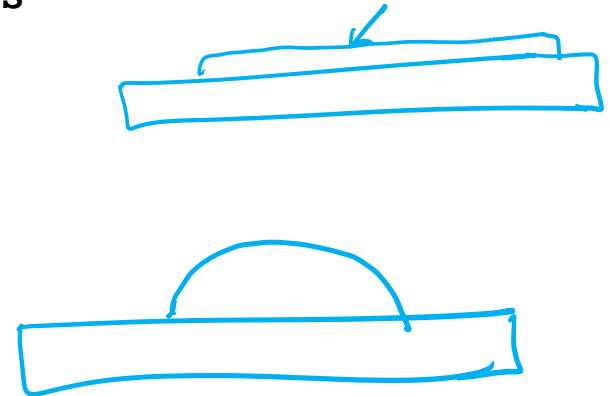
Unmelted powder particles



COMMON DEFECTS

4. Balling

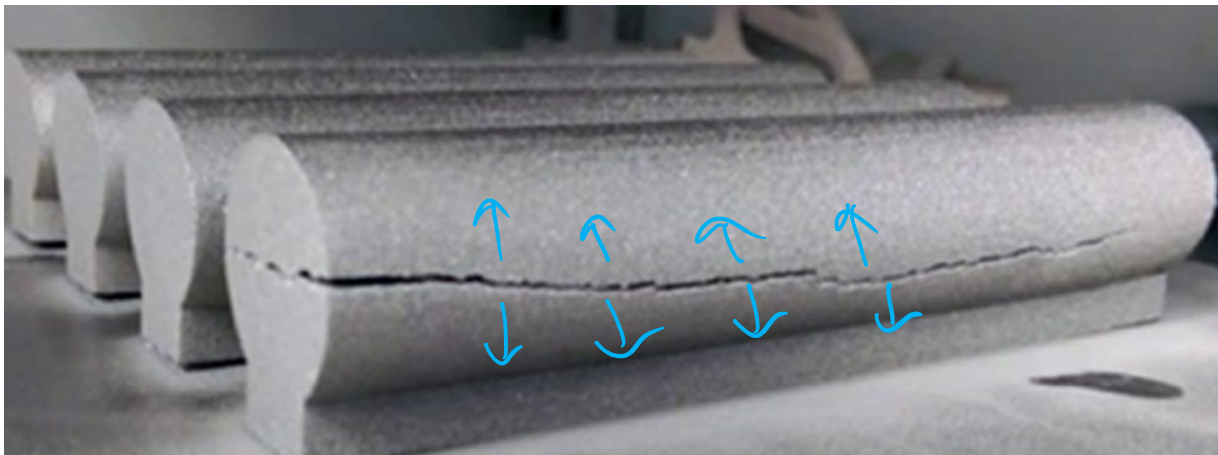
- Solidification of melted material into spheres ←
- Due to lack of wettability with the previous layer, driven by surface tension
- Directly related to melt pool characteristics



COMMON DEFECTS

5. CRACKING

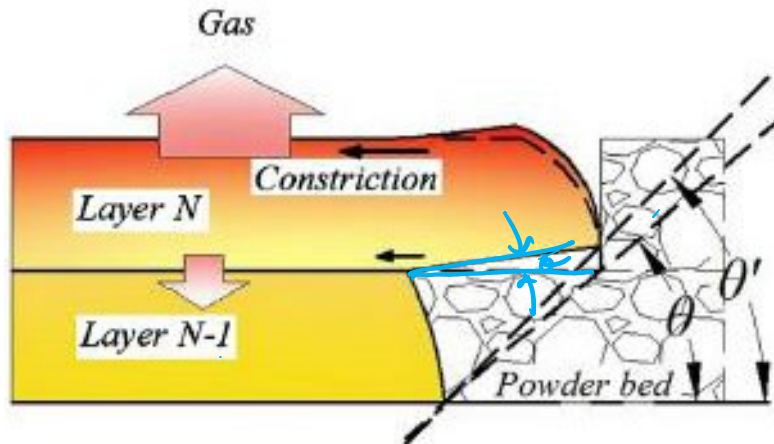
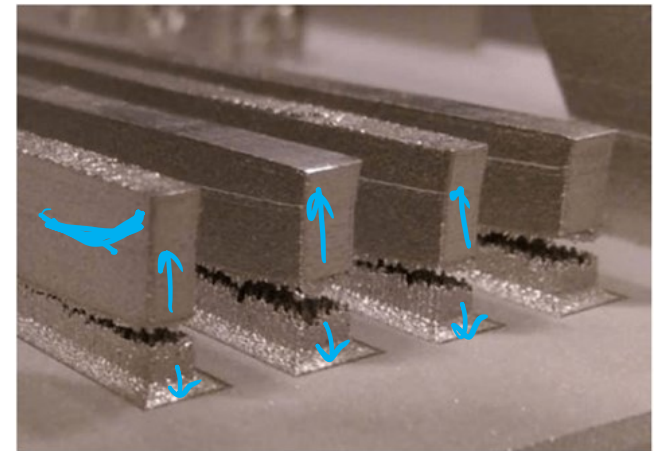
- Due to solidification cracking or grain boundary cracking or other macroscopic effects like
 - Residual stress
 - Surface roughness



COMMON DEFECTS

6. WARPING

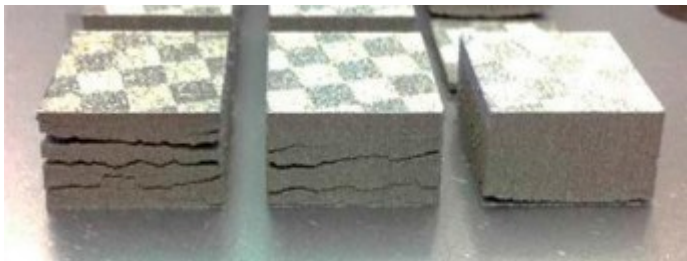
- Occurs between two layers or at the boundary between support and part layer (curling)
- Occurs when the build is stopped and re-started or at the boundary between substrate and first layers



COMMON DEFECTS

7. DELAMINATION

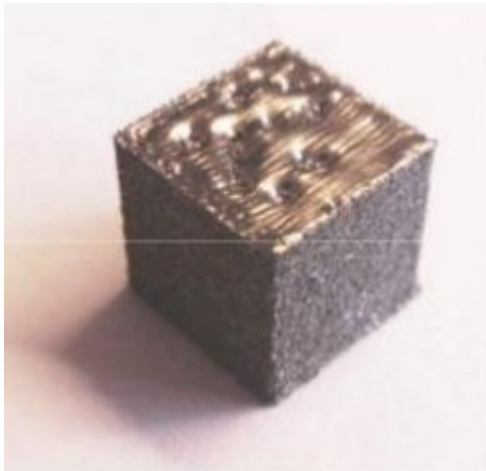
- Separation of successive layers
- Due to inappropriate melting overlap with previous underlying solidified powder or incomplete particles melting.
- Macroscopic effects cannot be repaired by post-processing



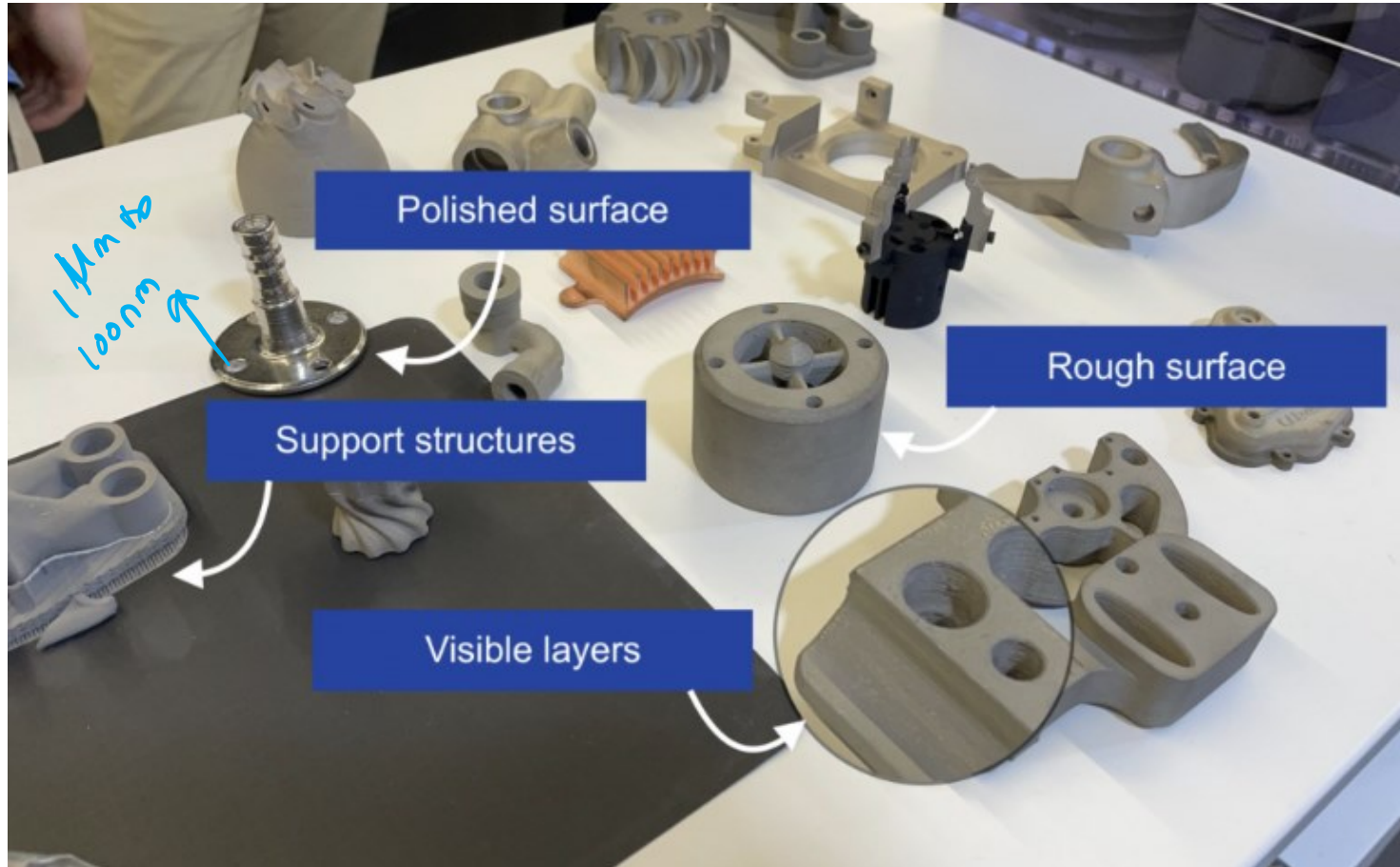
COMMON DEFECTS

8. SWELLING

- Similar to the humping phenomenon in welding
- Occurs due to surface tension effects related to the melt pool geometry



NEED OF POST PROCESSING



WHY DO AM SURFACES NEED TO BE FINISHED?

- AM has the potential to transform the component design in high-value and/or low-volume manufacturing.
- AM applications range from topology optimization for fatigue performance and light-weighting in aerospace to bespoke one-off components for patient implants and operation guides in medicine.
- Surface topographies may alter functional requirements for these applications' components.

→ R_a^+ → need → Bio medical
↳ cell attached.

R_a^- → need → also + auto



POST PROCESSING

Post processing can be divided into three categories:

1. Process-inherent process

- i. De-powdering
- ii. Support removal
- iii. Stress relief

2. Mechanical properties

- i. Heat treatment (affecting hardness, ductility, and fatigue life)
- ii. Surface treatment and finishes (maximize visual appeal)

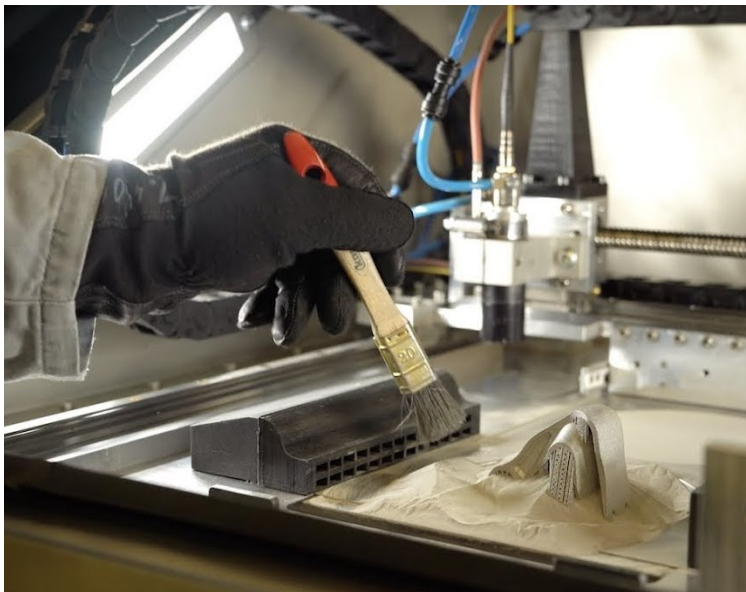
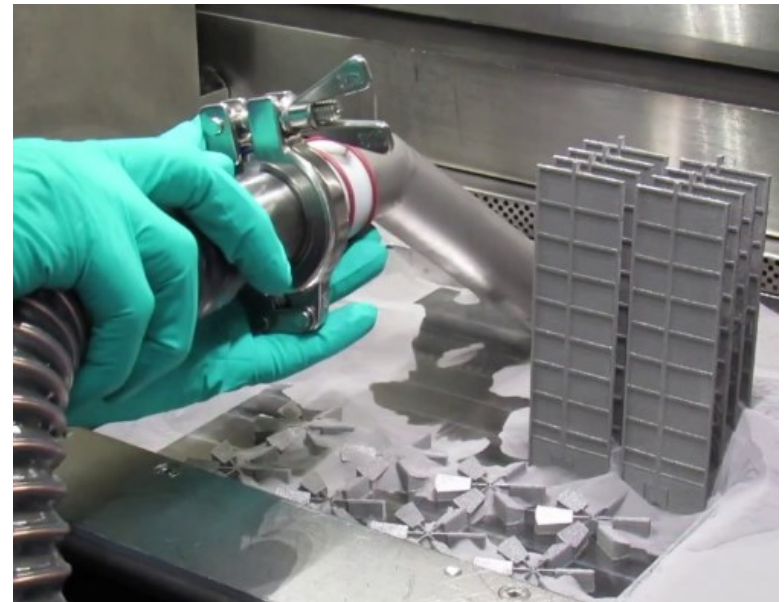
3. Visual inspection



POST PROCESSING

■ POWDER REMOVAL

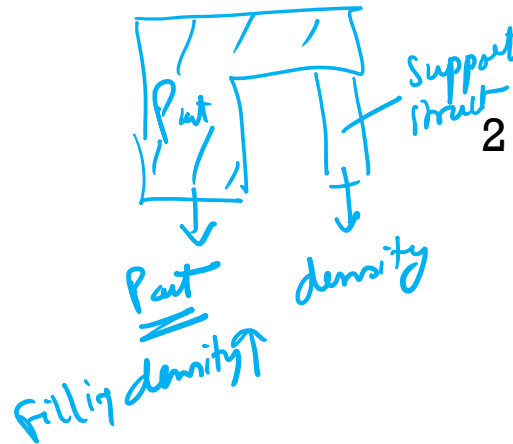
- Achieved with standard cleaning procedures
- Often unused powder is recycled and reused



POST PROCESSING

■ SUPPORT REMOVAL

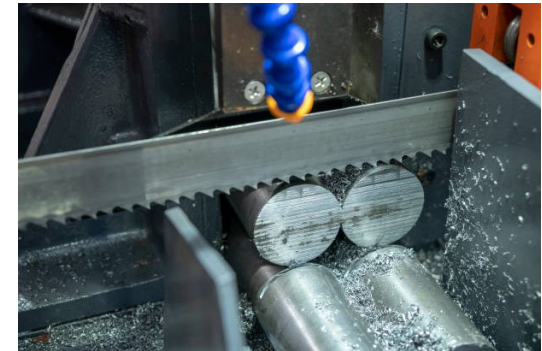
1. Cutting /
2. Band Saw /
3. Drilling /
4. CNC Machining /
5. Wire EDM /



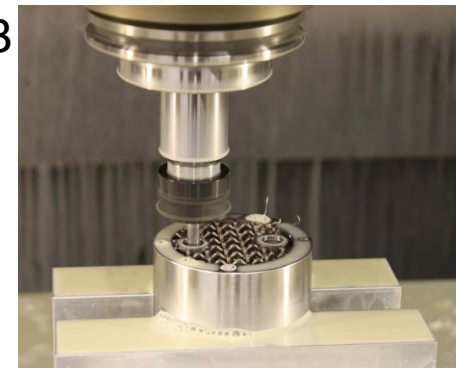
1



2



3



4



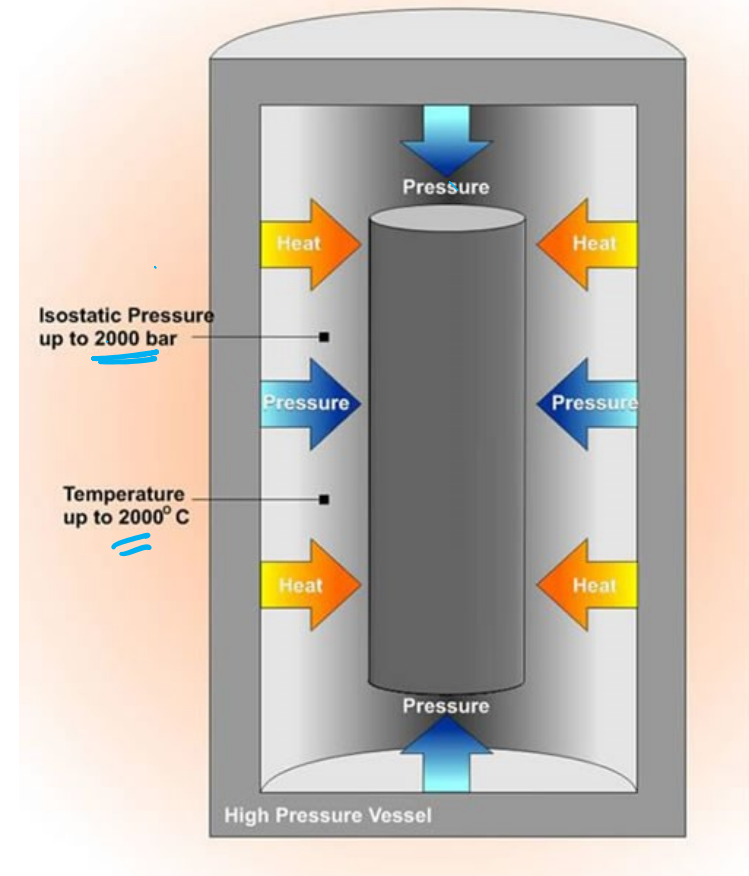
5



POST PROCESSING

HEAT TREATMENT

- Hot Isostatic Pressing (HIP)
- Densifies material and removes the defect
- Improves mechanical properties
- Increase reliability and performance
- High Efficiency and lower production cost



POST PROCESSING

ANNEALING

- Increased stress relief
- Improved mechanical properties



- Selective HT
- Bulk HT



POST PROCESSING

SURFACE FINISHING

- Last Touch
- Smoothing and Polishing of surface
- Optimize aesthetics → metal mirrors
- Reduce roughness to a minimum (if required)



POST PROCESSING

COMMON SURFACE FINISHING OPERATION

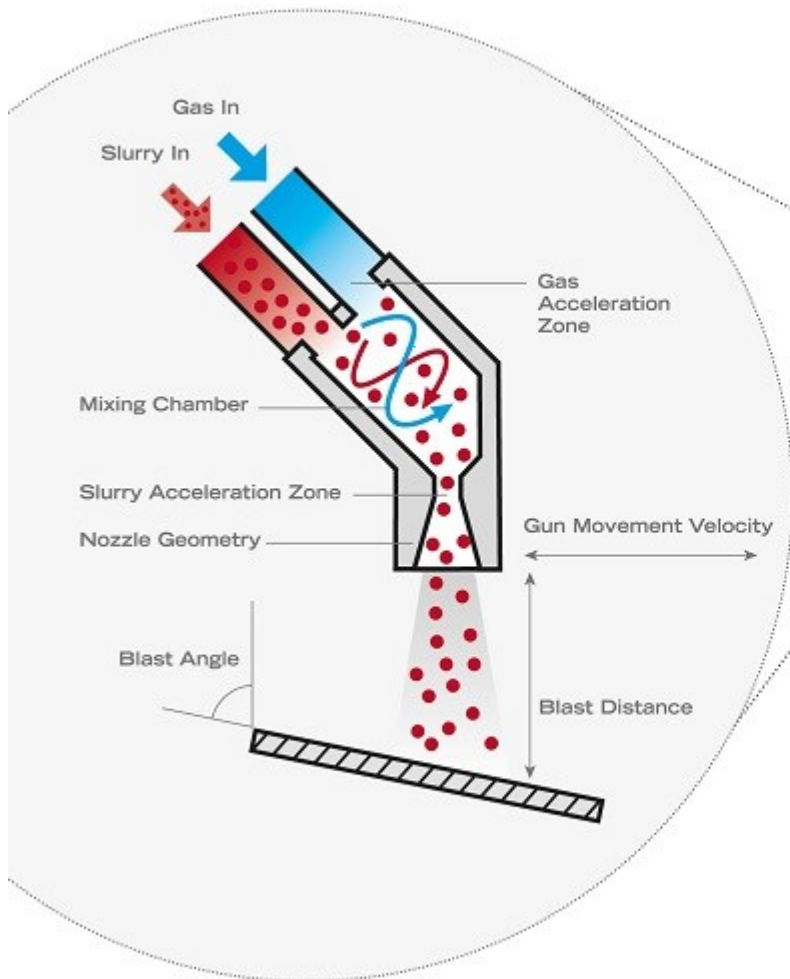
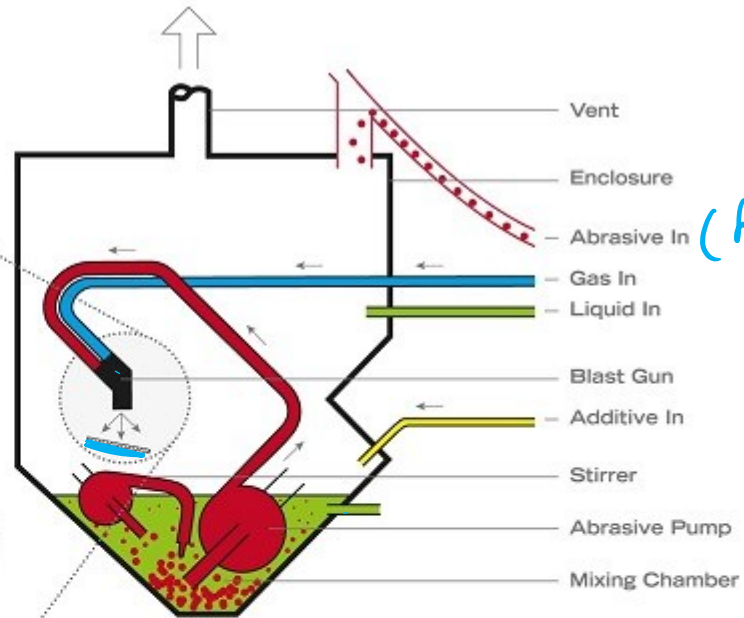
- Bead blasting ←
- Anodizing ←
- Electroplating or metal plating ←
- Laser polishing ←

..... → glass bead → Pressurized air
↓
Work Piece.



POST PROCESSING

BEAD BLASTING



Controllable Factors

Gas - Type, Pressure, Flow Speed and Temperature

Slurry - Solid/Liquid Ratio

Liquid - Type, Pressure, Flow Speed and Temperature

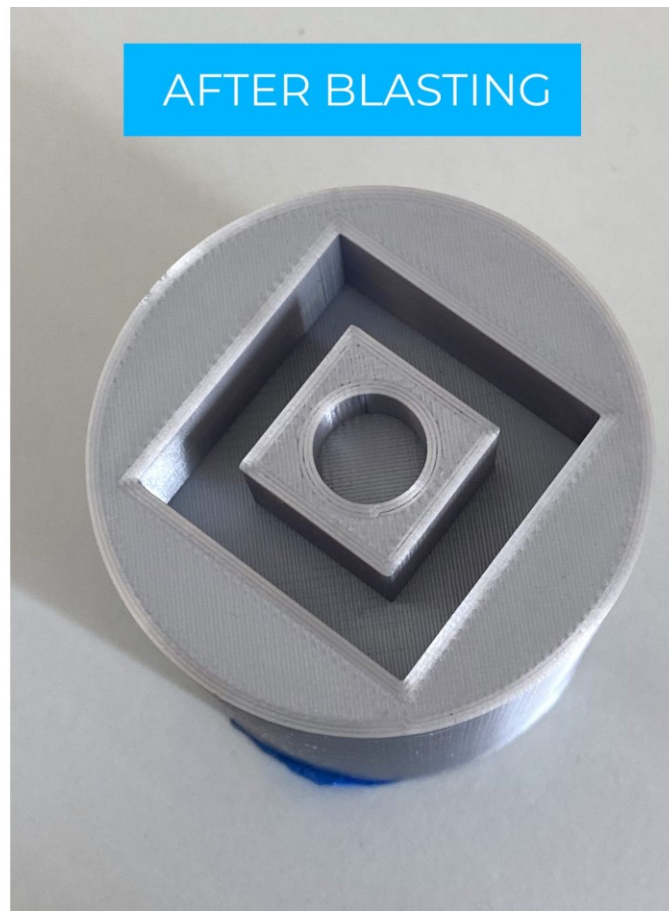
Solid - Type, Size, Hardness and Shape

Gun/part kinematics - Velocity, Distance and Angle



POST PROCESSING

BEAD BLASTING



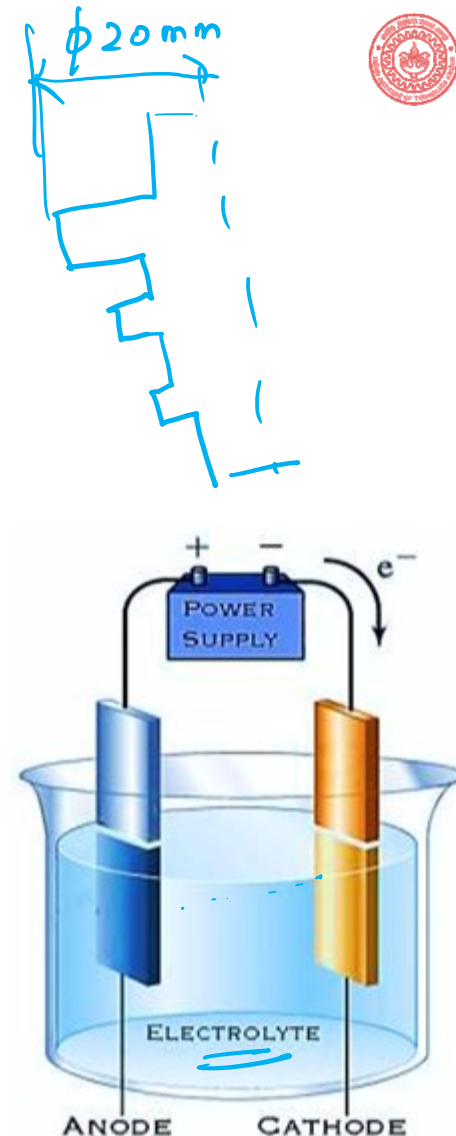
POST PROCESSING

ANODIZING

- The part is dipped in an electrolytic solution and endowed with a protective anodic layer that increases hardness and resistance to corrosion, wear, and electrical conductivity.

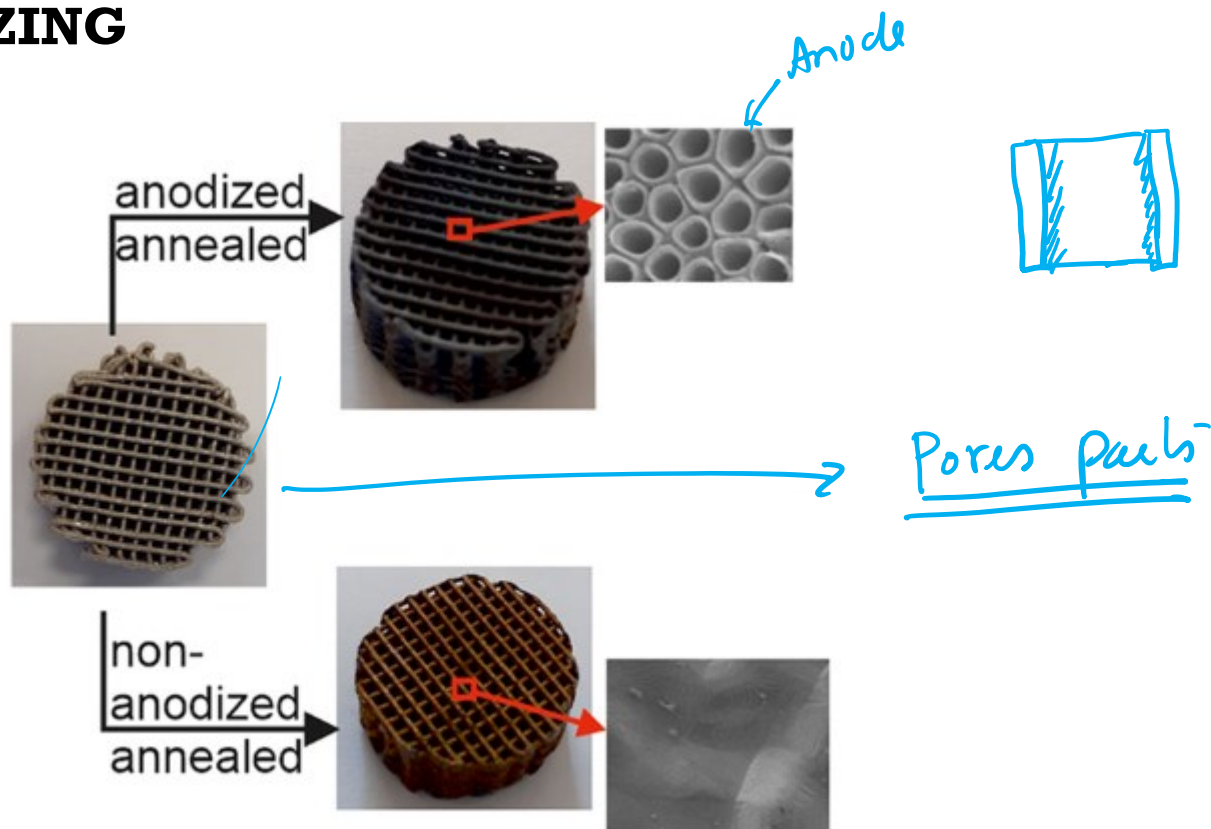
▪ ELECTROPLATING

- Similar to anodizing
- Metal coating
- Prevents corrosion



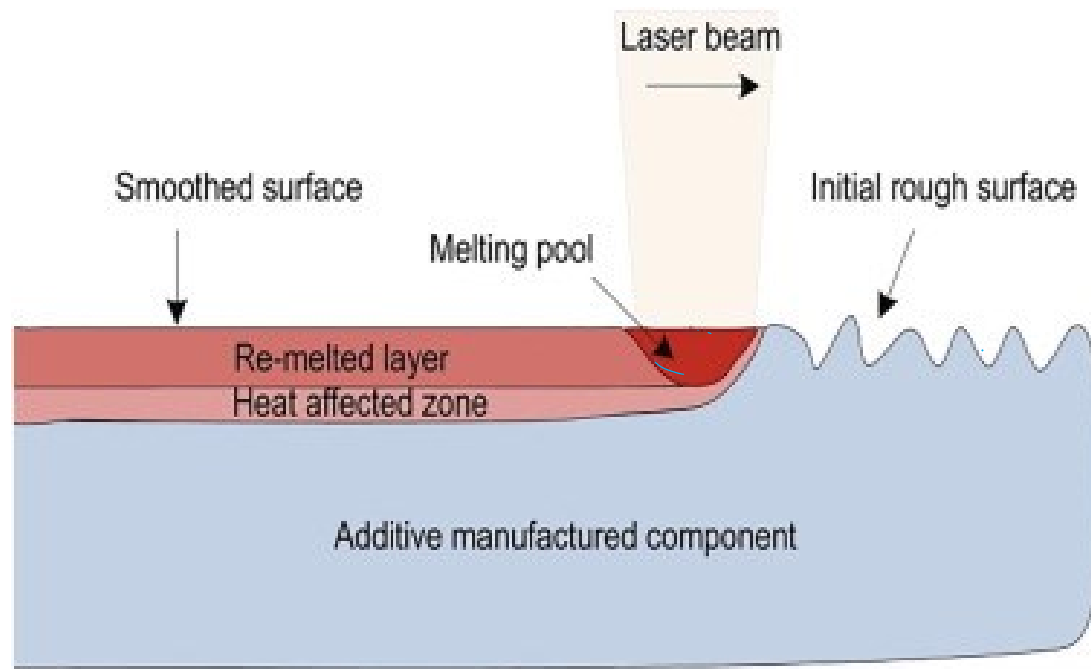
POST PROCESSING

ANODIZING



POST PROCESSING

LASER POLISHING



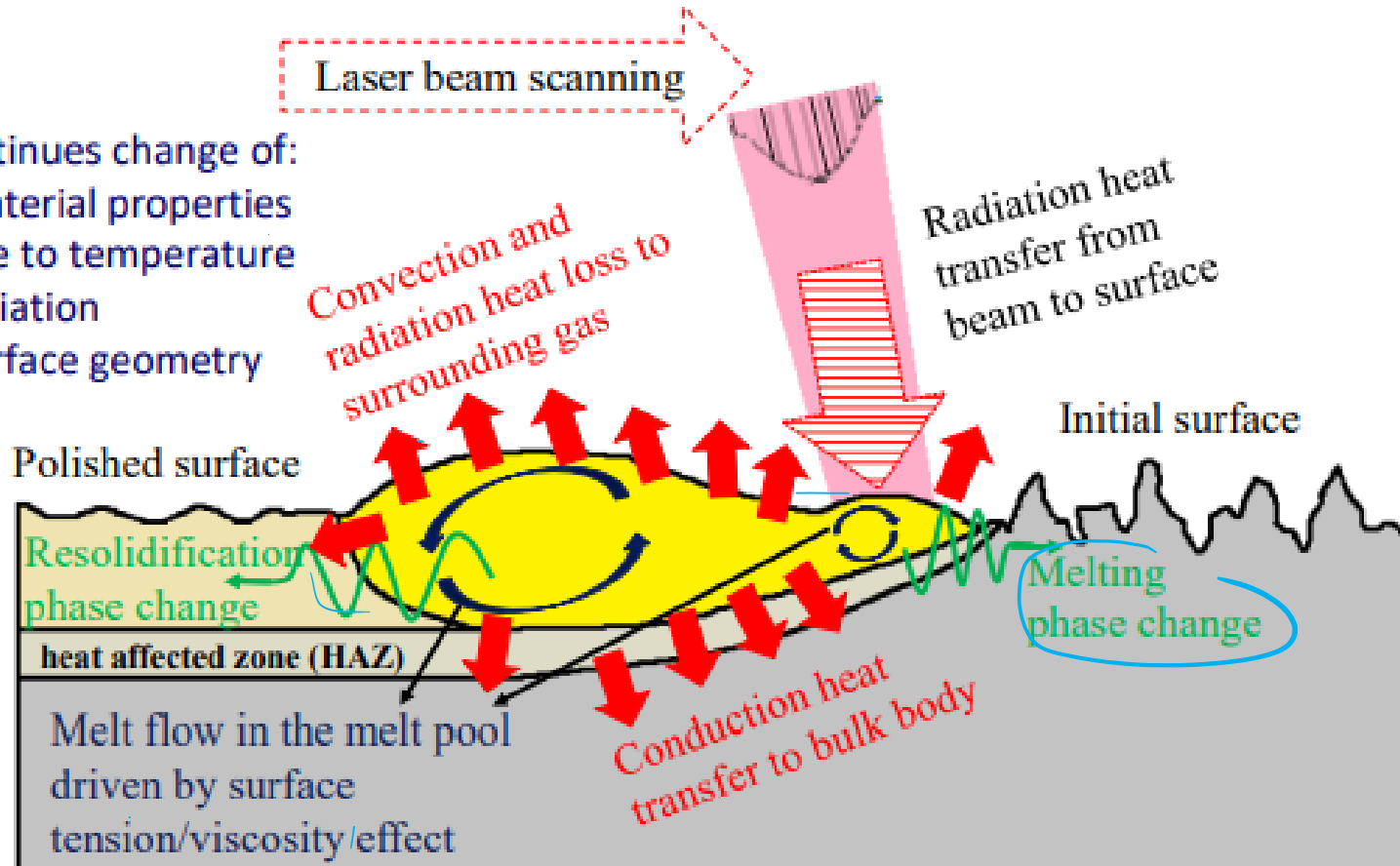
POST PROCESSING

LASER POLISHING

- Laser AM
- Laser Spectroscopy
- Laser Polish

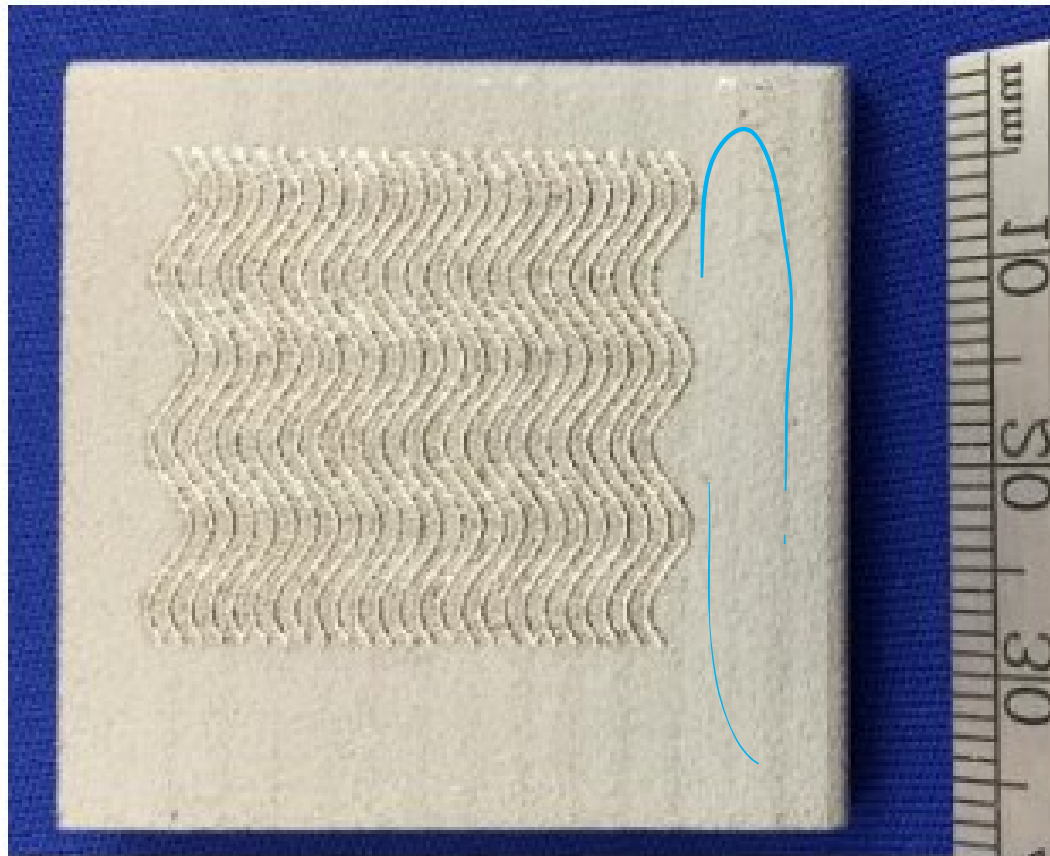
Continues change of:

- Material properties due to temperature variation
- Surface geometry



POST PROCESSING

LASER POLISHING



POINTS TO PONDER

- Name the common defects in metal printed parts
- What is the importance of post processing?
- What are major post processing techniques to remove defects?



ASSIGNMENT

- Make a chart of defects and their cause in MAM
- Provide solutions for MAM defects

PBF < L
E
DEP



THANK YOU

