



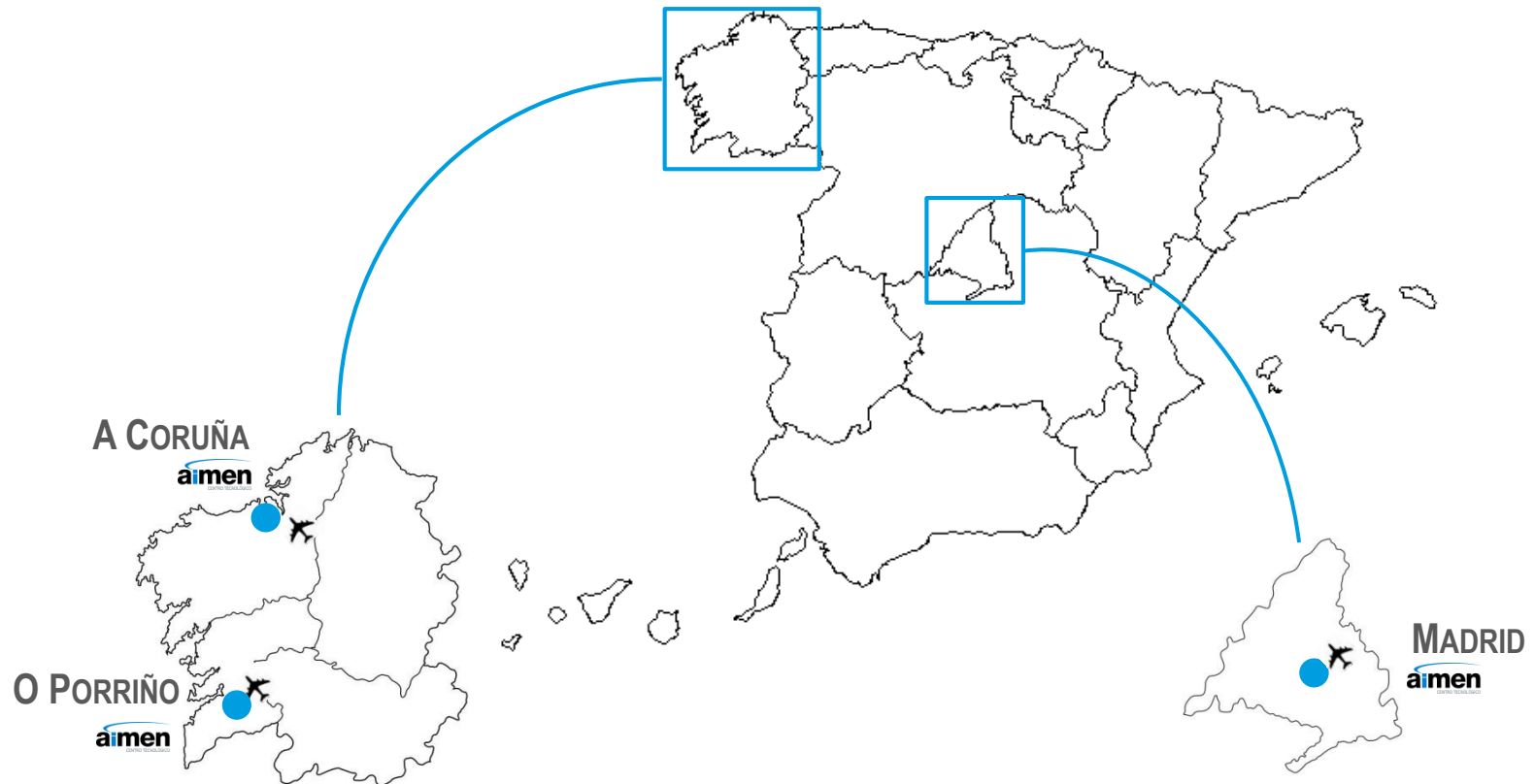
Single mode fiber laser for surface structuring

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CENTRO TECNOLÓGICO

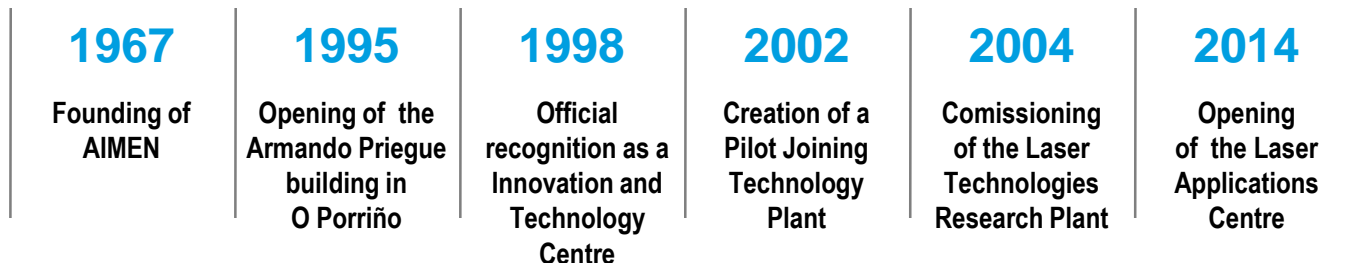
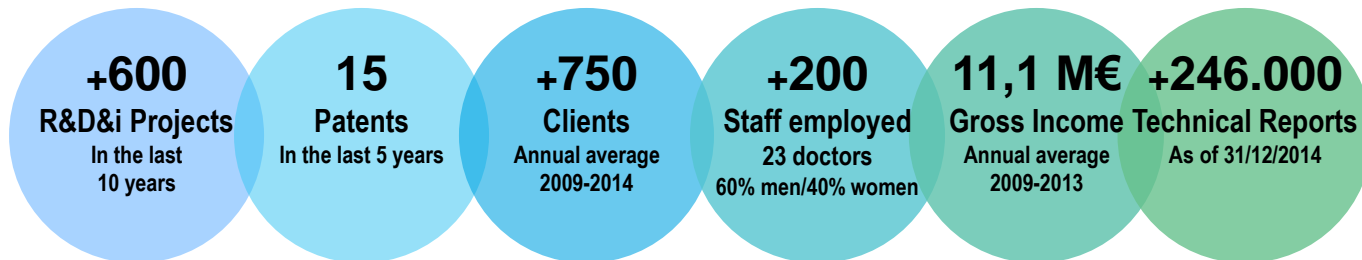
Locations





We are an **Innovation and Technology Centre** specialized in **research** and in providing advanced **technological services** in the fields of **joining technologies, materials and laser technologies** applied to materials processing.

Our **VISION** is to become a strategic technology partner for each and every one of our associates and customers, contributing to improving their technological capabilities.



R&D



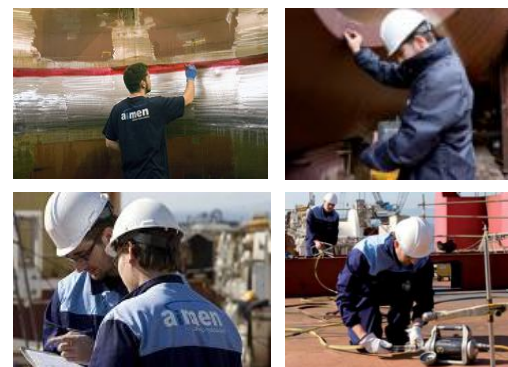
Industrial Services



Testing and Analysis



Training



FIELDS OF SPECIALIZATION

R&D

- Advanced Materials
- Robotics and Control
- Advanced Manufacturing Processes
- Environment



Industrial Services

Manufacturing Engineering

Numerical Calculation and Simulation

Mechatronics

Motivation

Experimental Work

Results and Discussion

- Additive technique
- laser direct texturing

Conclusions

Motivation



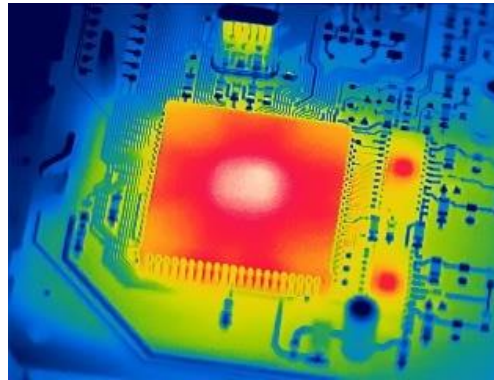
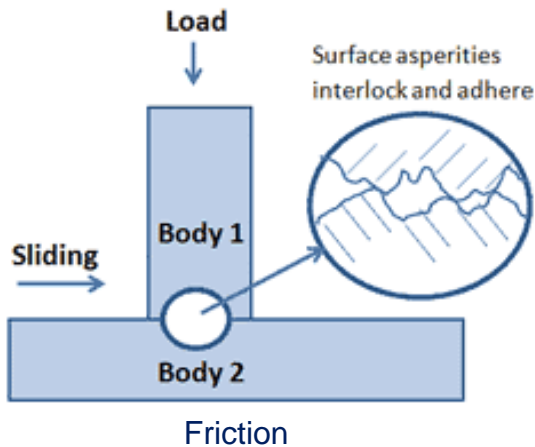
Required characteristics

Design of engineered components

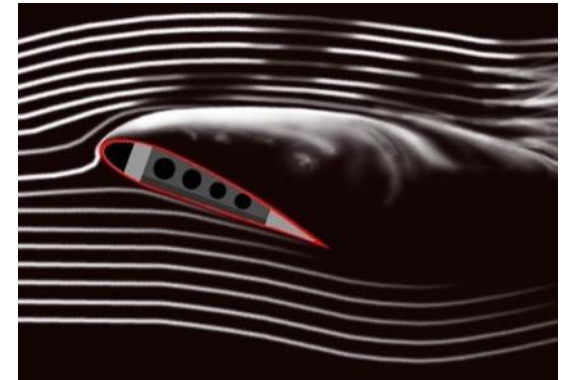
- Compromise between: shape, material, cost and performance.

Surface

- Physical interaction with the medium
- Source for most process inefficiencies



Heat transfer



Fluid-dynamics

- Need for micron sized features:
 - Hydrodynamical improvement
 - Reduction of drag forces

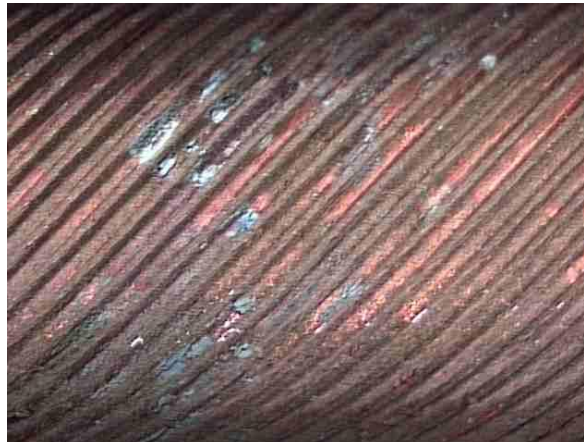
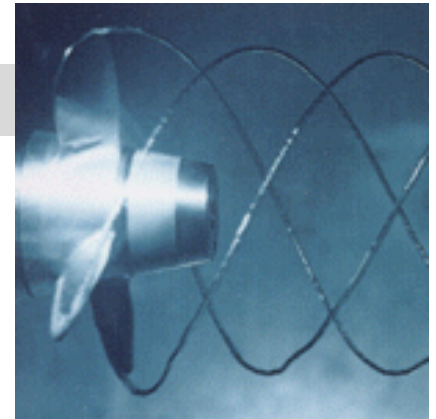
Required characteristics

Geometrical quality

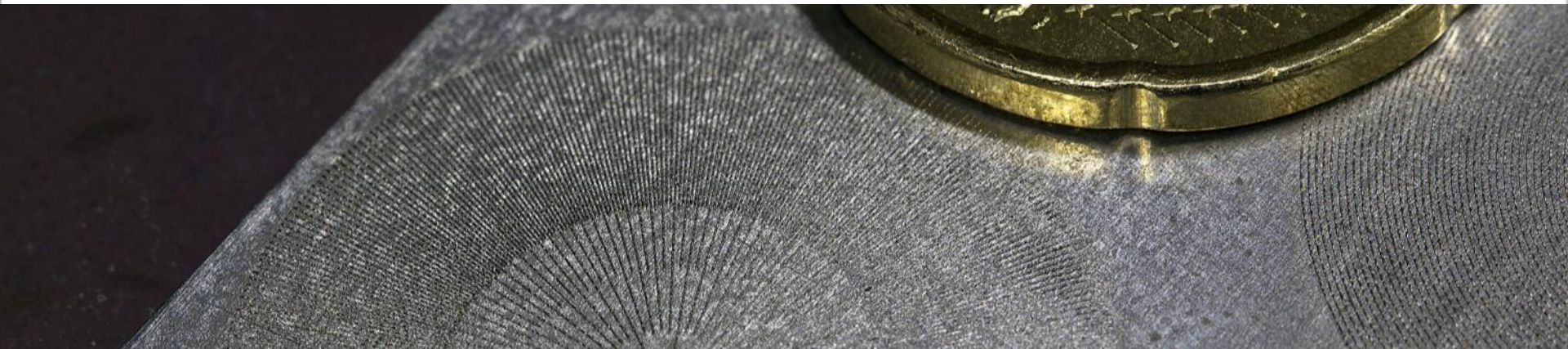
- Surface structures must withstand harsh environments without geometrical degradation.
- High dimensional stability in time required.

Durability

- High corrosion and wear resistance
- High adhesion
- Good chemical and mechanical properties



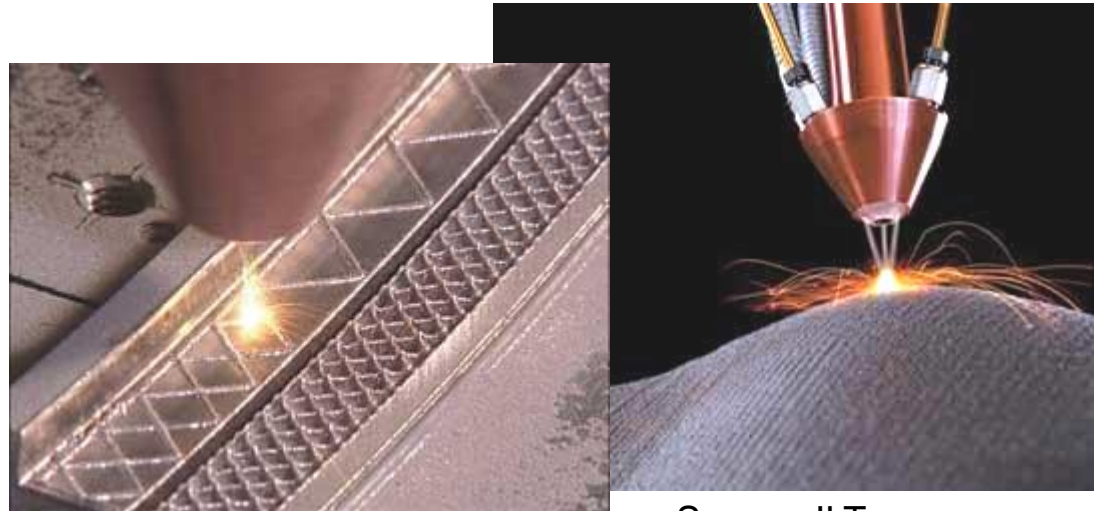
Additive Technique



Fabrication

Proposed Technique

- Micro-cladding: Micron-sized features by melting of additive material on the substrate
- Micro-cladding applications: Micro- features production, precision repairing and direct manufacturing:
 - Texturing of functional surfaces
 - 3D microstructures for prototyping
 - Repairing and net shape manufacturing
 - Modification of injection moulds for mass production of microfeatured components
- Limits:
 - Controlled energy delivery
 - Precise dilution control
 - Material feeding



Source: ILT

Equipment

Laser Source

- Single Mode Fiber Laser. Fibre core 11microns
- High Beam Quality (Diffraction limited)
- High Brilliance
- Power up to 400W

Optics

- Scanning head with field optics
- Spot size about 20microns

Movement system

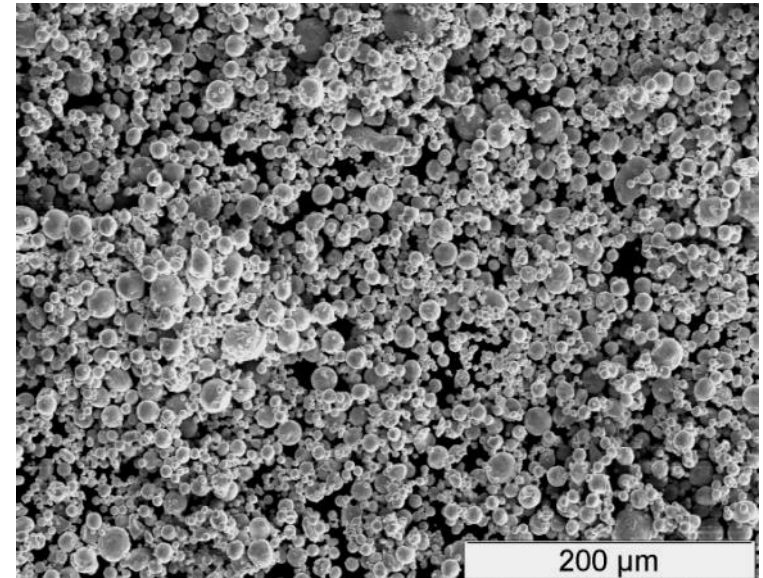
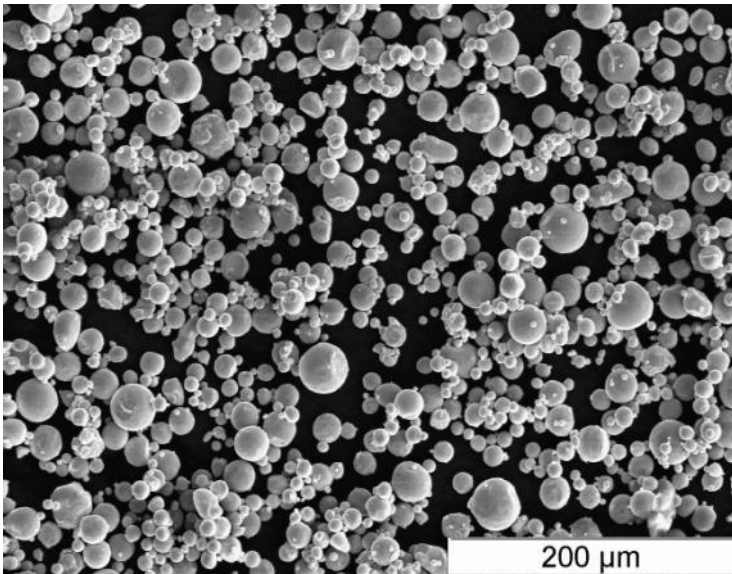
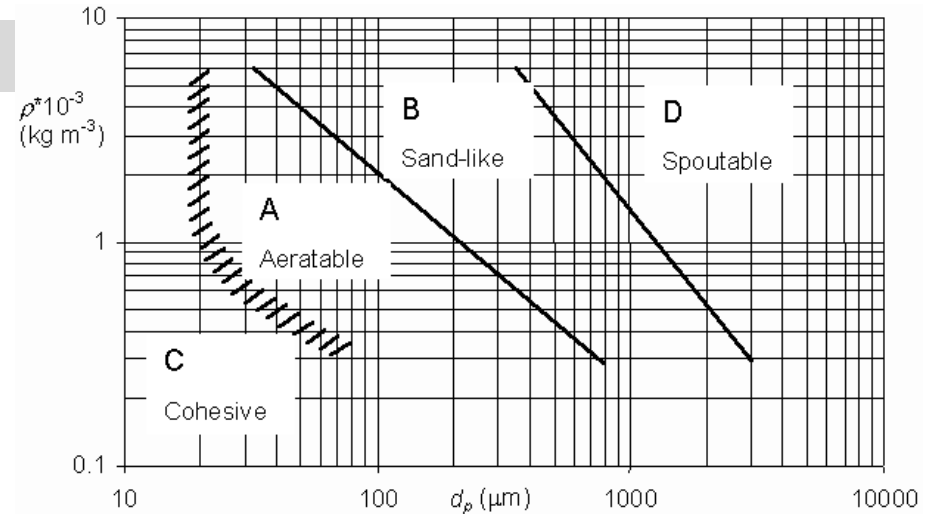
- CNC stage



Fabrication

Problems

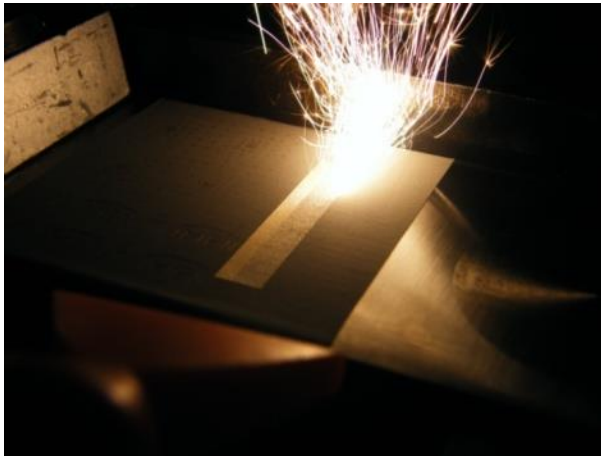
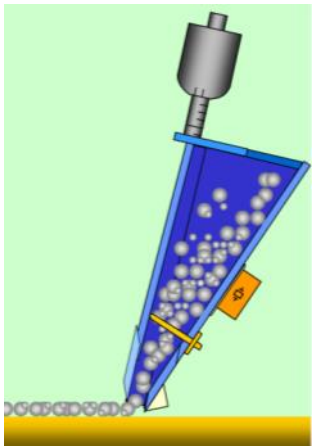
- Powder type C of Geldart classification
- Economy and efficiency:
 - Sophisticated equipment
 - Low productivity
 - Too general application



Procedure

Powder pre-placing and laser consolidation

- To avoid the need of fluidizing and transporting particles
- A thin and homogenous layer of powder is placed on the surface to be textured
 - Dry preplacement
 - Wet preplacement
- Scanned laser source → powder consolidation



Materials

Base materials

- Flat polished samples
- Commercial alloys:
 - Titanium Grade V:
 - aeronautic and biomedical
 - Tool Steel
 - high corrosion resistance
 - Forging, die casting
 - low toughness, difficult to repair, low weldability, large and weak HAZ
 - Brass
 - harsh environments
 - biocide properties
 - chemical and wear resistance

Powders

- Different metallic and ceramic commercial powders for surfacing and rapid prototyping

Parametric search

Process parameters

Laser Power: 12-200W

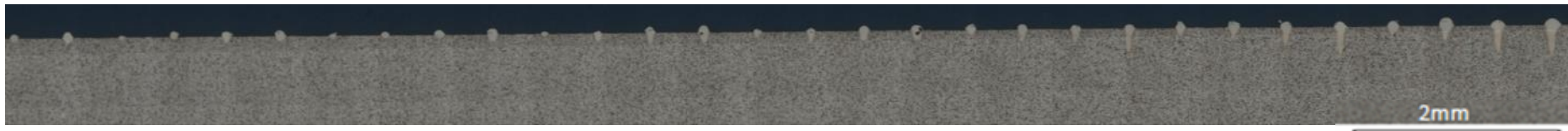
Focus position

Scanning speed: 100 – 1000mm/s

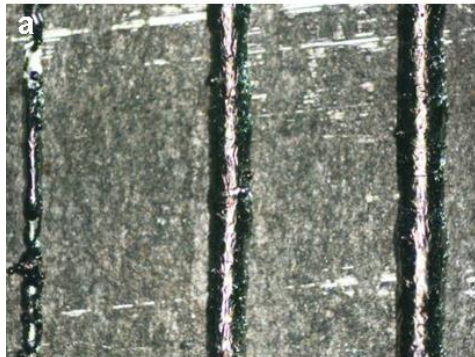
Powder predeposition: Dry / Wet

Shielding gas

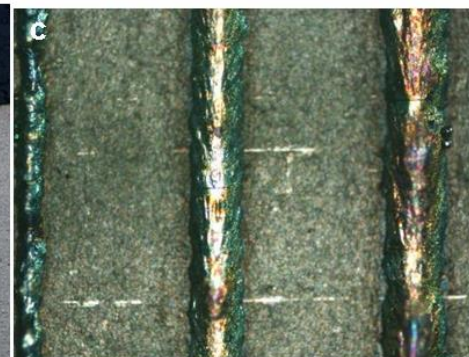
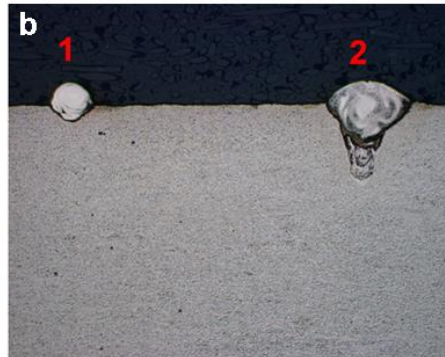
- Fuence: Slightly higher than powder melting threshold. (about 10MW/cm²)



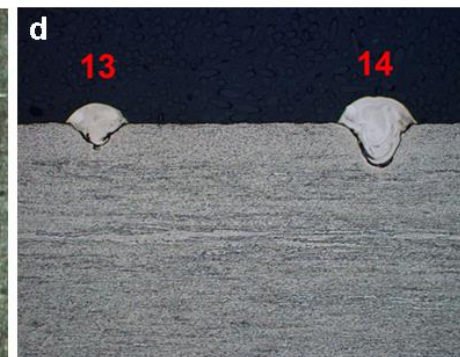
D2 Tool Steel + tool steel powder



Stellite on Titanium



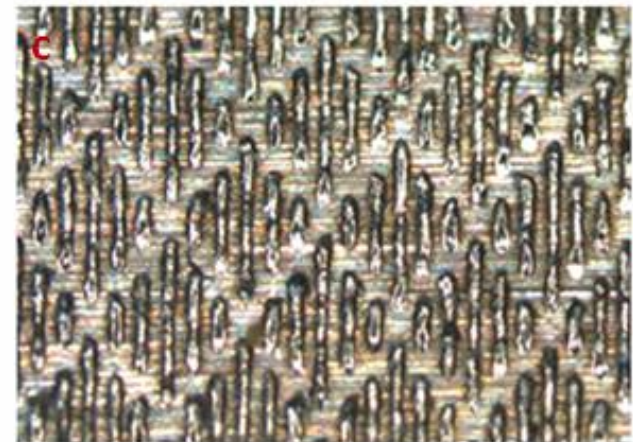
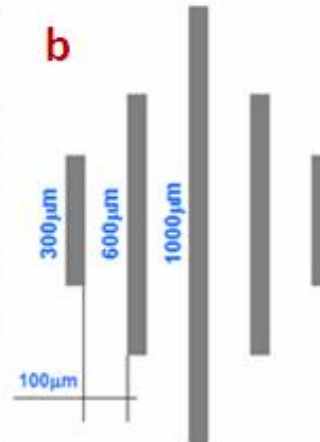
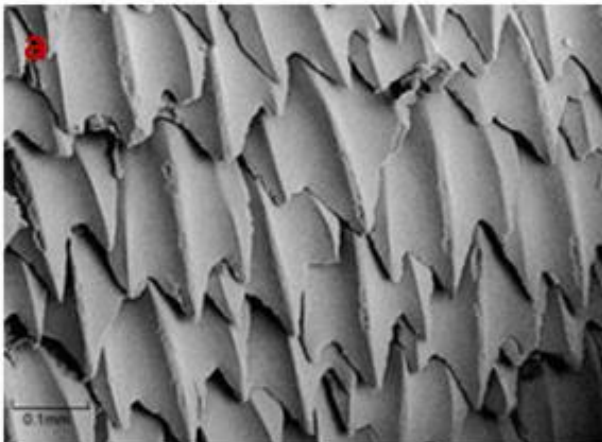
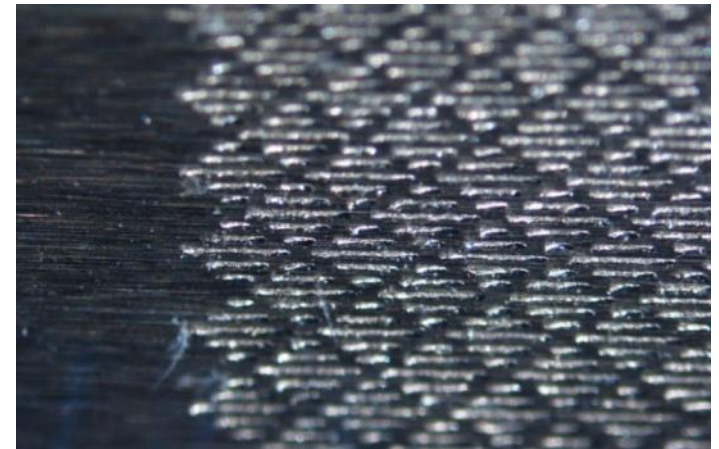
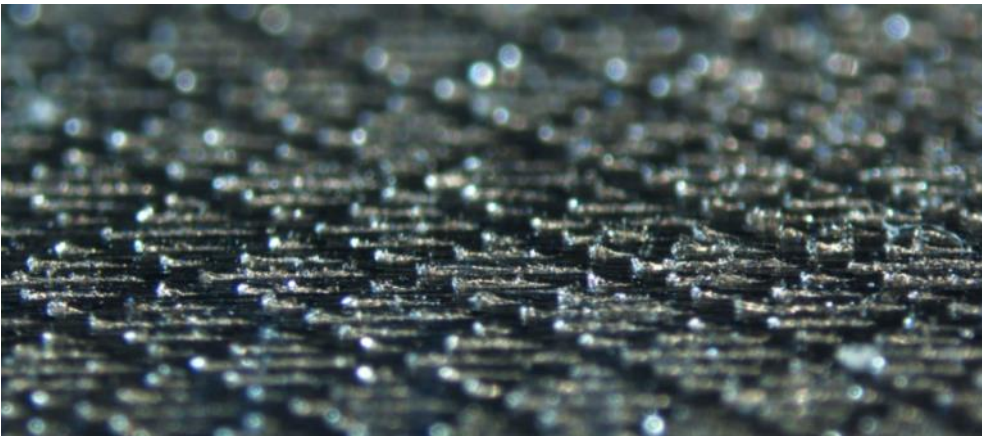
Inconel on Titanium



Practical Issues

Shark Skin

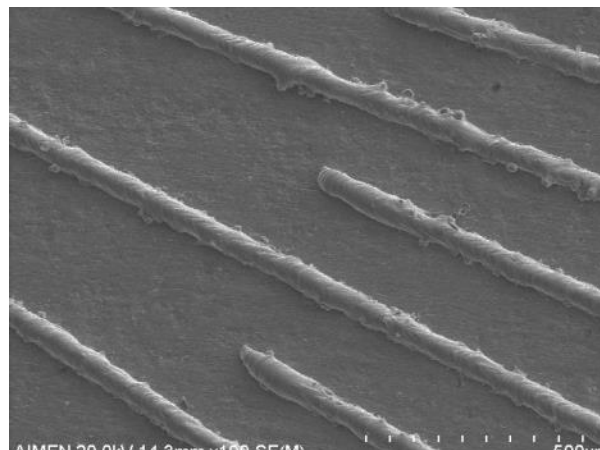
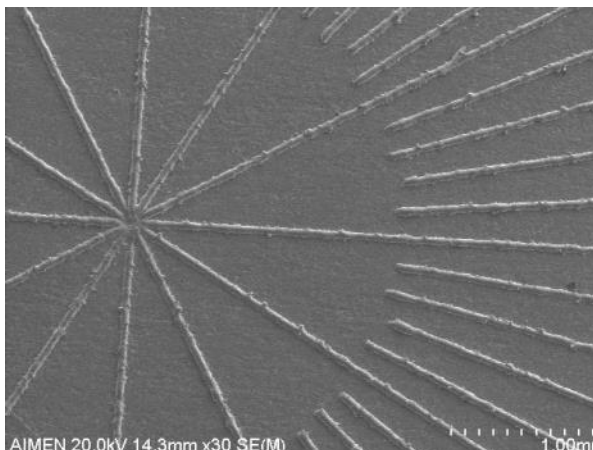
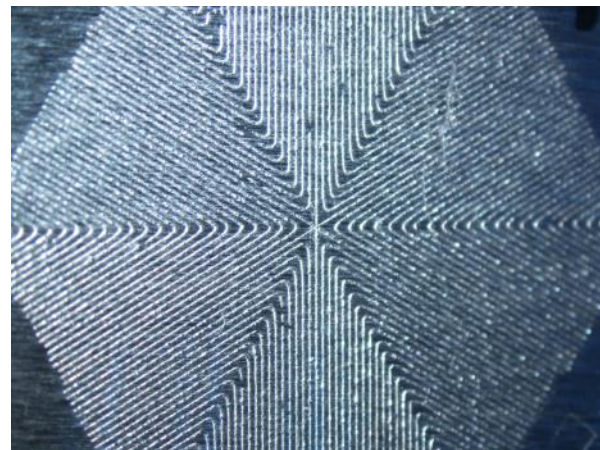
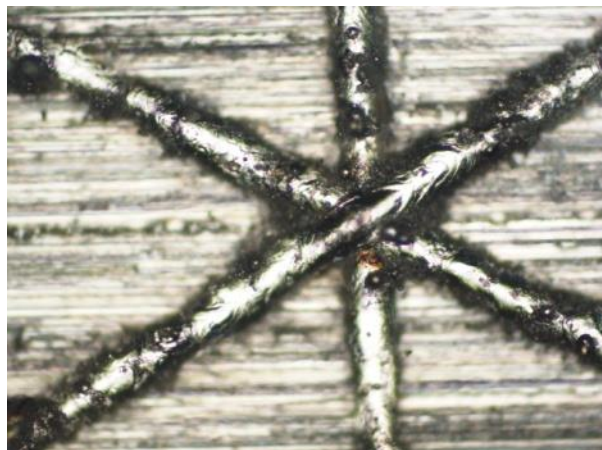
- Difficulties in programming
- Defects in initiation and end of each track
- Possibility of using beam modulation



Practical Issues

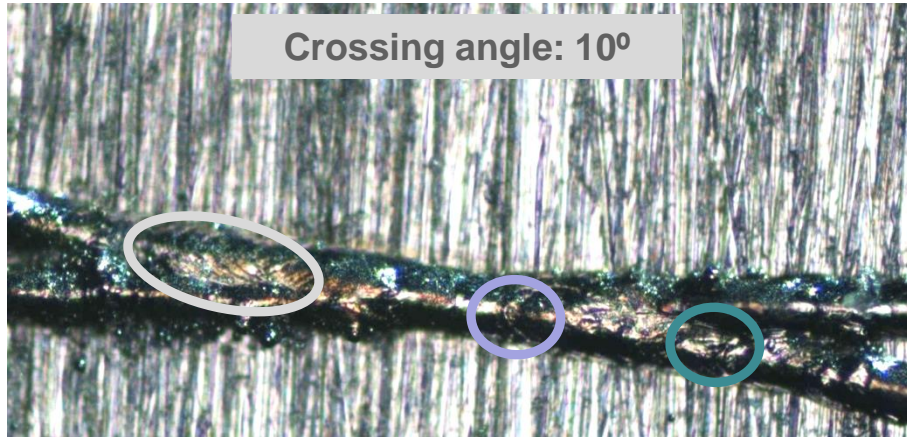
Complex geometries

- Importance of constant power density
- Effects of crossing path on overall height



Geometrical limits of the method

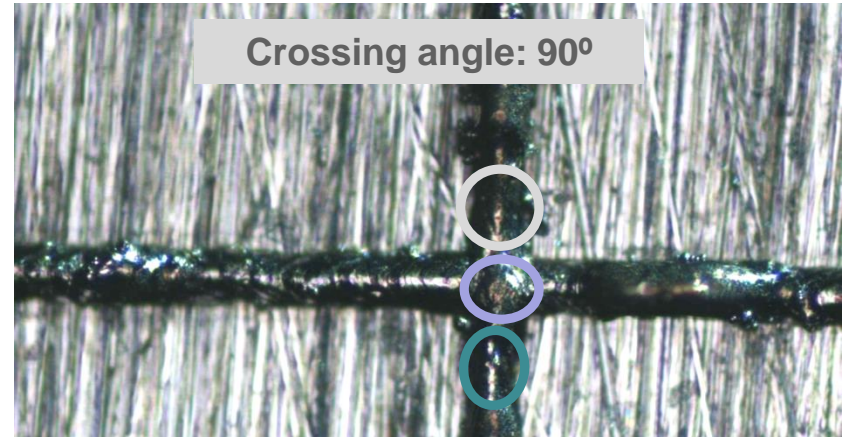
Crossing angle



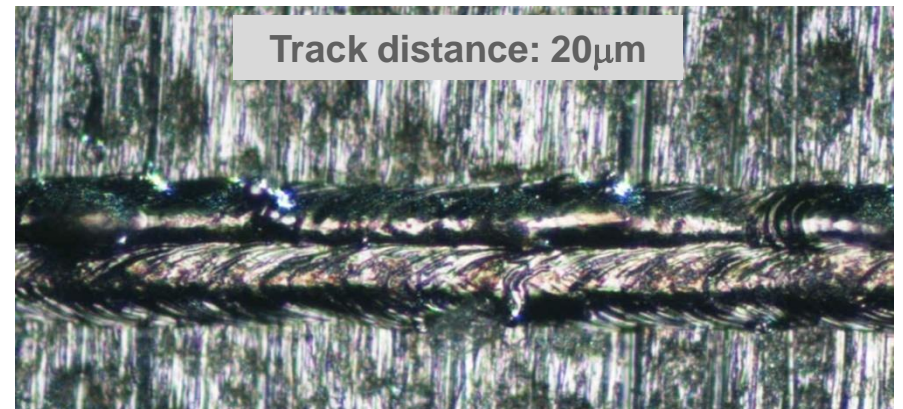
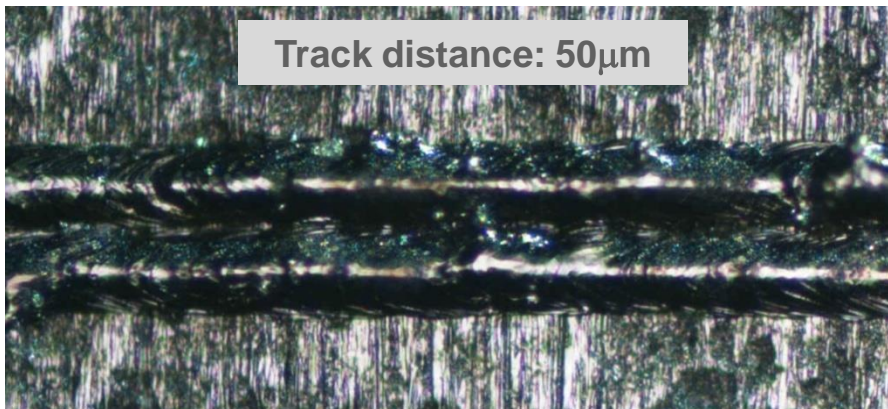
— Dragging material

— Prior track displacement

— Lack of material

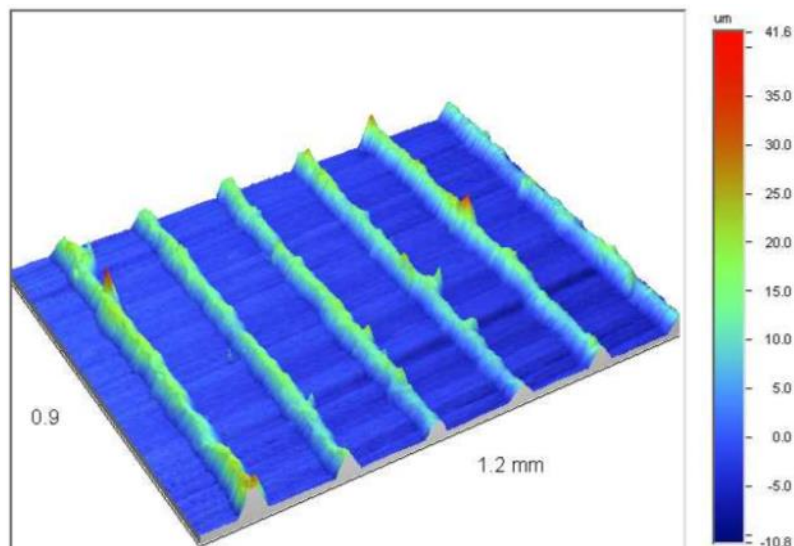


Track distance

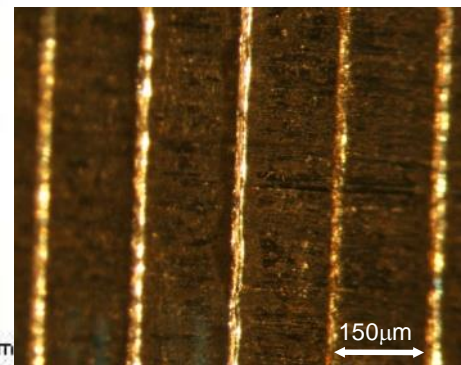
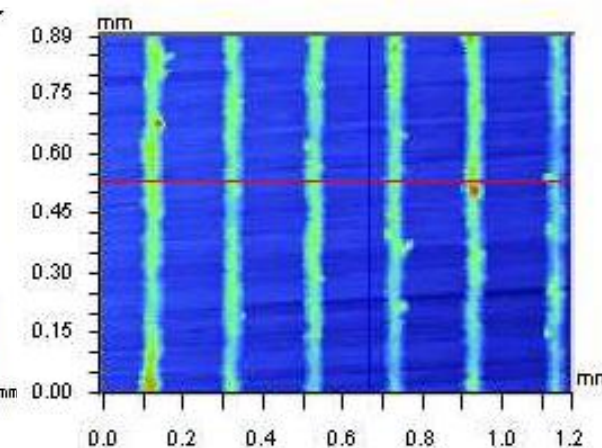
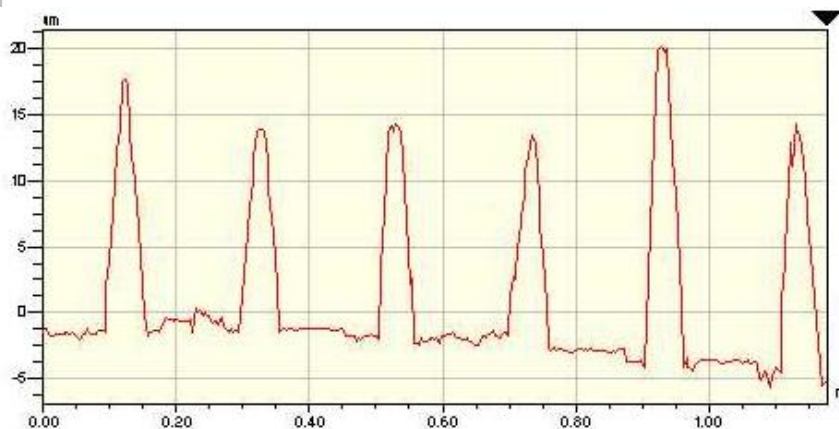


Quality assessment

Geometry

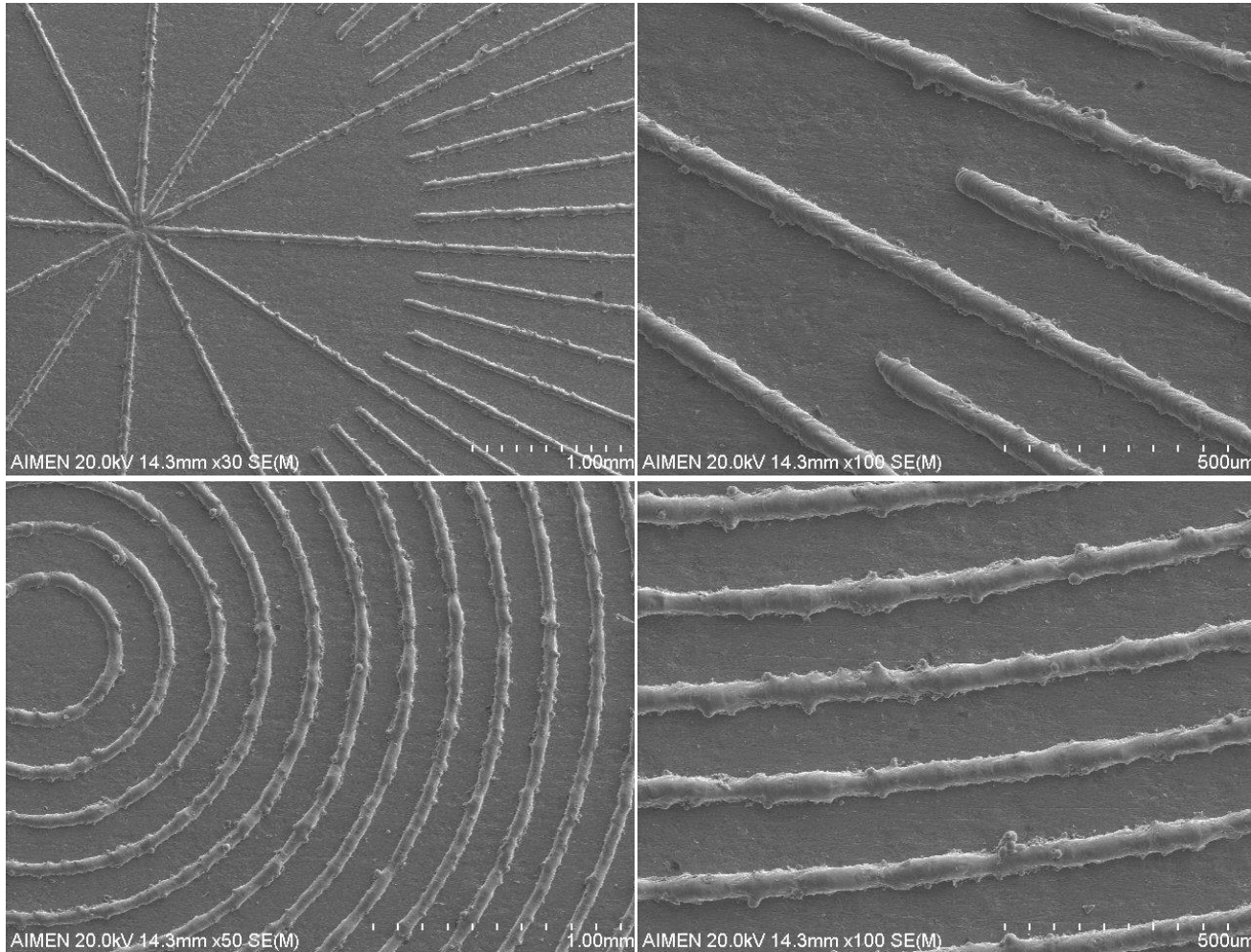


D2 Tool Steel + tool steel powder (particle size < 20 microns)



Practical Issues

Complex geometries



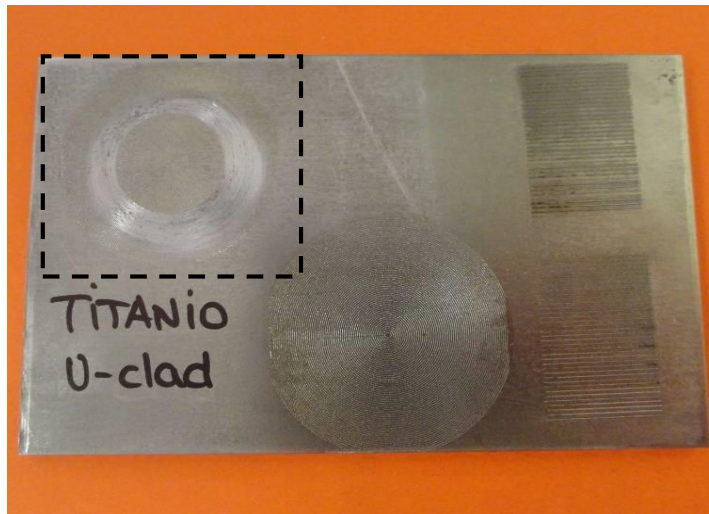
✓ Material:

Titanium on Titanium

- Good adhesion of tracks to substrate
- Homogeneous tracks

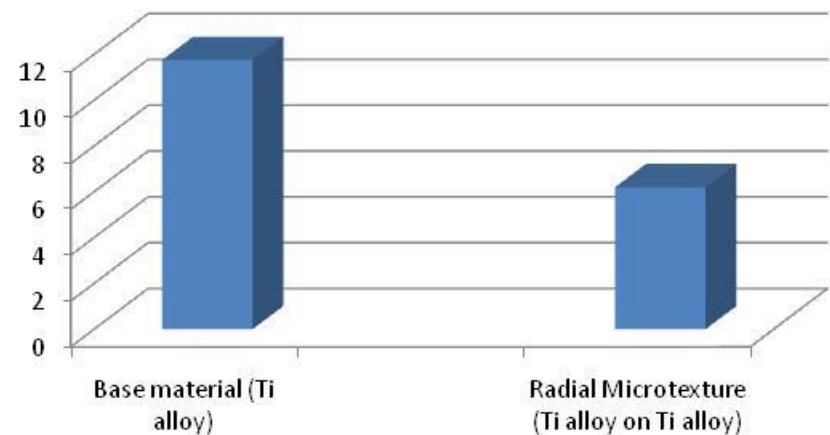
Quality assessment

Wear



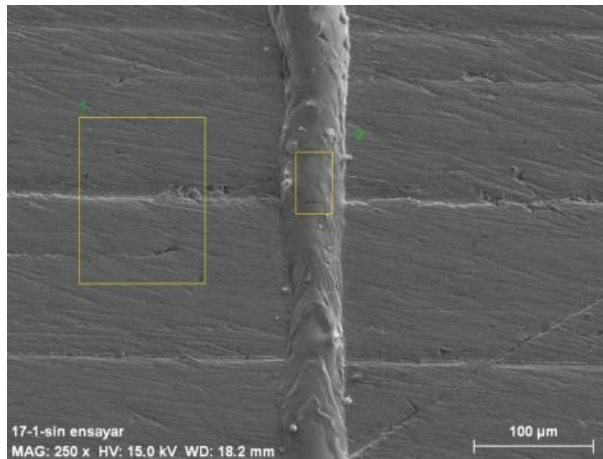
- ✓ Material: Titanium on Titanium
 - Good adhesion of tracks to substrate
 - Friction coefficient (without lubricant)
 - In the same range (unstructured and structured surface)
 - Better results: Radial symmetry
 - Further work: test with lubricant

Weight loss (mg)

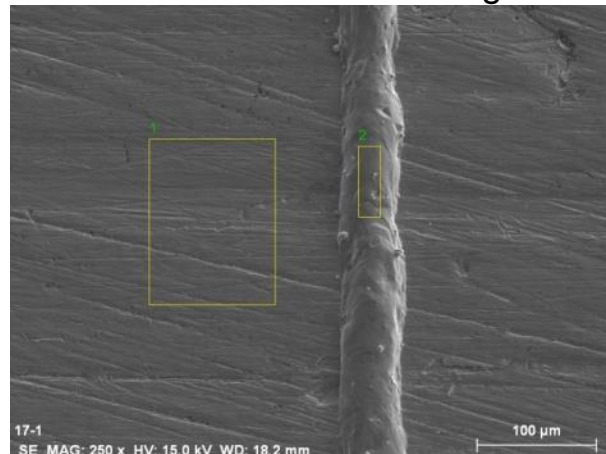


Quality assessment

Corrosion



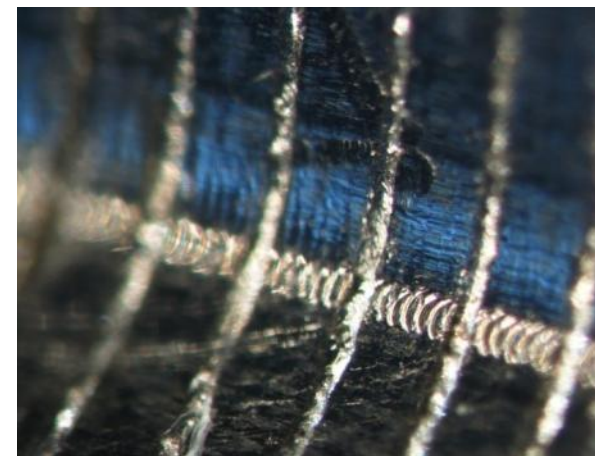
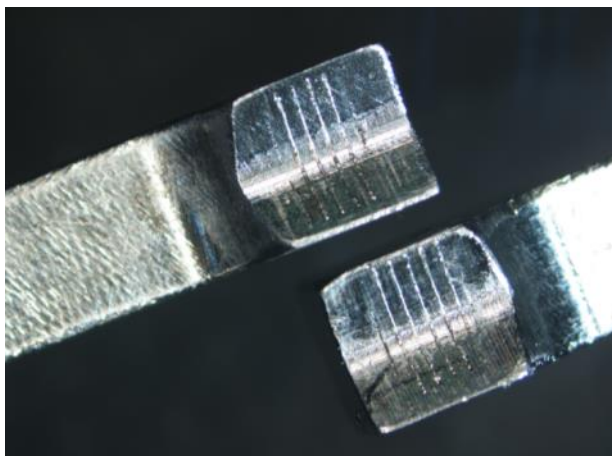
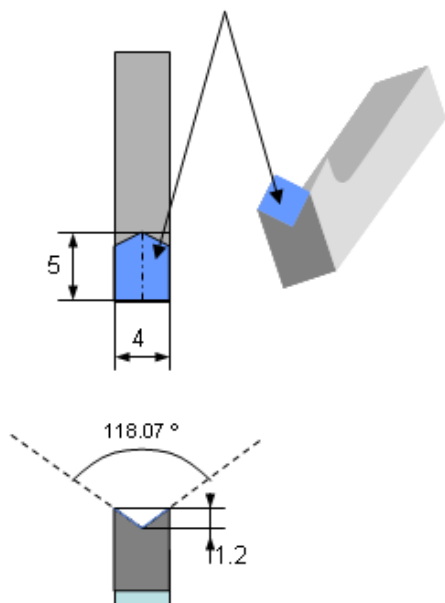
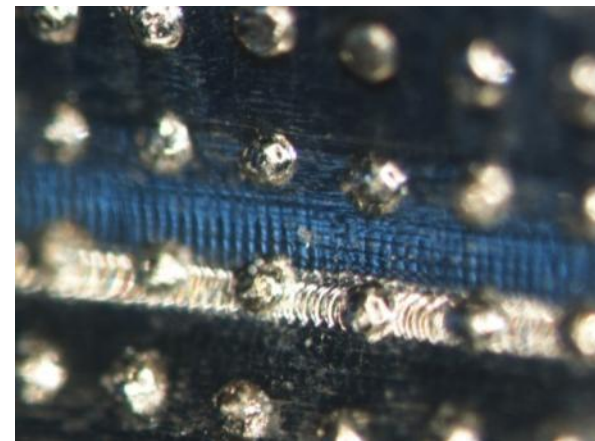
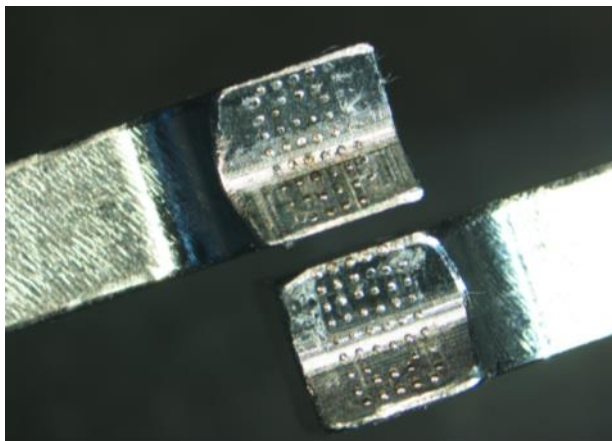
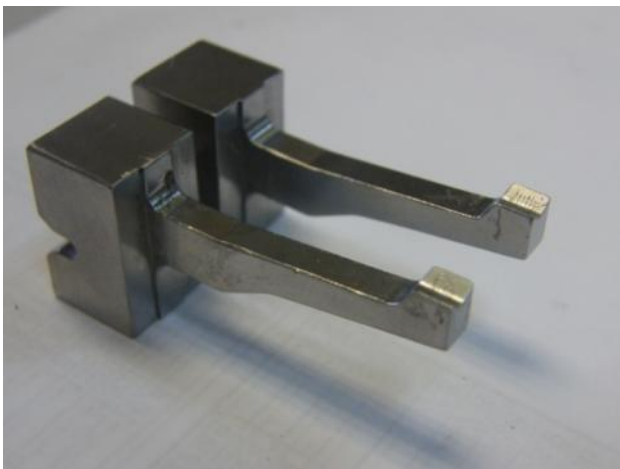
Prior to corrosion testing



After corrosion testing

| Area | Corrosion Test | Mass percent (%) | | | | | | | | |
|------|----------------|------------------|------|------|------|-------|------|-------|------|------|
| | | O | Si | S | V | Cr | Mn | Fe | Ni | Mo |
| 1 | No | 1,03 | 0,24 | 0,02 | 1,41 | 15,94 | 0,52 | 80,04 | 0,12 | 0,66 |
| | Yes | 1,2 | 0,23 | 0,12 | 1,21 | 14,65 | 0,49 | 81,42 | 0,22 | 0,48 |
| 2 | No | 1,2 | 0,37 | 0,02 | 0,57 | 9,6 | 0,53 | 84,63 | 2,77 | 0,32 |
| | Yes | 2,69 | 0,52 | 0,21 | 0,69 | 9,04 | 0,53 | 82,97 | 3,27 | 0,08 |

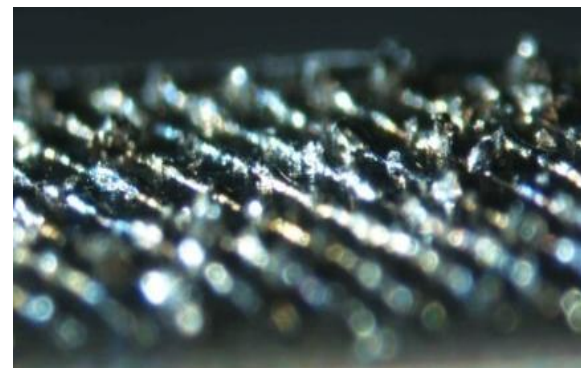
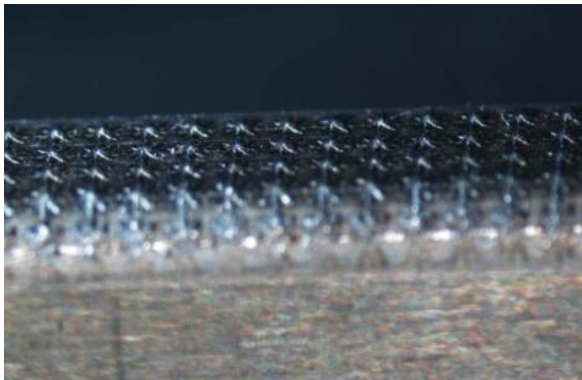
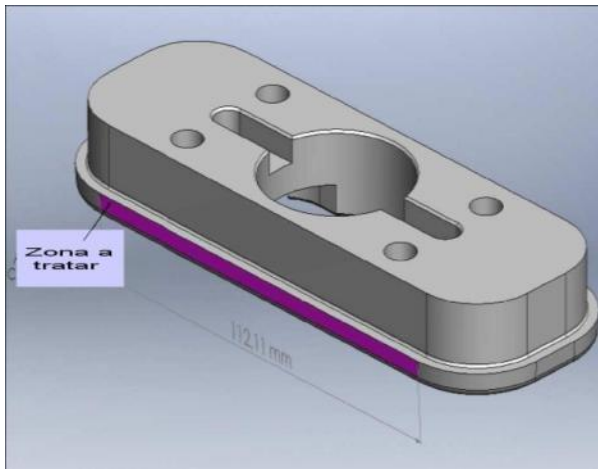
- SEM micrographs and EDS analysis performed prior and after corrosion tests
- No visible effect of corrosion test on quality or geometry of the track or the Heat Aff. Zone.
- No relevant variation of composition (loss of alloyants) after corrosion test.



| Probetas | Patrón | Pot.(W) | V _{scan} (mm/s) | T _p (ms) | Df (mm) | Atm. |
|----------|----------------|---------|--------------------------|---------------------|---------|-------|
| LA & LB | Cordones | 75 | 400 | - | ±0.6 | Argón |
| PA & PB | Protuberancias | 75 | - | 2 | ±0.6 | Argón |

Mejora del funcionamiento de herramientas

- Recubrimientos para mejorar de resistencia a corrosión
- Microprocesado láser para mejorar el agarre de superficies



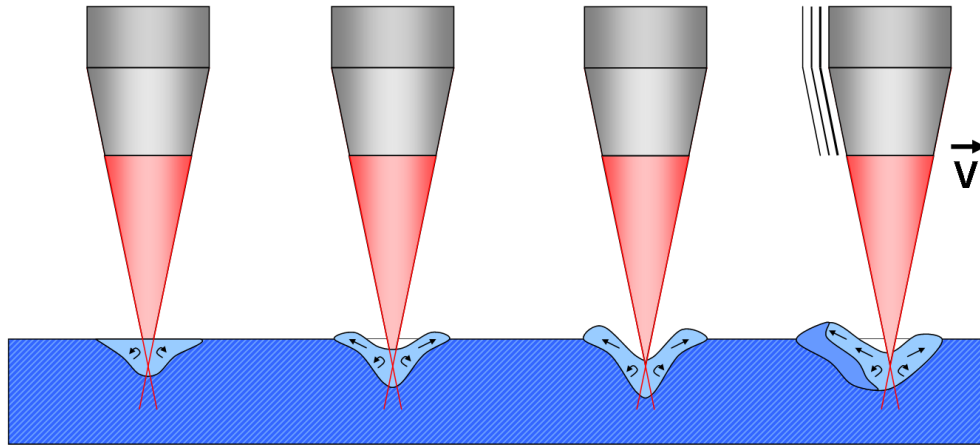
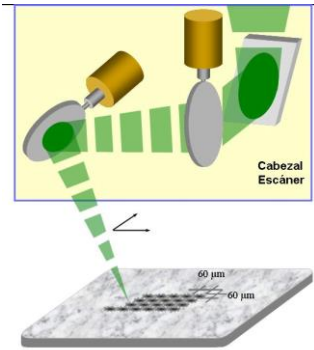
Melting Metal Regime



Looking for a better adhesive joint

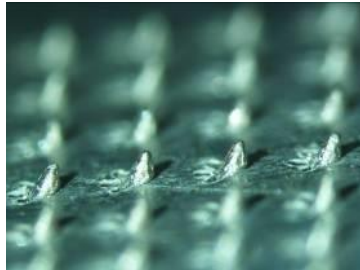
Generation of positive anchorage points to improve the joint between adhesive and substrate

- Several periodic patterns have been analyzed controlling: fill factor, feature high, etc.



Selected process parameters:

- 100W
- 400mm/s
- 10 repetitions per step



Engineering of surface properties for adhesive joints

Use in engineering:



Automotive industry:

High-end vehicles

Building:

Sealing and closures. Bond to isolation.



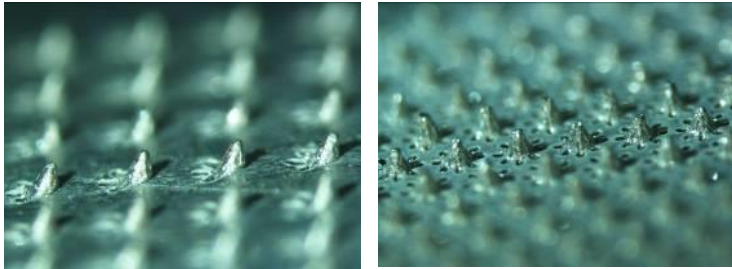
Aeronautics:

Aerostructures and bonding to composite

Looking for a better adhesive joint

Shear Strength Test

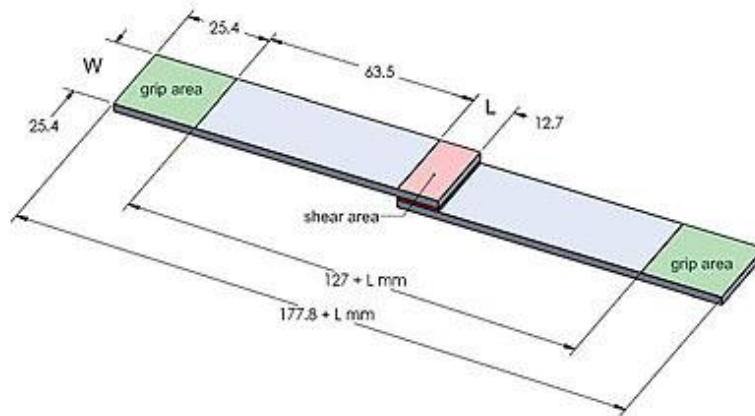
- Selected geometries have been tested in comparison with no textured surface.



Lap Joint Geometry:

UNE EN 1465

25 width
12.5 length



Looking for a better adhesive joint

Shear Strength Test

- Selected geometries have been tested in comparison with no textured surface.



Texture B

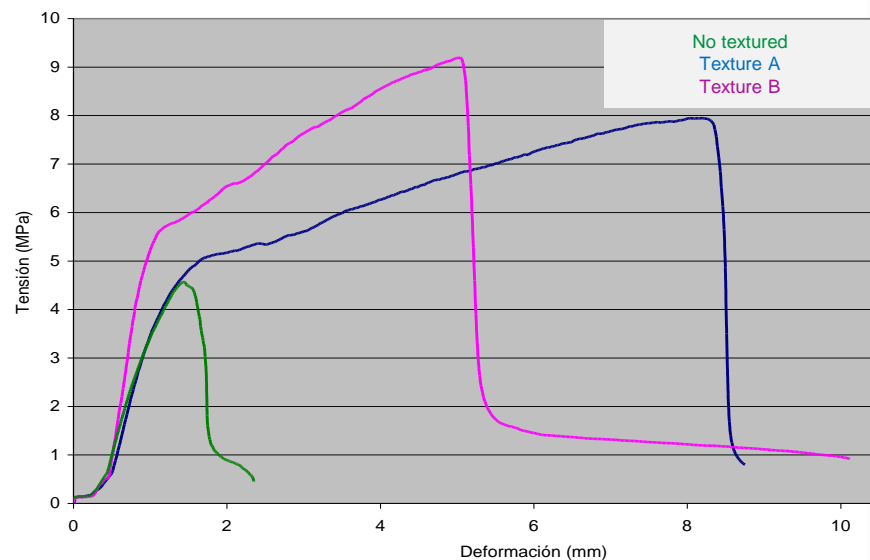
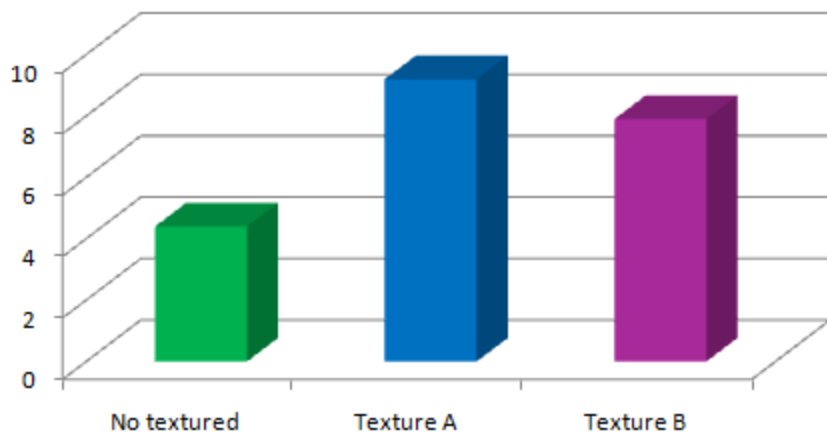


Texture A

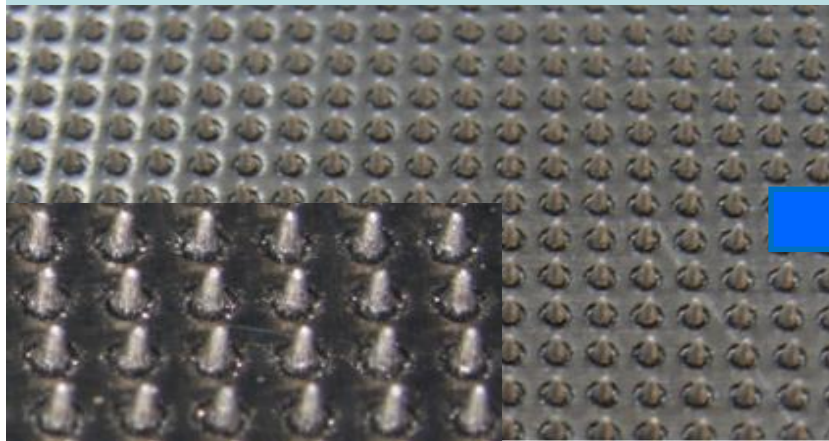


No Textured

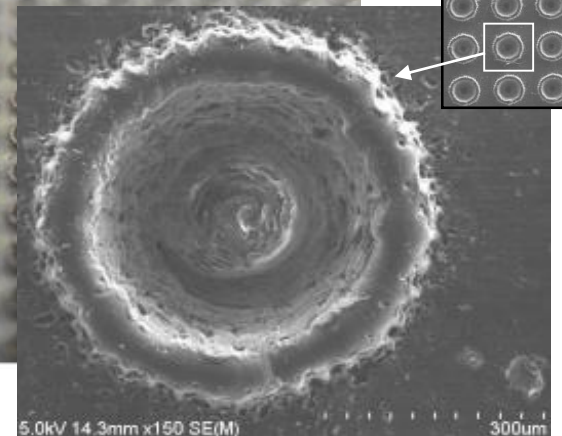
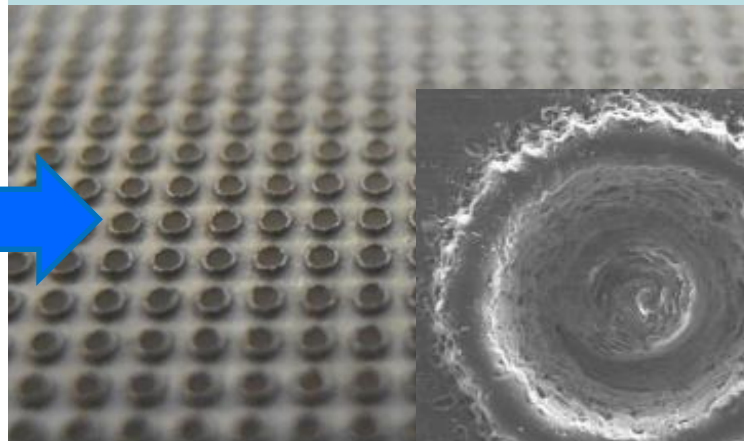
Maximum Stress (MPa)



Positive features insert



μ -holes Plastic sample

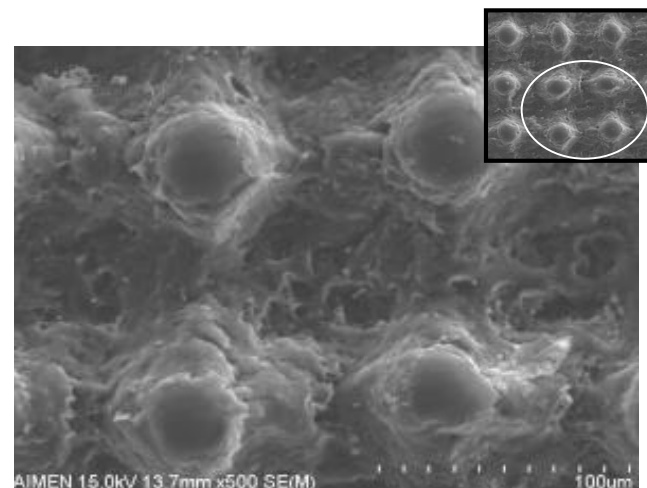


Periodic μ -holes



Period of 75 microns

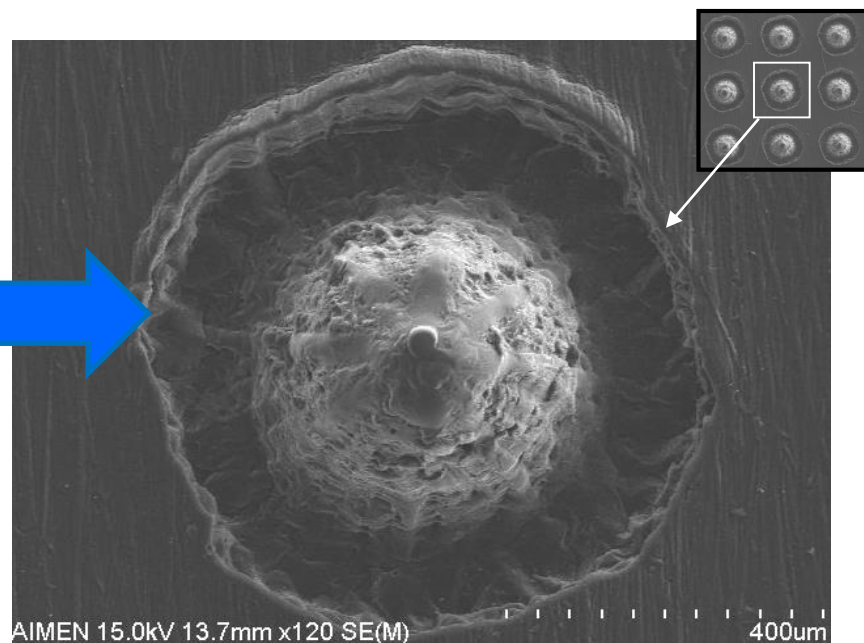
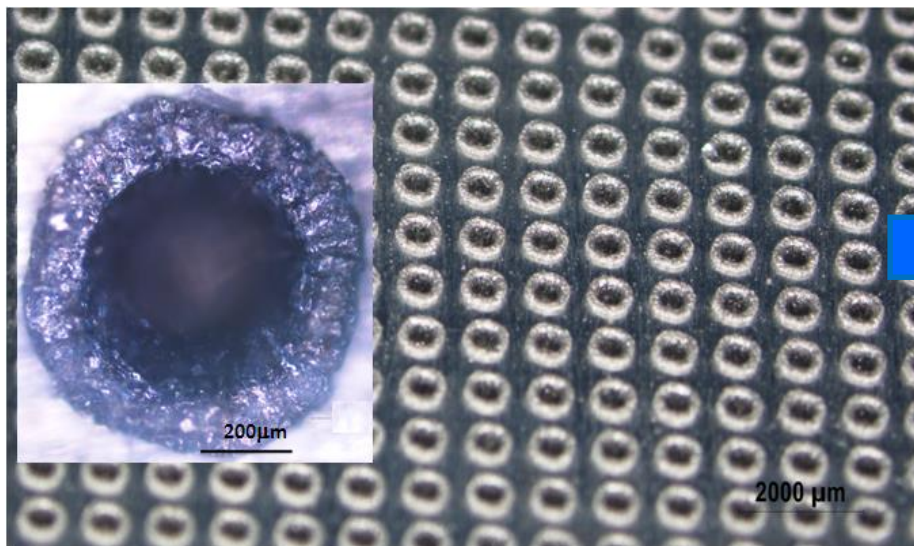
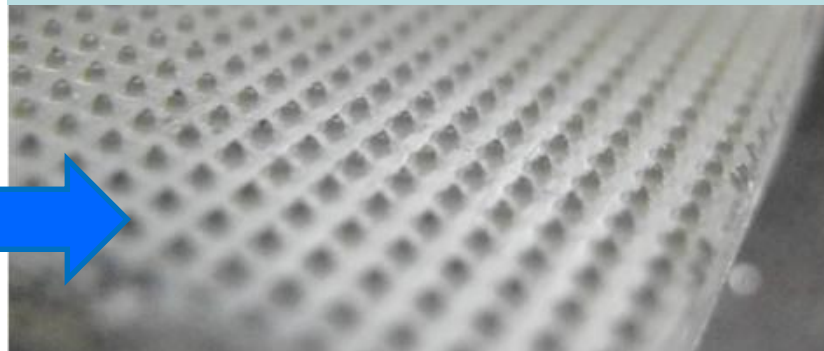
μ -holes Plastic sample



Micro-reservoirs



Positive anchorage points

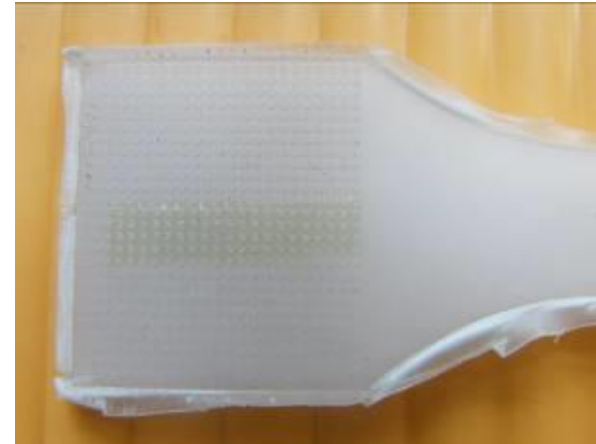


Surface tension analysis

Use of calibrated inks to check wettability under given liquid-atmosphere surface tension values.

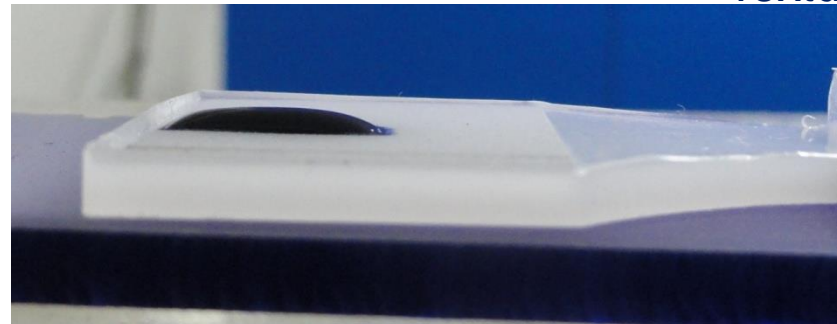
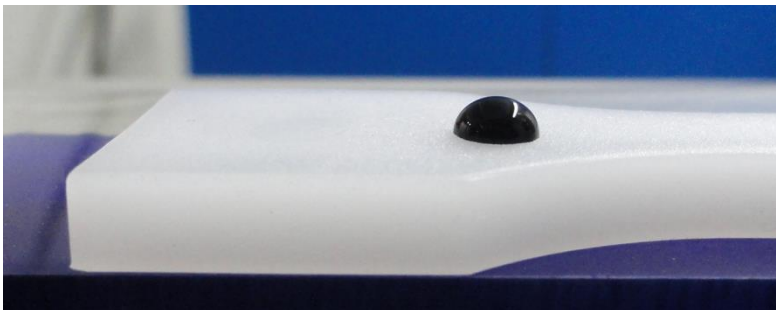


Not Textured



Texture 1

Textured



Texture 5

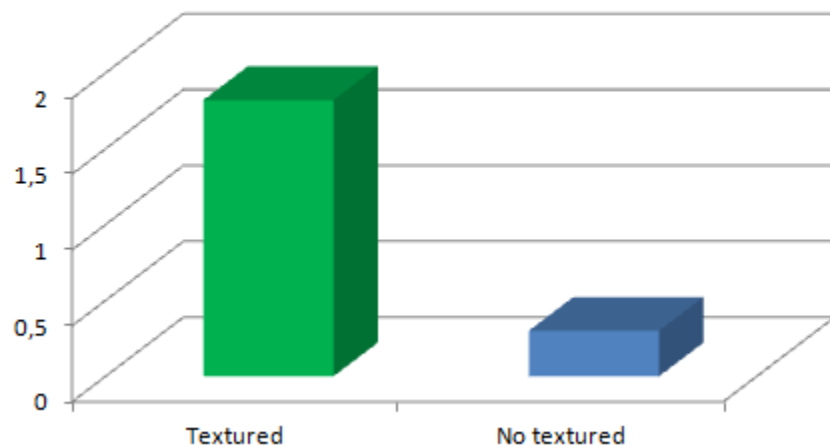
Shear Stress (UNE-EN ISO 13445)



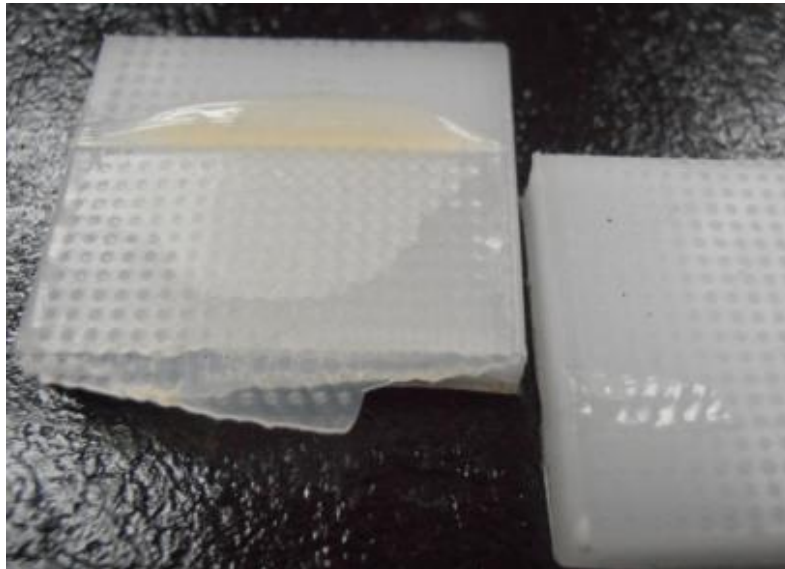
Shear



Max Stress (Mpa)



SIX TIMES HIGER!!

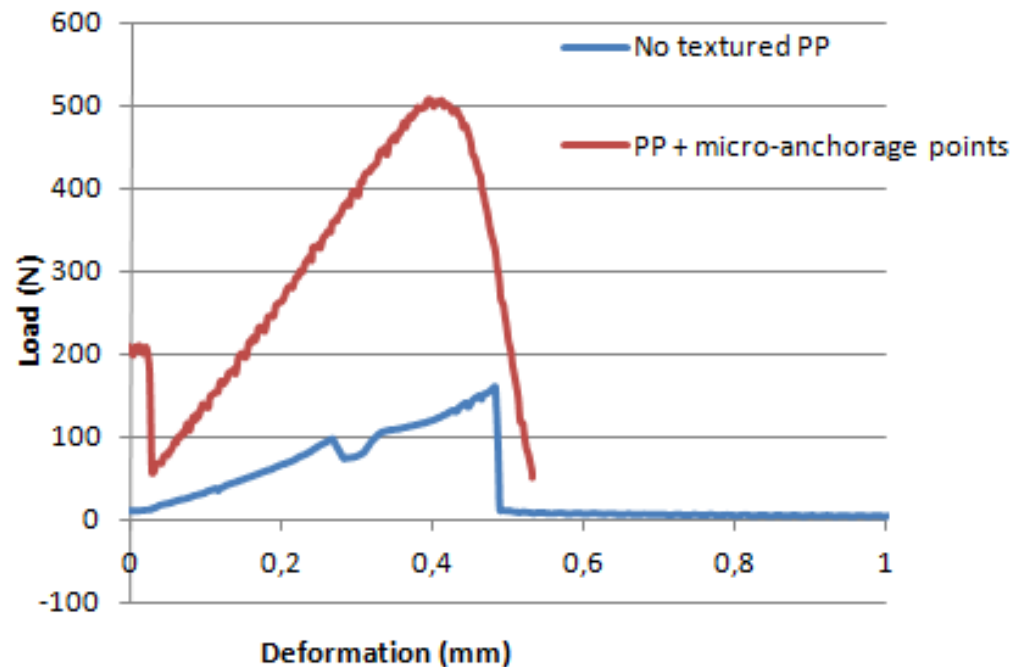


Shift of failure mechanism: adhesive to special-cohesive.

Partial shearing of polymer texture inside adhesive.

Damage in textured face during cohesive breaking.

Large energy absorbed by the deformation and breaking of polymer structures anchored inside the adhesive.

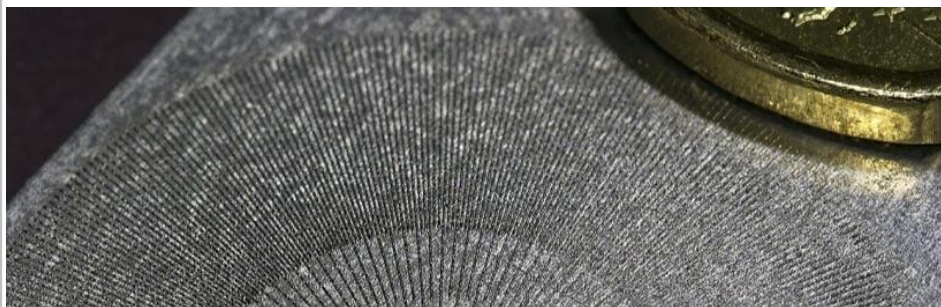


Conclusions



- ✓ Microcladding has been demonstrated as a feasible technique for producing microfeatures
- ✓ Stable, good quality tracks of 50 microns produced
- ✓ Variety of combinations of materials demonstrated
- ✓ Good adhesion, resistance and no damage to parent material
- ✓ Weak point: powder pre-placement, very influent on quality

**Fostering AIMEN Research Potential
in Laser Technology for Material Microprocessing**



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Thank you for your attention

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