

# PROCESSOS NÃO-CONVENCIONAIS

## SEP282 – PROCESSOS PARA INDÚSTRIA AERONÁUTICA

- AULA 14
- Processos com Laser

## Corte e Furação

Poucos materiais não podem ser cortados com laser

Mais comum em corte plano com pouca espessura



## Usinagem a Laser

**Corte a laser**

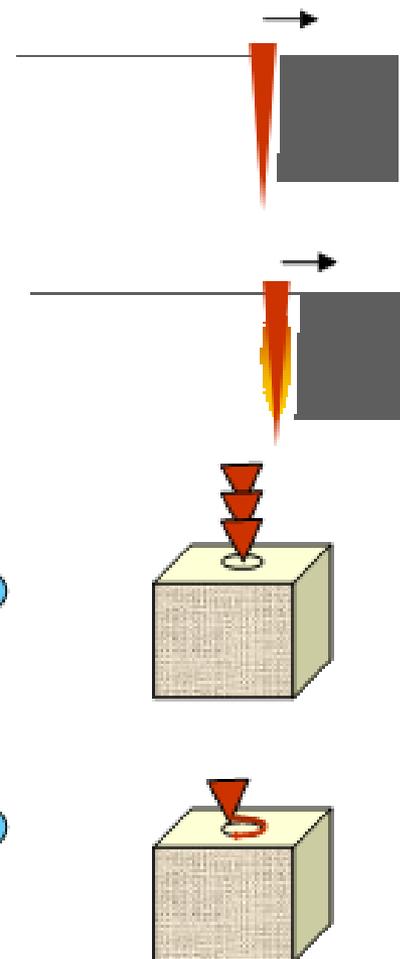
**Gás inerte**

**Gás ativo**

**Furação a laser**

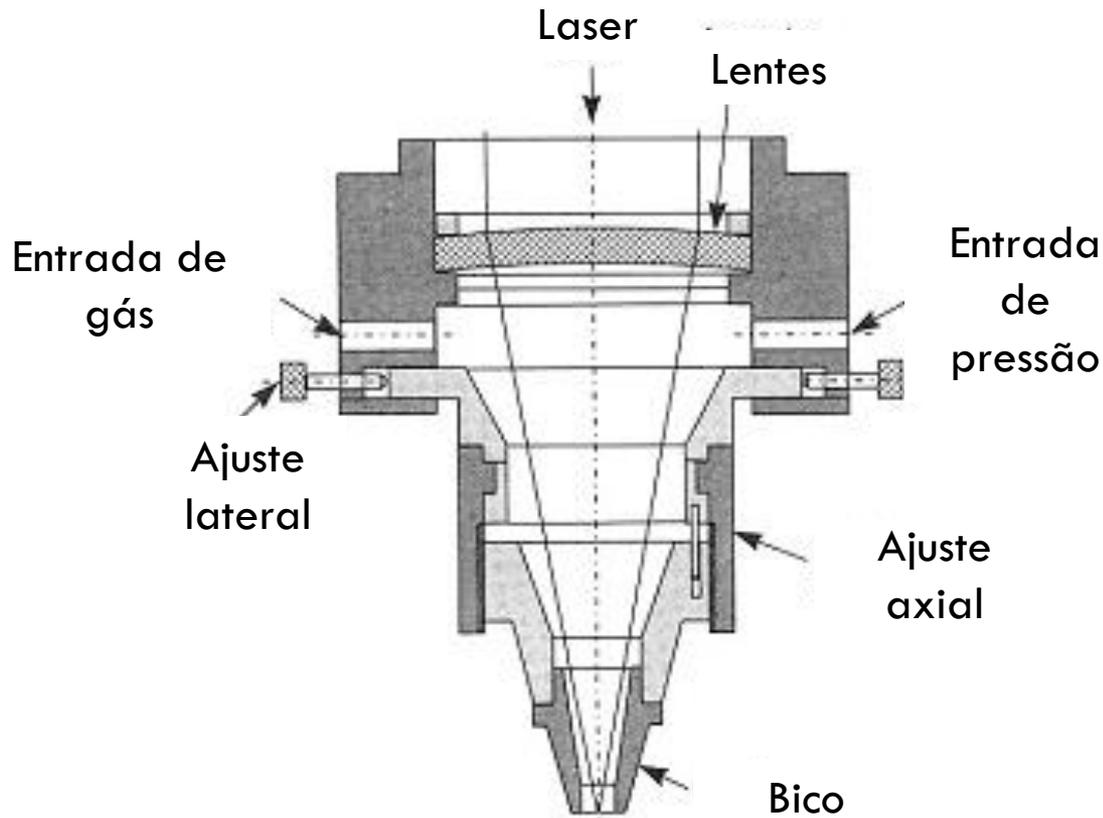
**Percussão**

**Trepanação**



# PROCESSOS NÃO CONVENCIONAIS - LASER

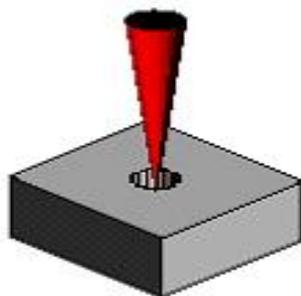
## Cabeça de Corte



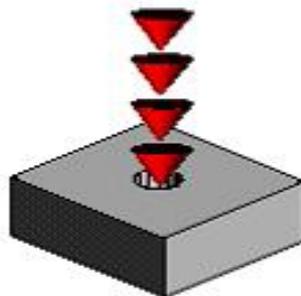
## Furação a Laser

### Técnicas de Processos

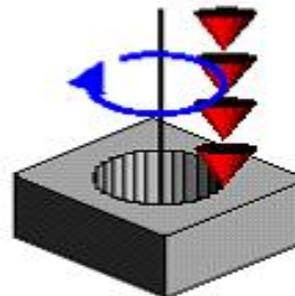
Pulso simples



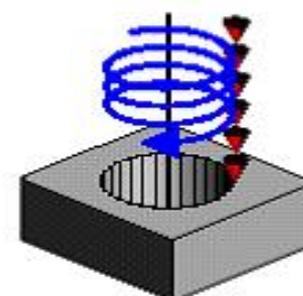
Vários pulsos



Trepanação



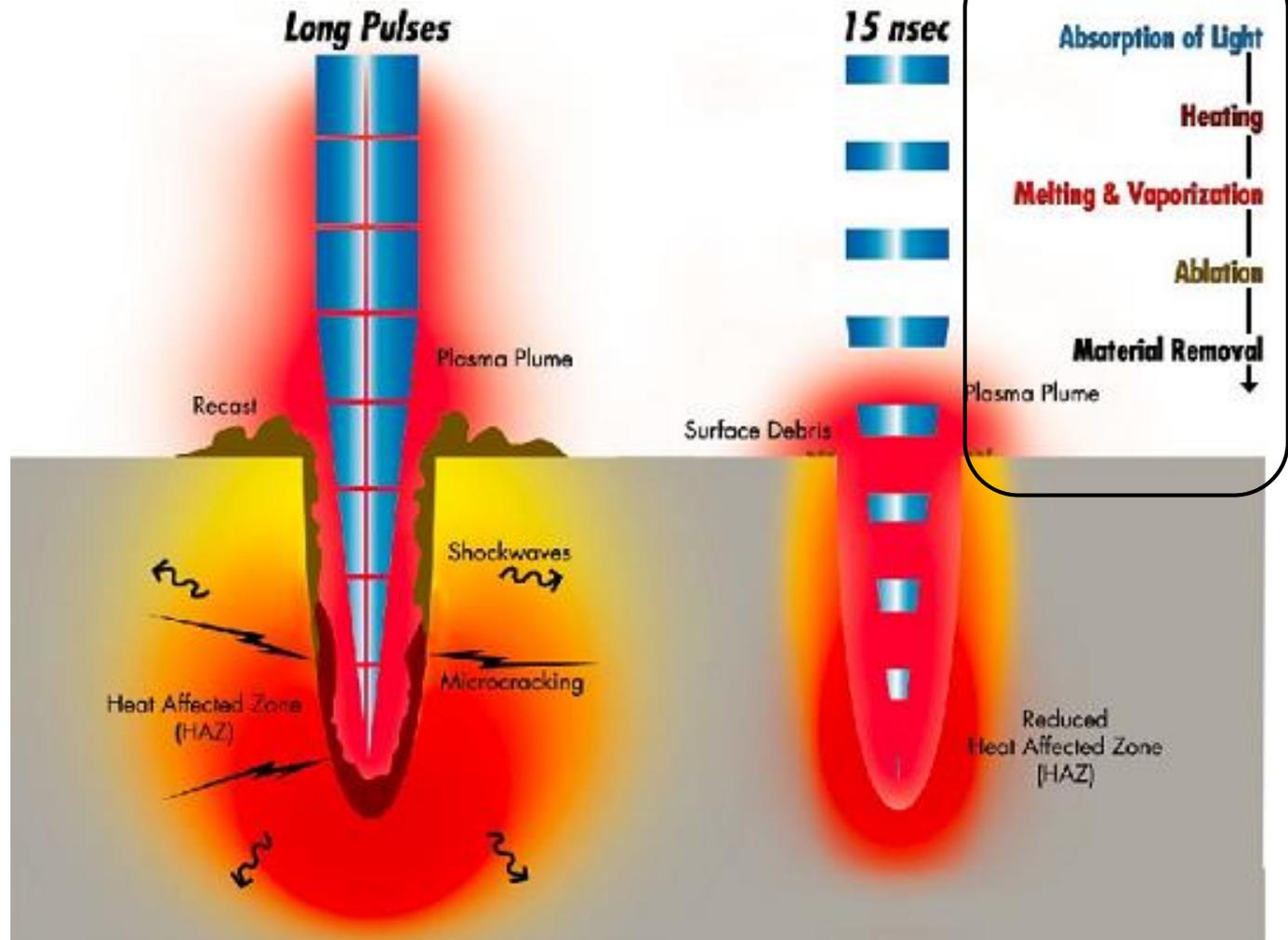
Helicoidal



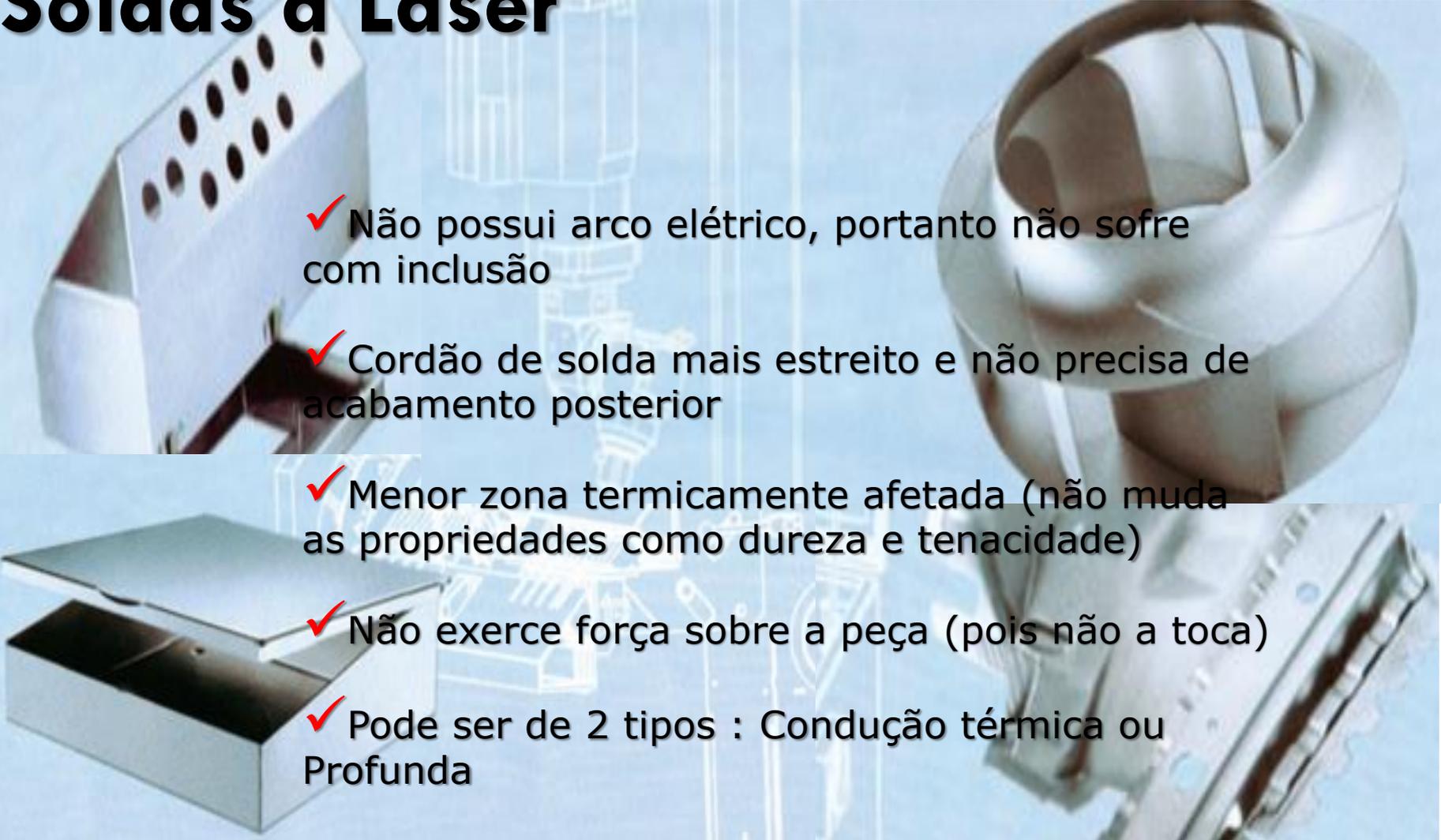
Duração do  
Pulso

Precisão

## Furação a Laser



## Soldas a Laser

- 
- ✓ Não possui arco elétrico, portanto não sofre com inclusão
  - ✓ Cordão de solda mais estreito e não precisa de acabamento posterior
  - ✓ Menor zona termicamente afetada (não muda as propriedades como dureza e tenacidade)
  - ✓ Não exerce força sobre a peça (pois não a toca)
  - ✓ Pode ser de 2 tipos : Condução térmica ou Profunda

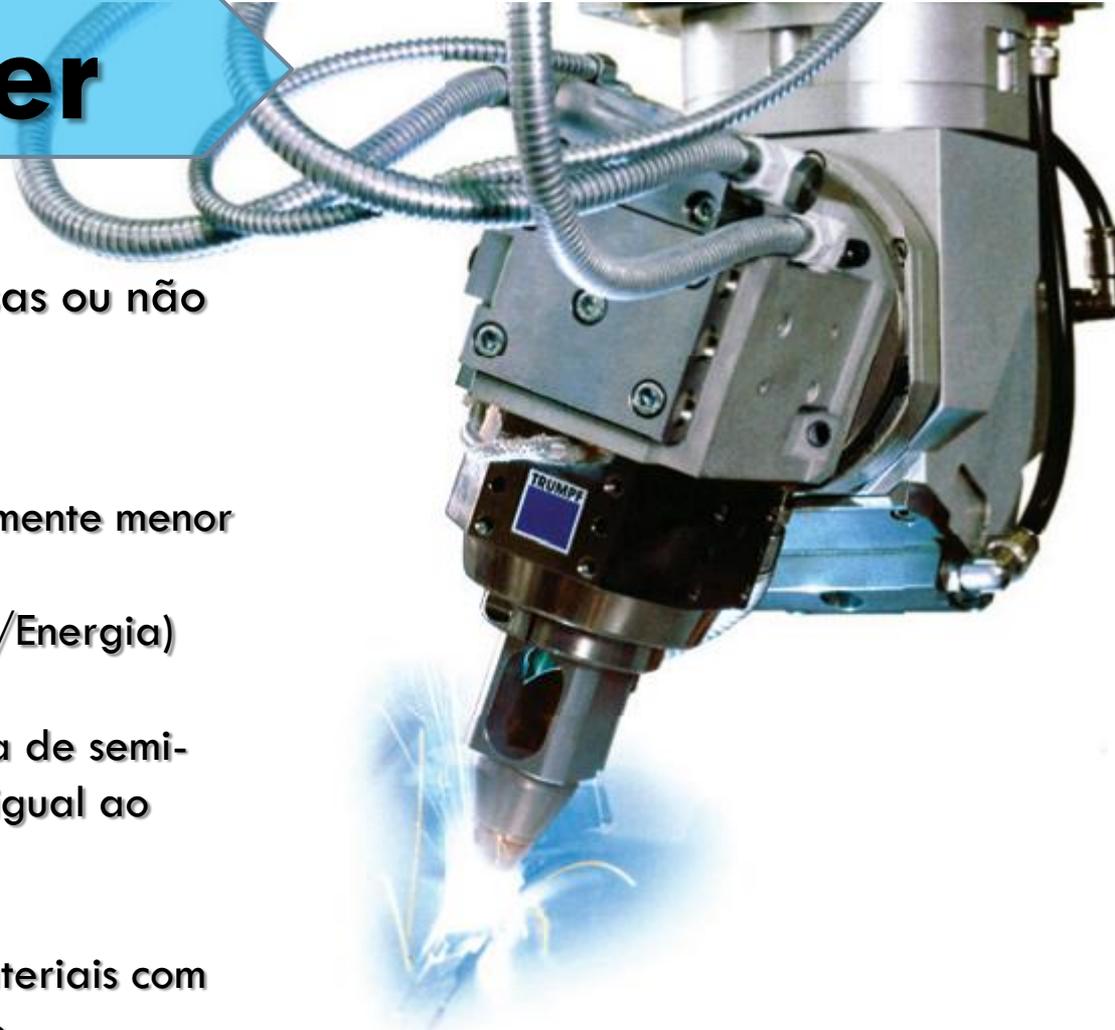
## Soldas a Laser

### Quando?

Têm-se o acoplamento de peças lisas ou não substancialmente deformadas.

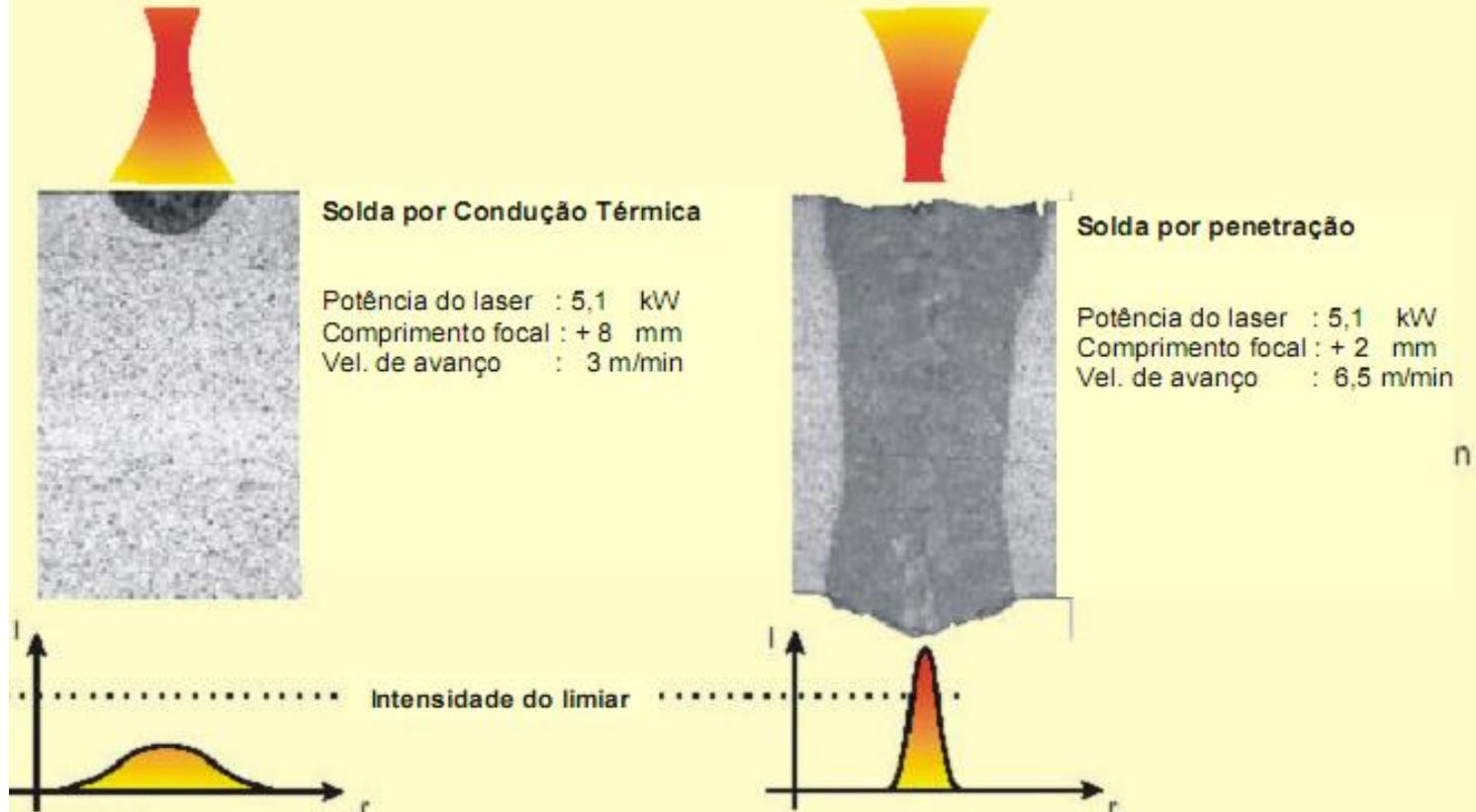
### Características

- -Velocidade de avanço comparativamente menor
- -Maior espectro de energia(Potência/Energia)
- -Seção do cordão de solda em forma de semi-círculo com largura aproximadamente igual ao dobro da profundidade
- -Junção por soldagem apenas de materiais com uma de oxida de baixo ponto de fusão



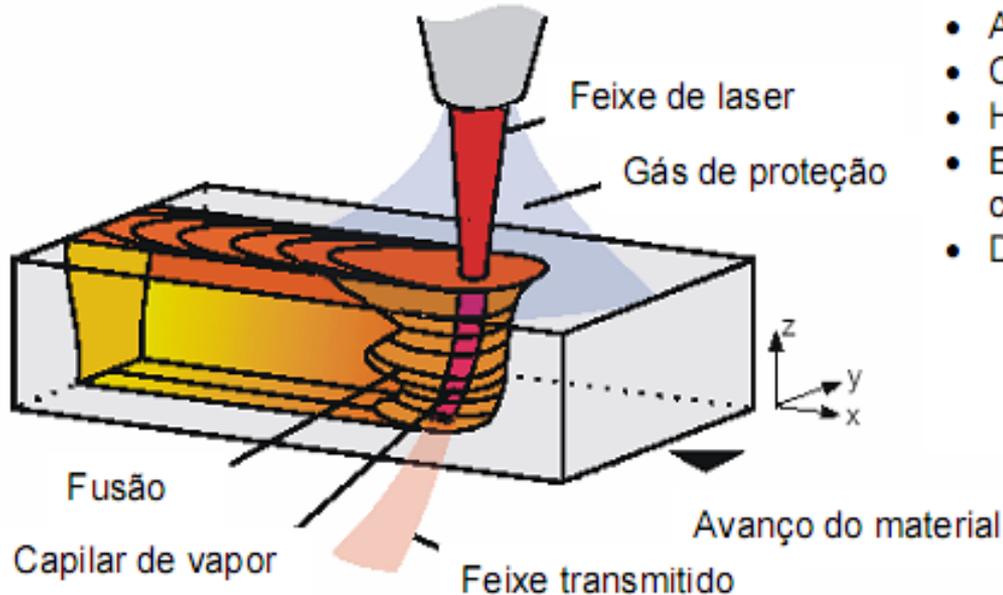
## Soldas a Laser

Soldagem a laser CO de uma liga EN AW-6016 (AlMg0,4Si1,2)



## Soldas a Laser

O processo global de soldagem profunda a laser é um processo físico complexo constituído por diversos outros processos parciais acoplados uns aos outros:



- Absorção da radiação laser
- Condução térmica na peça
- Hidrodinâmica da poça de fusão
- Evaporação na superfície do capilar
- Dinâmica dos gases no capilar

## Soldas a Laser

- Vantagens a frente à soldagem MAG:

- Menor necessidade de retrabalho

- Vantagem frente à solda por feixe de elétrons:

- Ausência do custo mais elevado e consumo de tempo para evacuar a câmara de soldagem

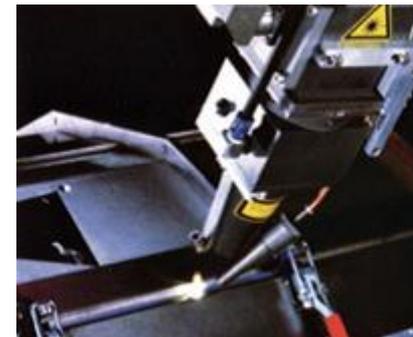
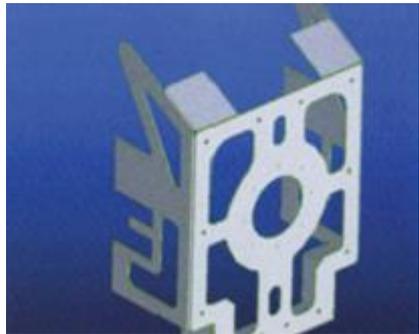
- Vantagens frente à solda ponto:

- 30% mais resistência sob solicitação dinâmica

- 50% mais resistência sob solicitação dinâmica

- Melhor aspecto ótico

- Menor necessidade de superposição nas junções



# PROCESSOS NÃO CONVENCIONAIS - LASER



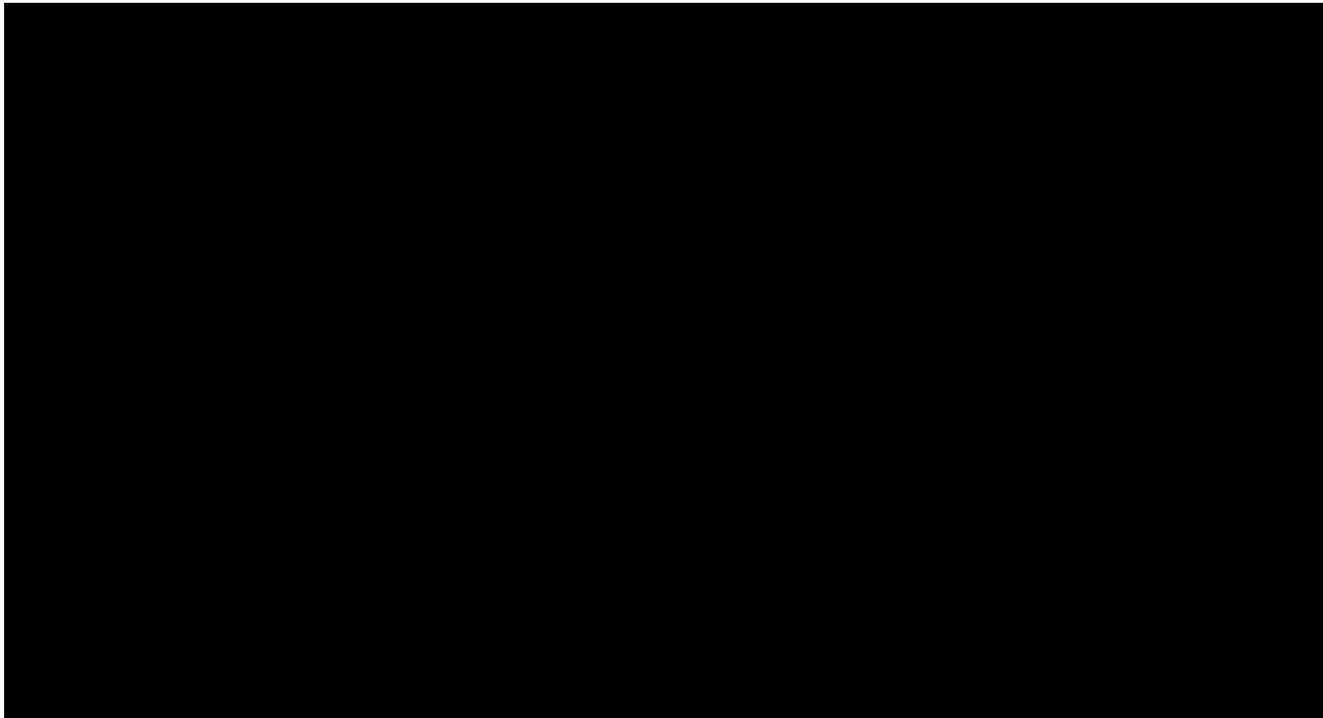
**Stents**



**Soldas em componentes  
de câmbio**

# PROCESSOS NÃO CONVENCIONAIS - LASER

Processo aditivo –  
Powder Bed Fusion - PBF

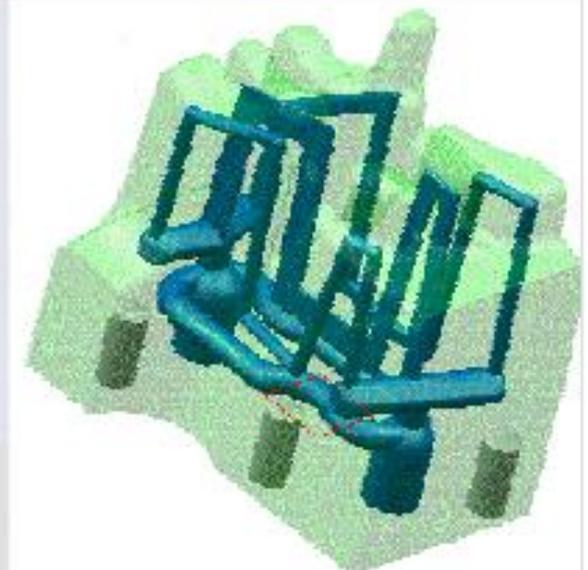


## Processo aditivo – Powder Bed Fusion - PBF

### FABRICAÇÃO DE FORMAS COMPLEXAS



LaserCUSING®  
Quelle: Concept Laser GmbH



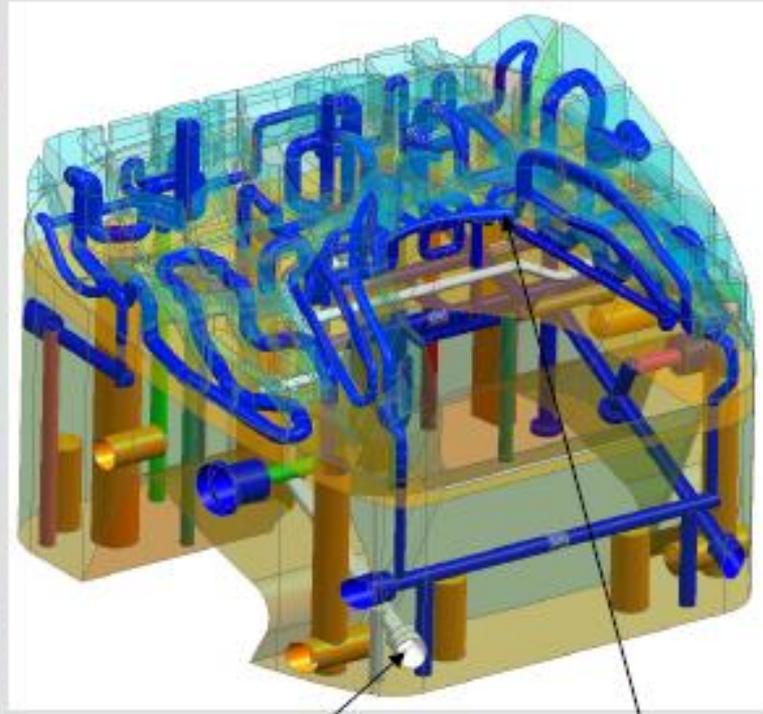
## FABRICAÇÃO DE FORMAS COMPLEXAS



CNC machined

LaserCUSING®

Mold insert for vacuum cleaner appr. 250 x 220 x 170mm



Air pressure demolding

Cooling channel

# PROCESSOS NÃO CONVENCIONAIS - LASER

## IMPLANTES DENTÁRIOS E MÉDICOS DIVERSOS



# PROCESSOS NÃO CONVENCIONAIS - LASER

## D.E.D. – Direct Energy Deposition



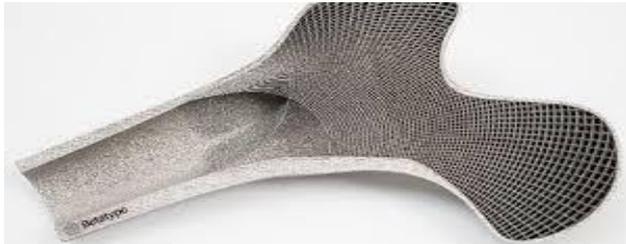
# PROCESSOS NÃO CONVENCIONAIS - LASER

**HYBRID PROCESSES = Additive Manufacturing + Machining**

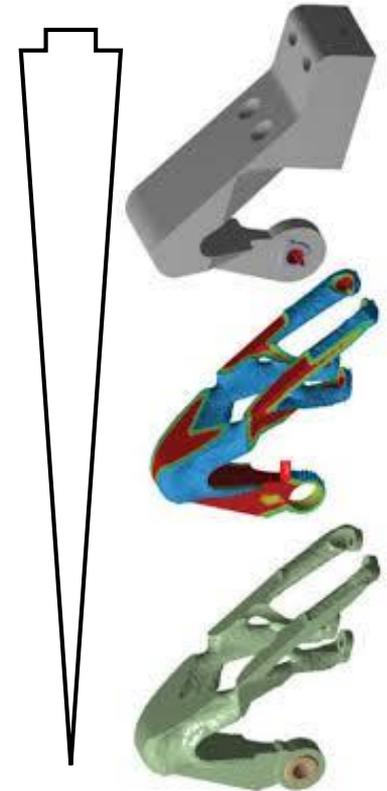


# PROCESSOS NÃO CONVENCIONAIS - LASER

What can be made using HYBRID 3D printing?

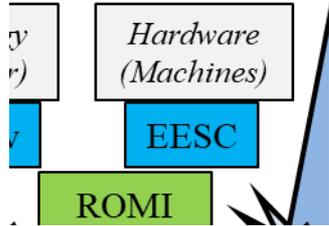


<http://www.todaysmedicaldevelopments.com/article/renishaw-additive-manufacturing-orthopedic-implants/>

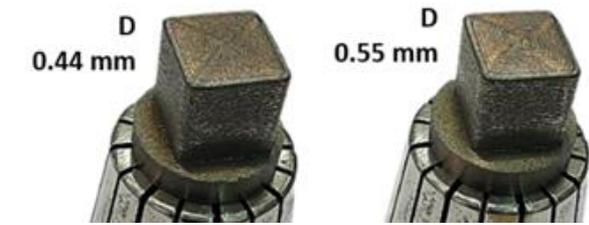
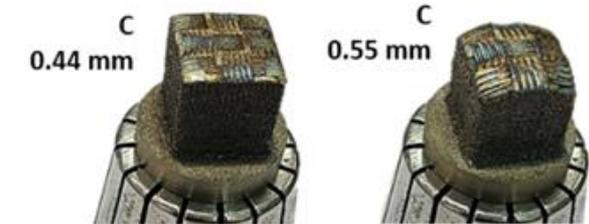
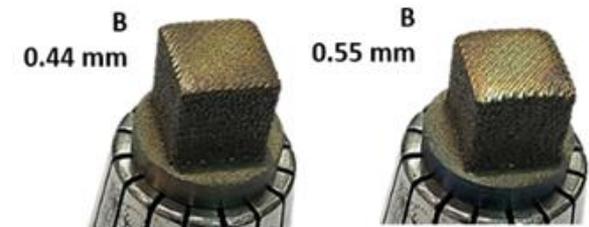
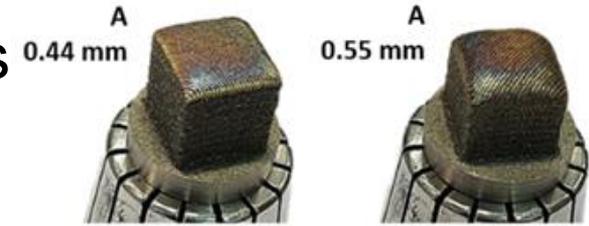
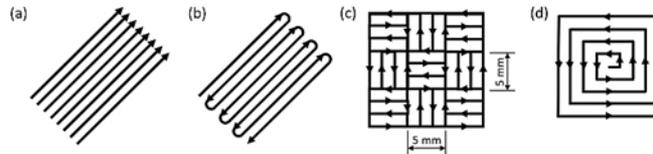


HYBRID 3D printing +  
Topographic optimization

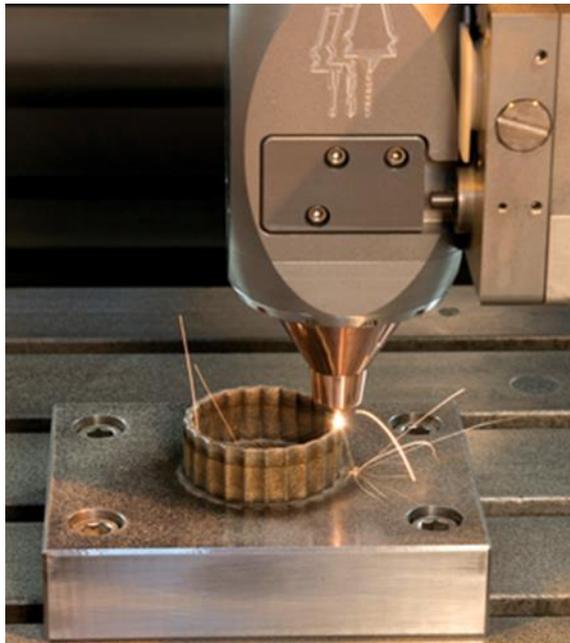
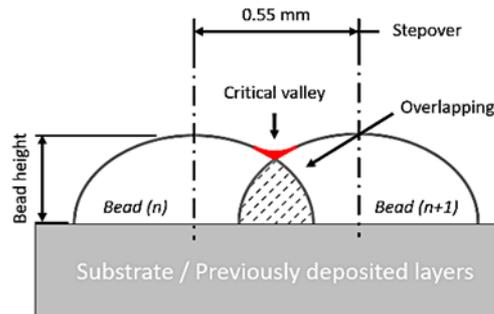
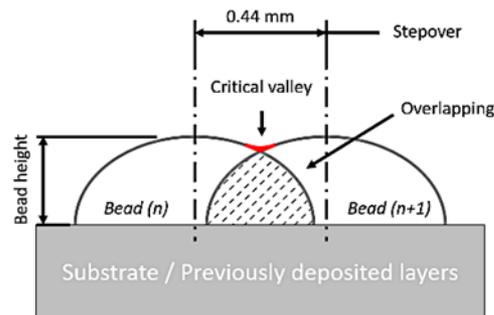
# PROCESSOS NÃO CONVENCIONAIS - LASER



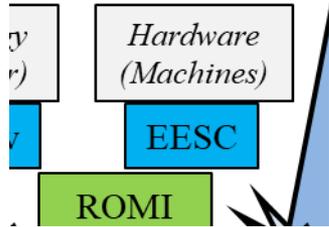
## Test of different filling strategies



## Test of different step overs

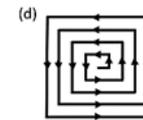
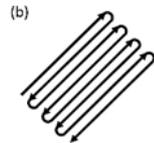


# PROCESSOS NÃO CONVENCIONAIS - LASER

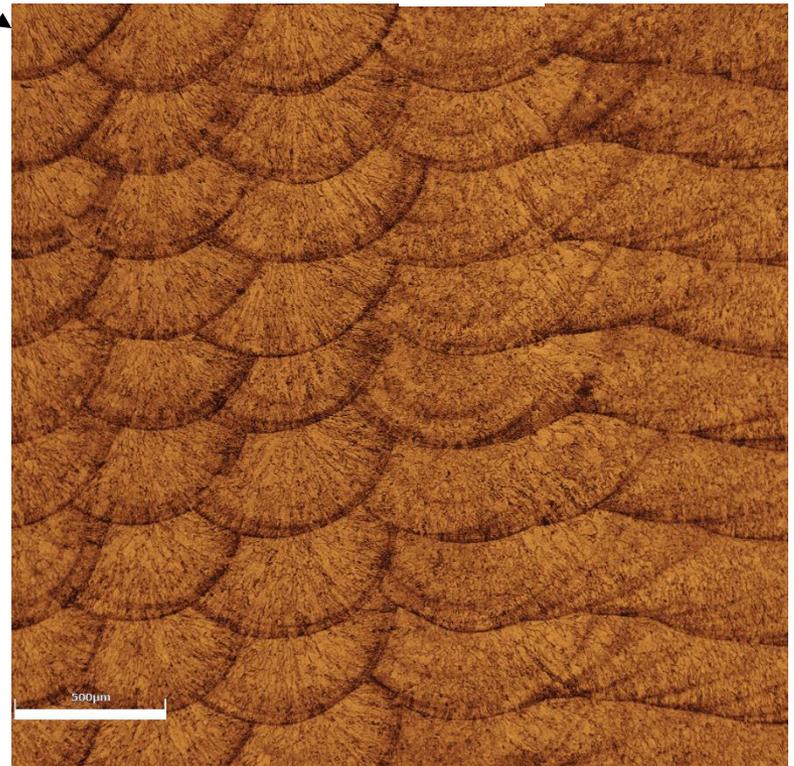
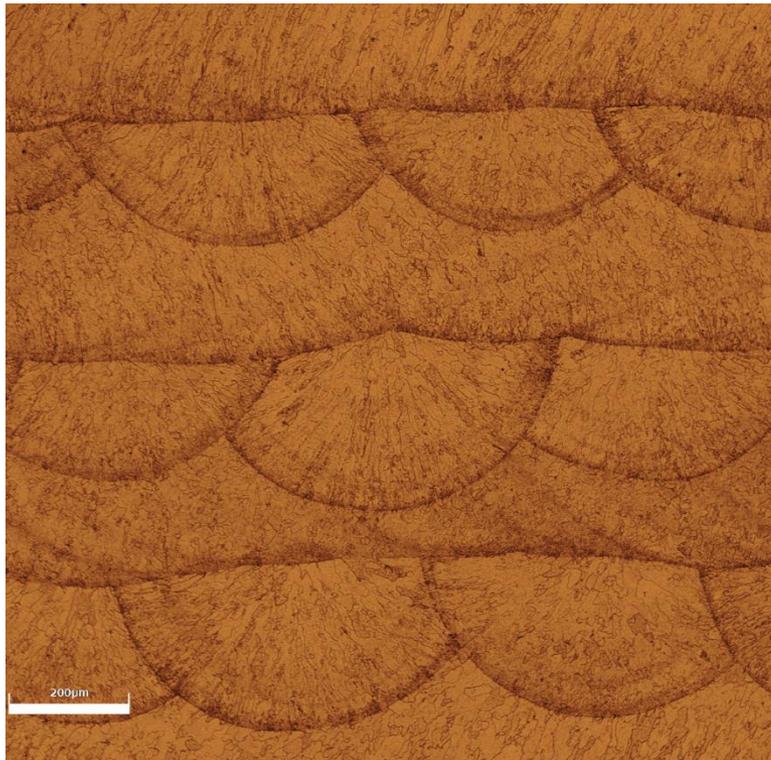


Test of different filling strategies and step overs

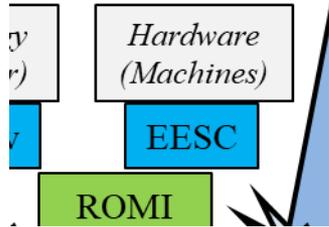
TYPICAL MICROSTRUTURES



Layers



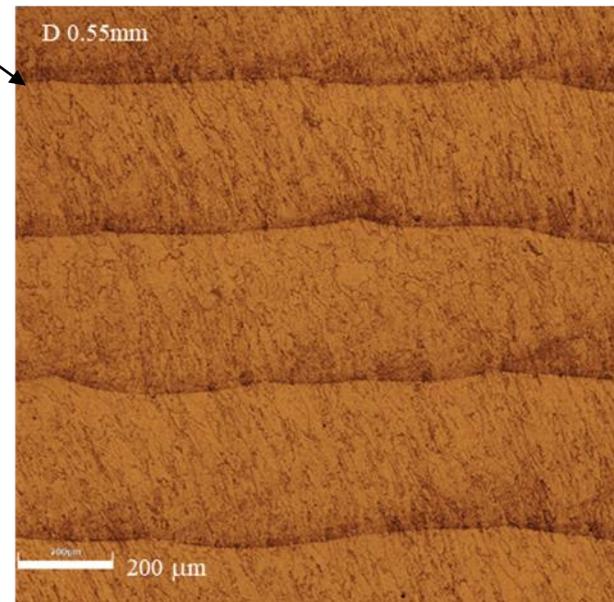
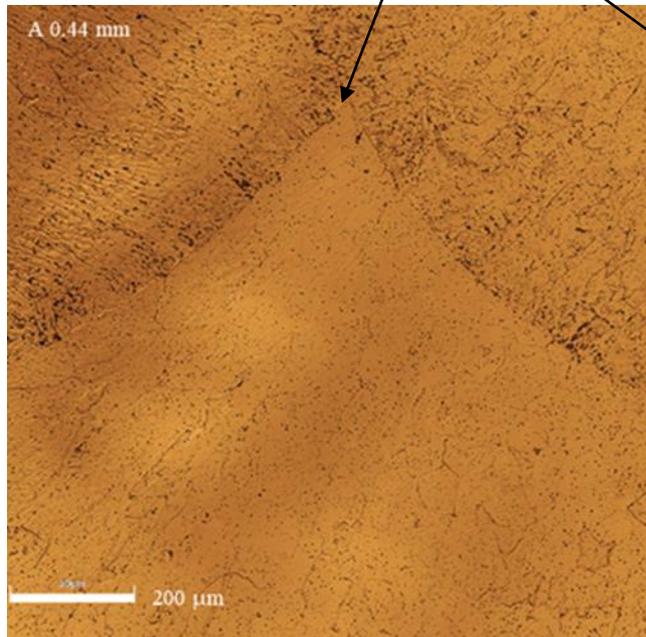
# PROCESSOS NÃO CONVENCIONAIS - LASER



Test of different filling strategies and step overs

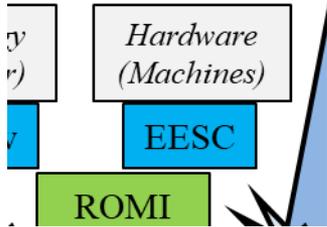
## MICROSTRUCTURES – MATERIAL INTEGRITY

Bonding



# PROCESSOS NÃO CONVENCIONAIS - LASER

Study of post processing strategies



Milling + Grinding



(a) After deposition,

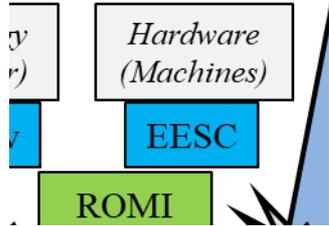


(b) After milling

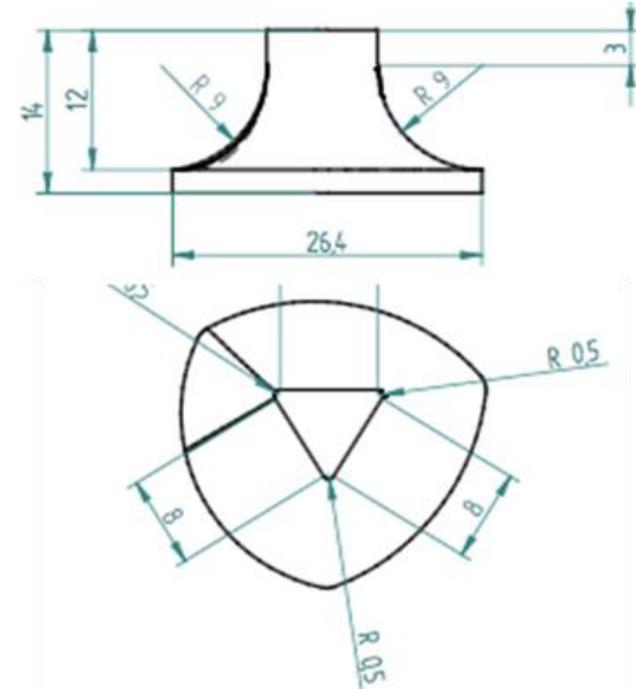
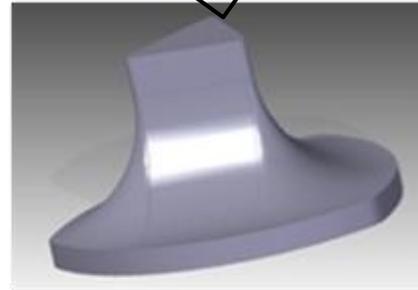
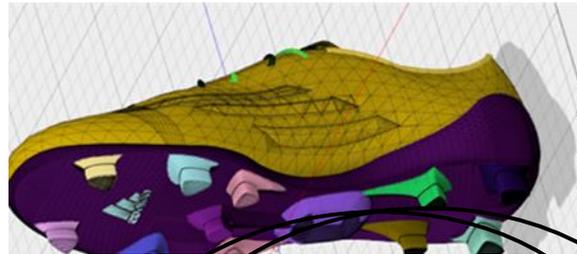


(c) After grinding

# PROCESSOS NÃO CONVENCIONAIS - LASER

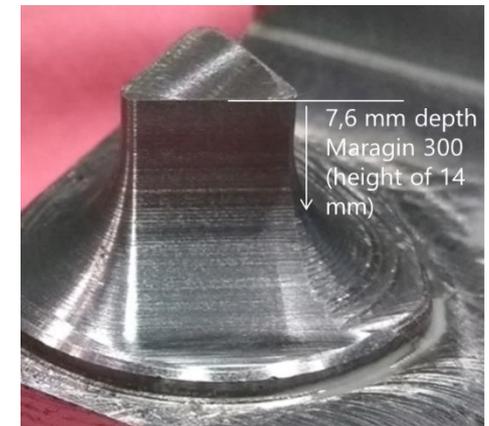
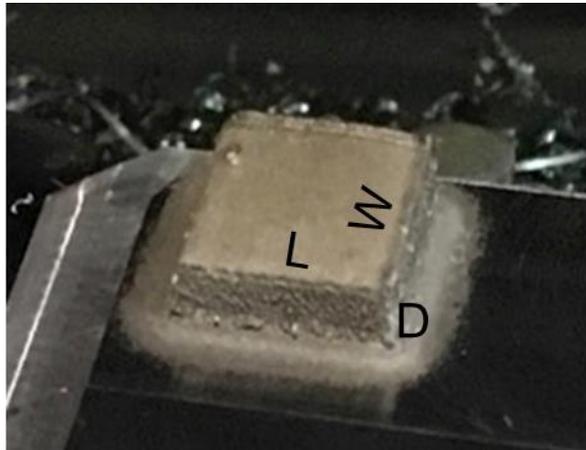
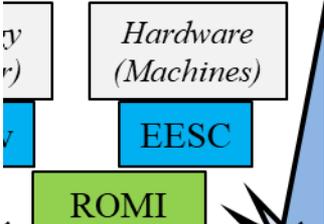


Example: An Injection mold for a Football boot



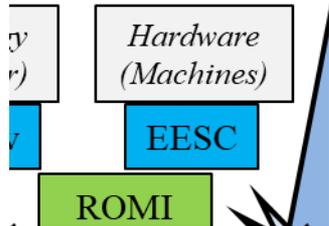
# PROCESSOS NÃO CONVENCIONAIS - LASER

Additive + Subtractive  
(Milling + Grinding)

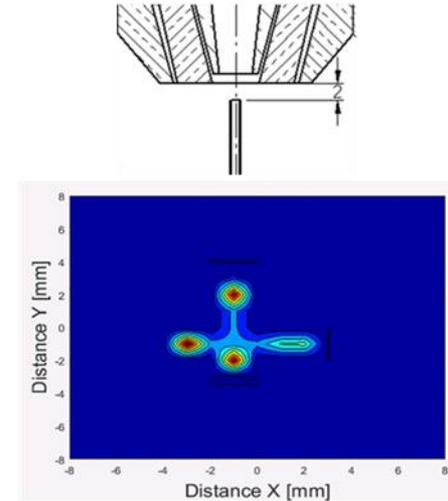
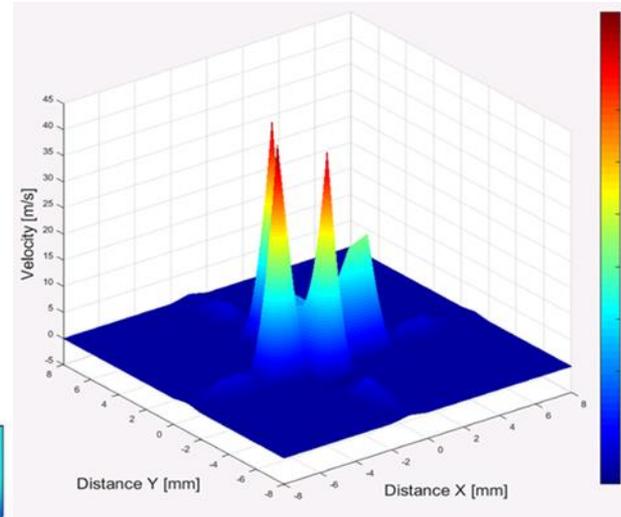
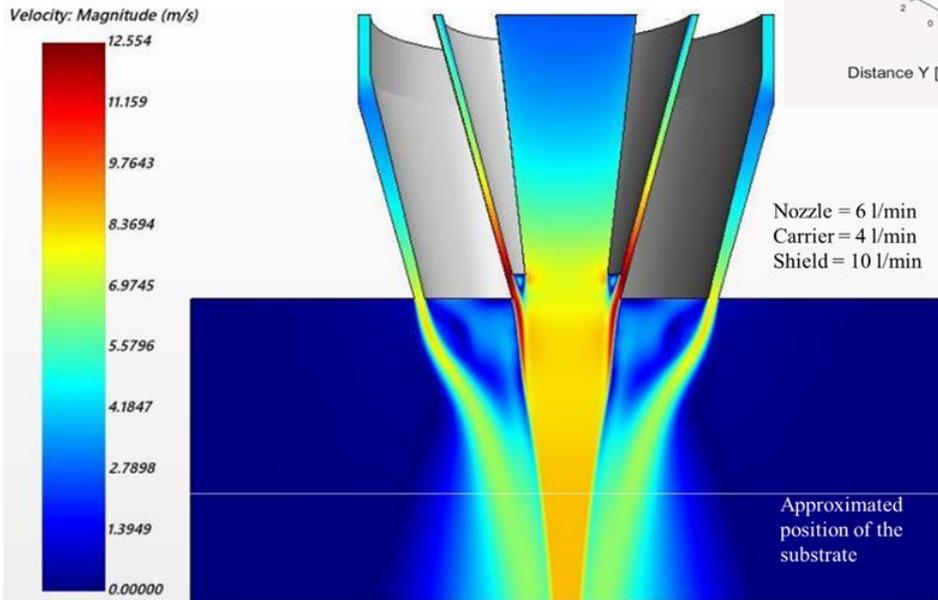


(LxWxD)=20.8 x 20.7 x 7.9 mm

# PROCESSOS NÃO CONVENCIONAIS - LASER



## CFD Simulation of nozzles



## Experimental measurements