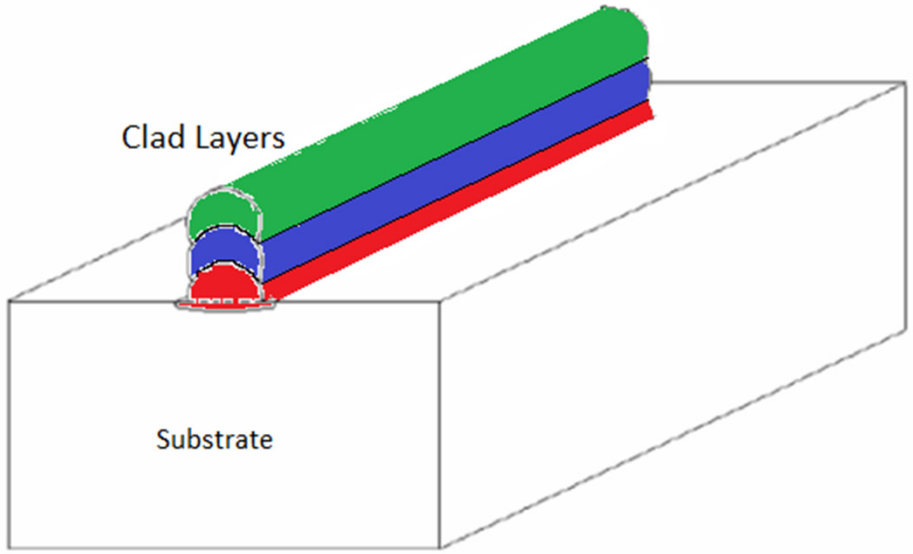
LASER SURFACE CLADDING

OUTLINE

- Process Description
- Mechanism of Laser Surface Cladding
- Power Attenuation
- Applications

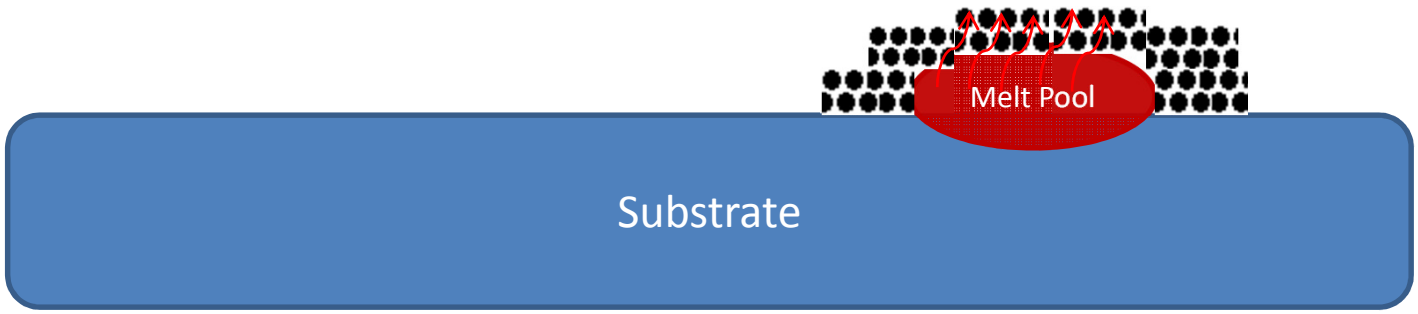
INTRODUCTION

- Fuse with laser beam another material - of desired properties - on substrate material
- Metallurgical Bonding at surface
- Minimal dilution between material layers



PROCESS MECHANISM

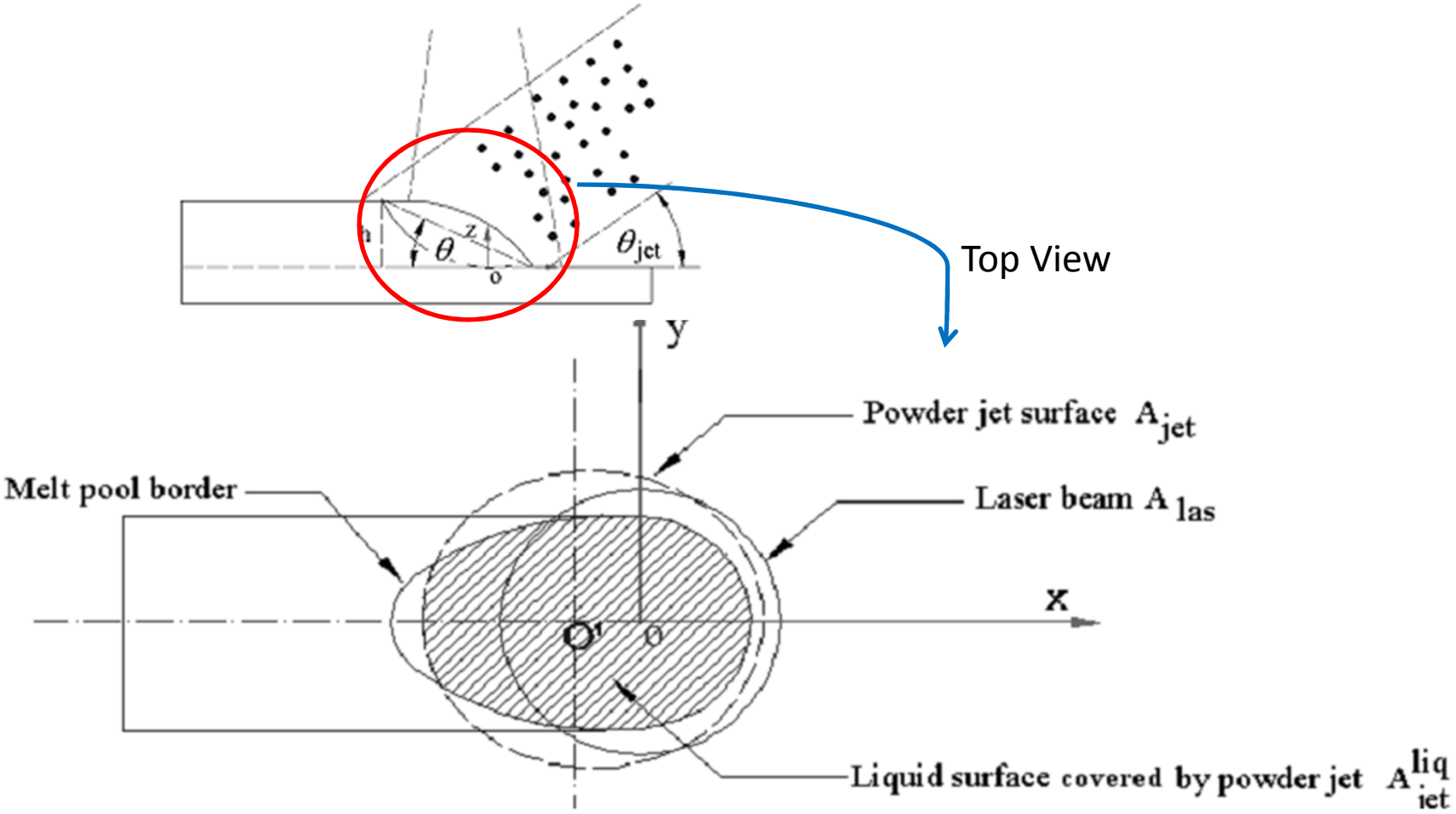
- Melt pool formation and fusion by moving Laser beam
- Surface tension gradient drives molten material flow
- Substrate & Clad material gets mixed in molten state at the interface forming metallurgical bond
- Physical Phenomena's occurring
  - Heat transfer, momentum, and continuity



PROCESS MECHANISM

- High cooling rate (quenching)
  - Formation of fine-grained microstructures OR meta-stable phases
- Supply of clad material to the substrate
  - Pre-Placed: prior clad deposition (aka laser sintering)
    - Melt-pool formed on top of clad layer and then proceeds downwards to the substrate
  - In-situ feeding: powder injection gun (coaxial OR lateral)
    - Melt-pool formation first occurs at substrate in which clad powder is being fed
    - On their way through the laser beam particles are preheated (Power Attenuation)

POWER ATTENUATION



Geometric characteristics process zone(Toyserkani et al., 2005)

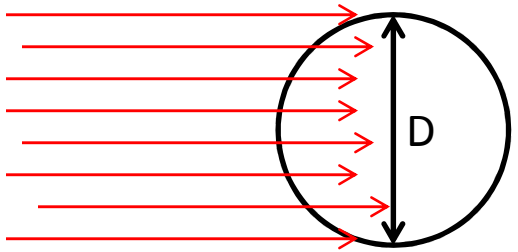
POWER ATTENUATION

- Energy absorbed by particle along its path
  - Spherical, Size>>Penetration depth

$$E_{absorbed} = E_{incident} - E_{reflected} - E_{transmitted}$$

$$E_{absorbed} = Absorptivity \times E_{incident}$$

$$E_{absorbed} = Absorptivity \times A_{proj} \times I(x, y, z) \times \Delta t$$



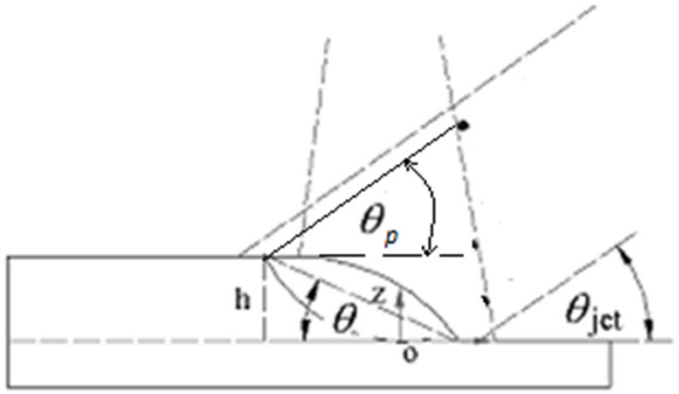
Clad particle Projected Area

POWER ATTENUATION

$$A_{proj} = {}^{\pi}/_{4}\, D^2$$

$$\Delta t = \frac{d(path)}{v_p cos\theta_p}$$

$$I_z = I_o e^{-\beta \times depth}$$



Clad particle interaction path

HEAT PARTITION

$$E_{abs} = \int_{t_{in}}^{t_{out}} Absorptivity \times {}^{\pi}/_{4}\, D^2 \times I_o e^{-\beta \times depth} \times dt$$

$$E_{abs} = \int_{path_{in}}^{path_{out}} Absorptivity \times {}^{\pi}/_{4}\, D^2 \times I_o e^{-\beta \times depth} \times d(path)$$

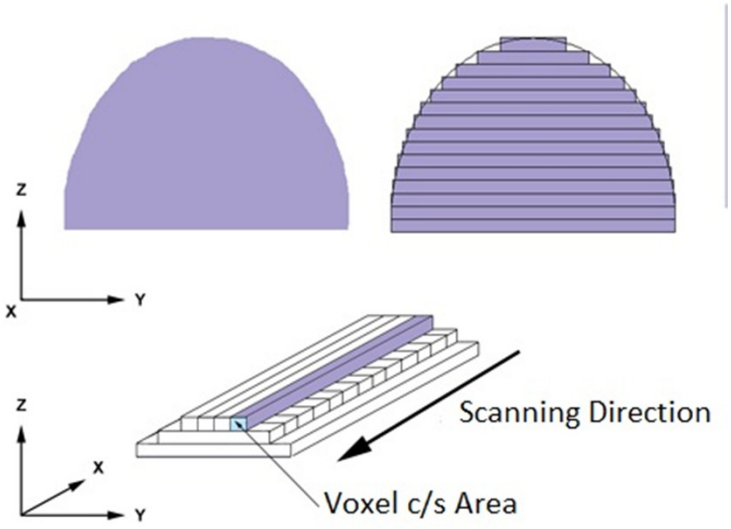
$$m_p c_p \Delta T = E_{abs}$$

- Average pre-heating of particles estimated
- Remaining heat goes into substrate

APPLICATIONS

- Surface properties enhancement
- Component repair
- Rapid prototyping
- Functionally graded components

Parts repair (Toyserkani et al., 2005)



Rapid prototyping

http://lastanzadellemeraviglie.nova100.ilsole24ore.com

Turbine wheels repair(Rombouts et al, 2006)