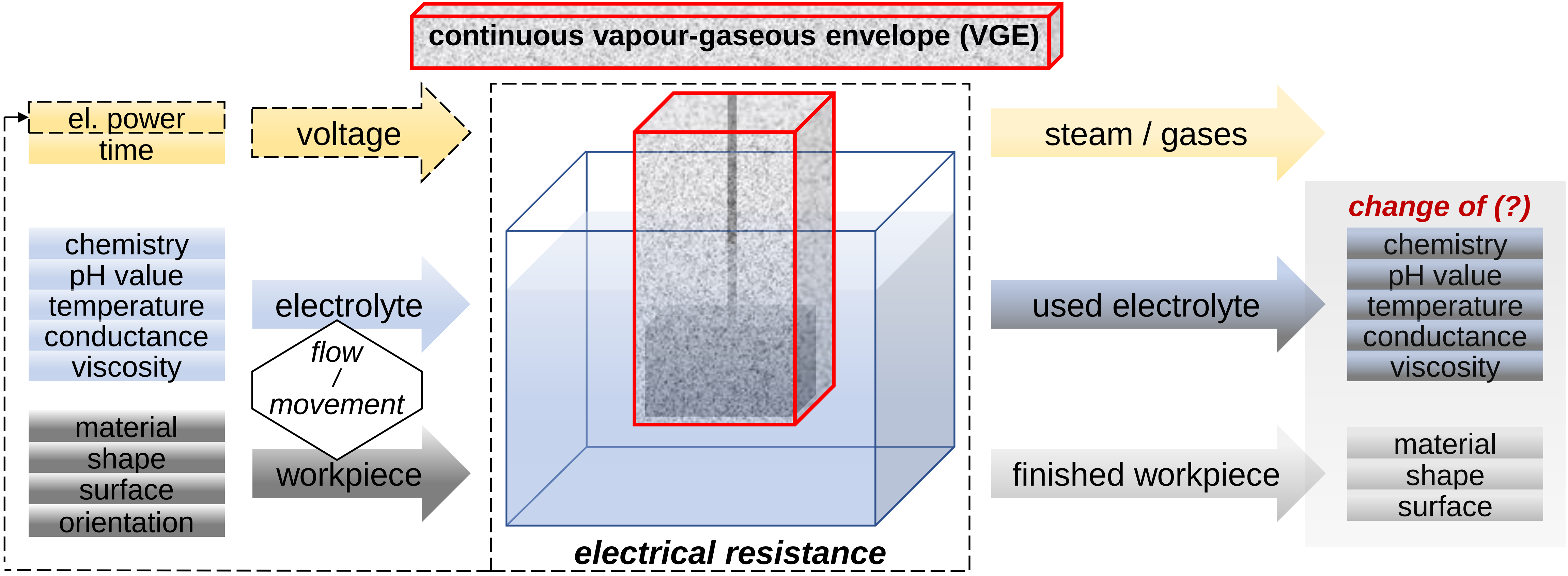
TUBAF
Die Ressourcenuniversität.
Seit 1765.

INSTITUT FÜR MASCHINENELEMENTE
KONSTRUKTION UND FERTIGUNG
PROFESSUR ADDITIVE FERTIGUNG

PEP OF COMPLEX PARTS

IMKF | Professur Additive Fertigung | Prof. Dr.-Ing. Henning Zeidler

PeP of Complex Parts



(not) a simple process with complex relations?!

PEP of complex parts: influence of initial surface topology

Geometry, i.e., shape, form, size etc., **of a part and its initial surface quality influence the outcome of the PEP process**. The following challenges could be present and taken into consideration before the PEP-treatment of complex parts:

- Are there fine grid-like structures present?
- Are there inner surfaces present?
- Does any segment of the part cast a hydrodynamic shadow to other part segment or area?

All these challenges **restricts electrolyte flow** around the surface thus prohibiting development of plasma skin. Therefore the parts, or its area, cannot be (effectively) polished.

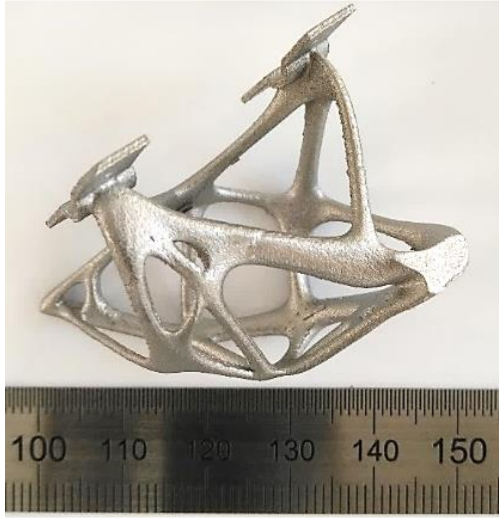
PEP of complex parts: influence of initial surface topology. Examples

Titanium butterfly. Challenges:

- Inner surfaces
- Grid-like structures (not too fine though)
- When not properly positioned casts hydrodynamic shadow to some part segments

Titanium joint. Challenges:

- Inner narrow surfaces
- Pipe-like surfaces
- When not properly positioned casts hydrodynamic shadow to some part segments



Titanium part (AM). Challenges:

- Inner surfaces
- Grid-like structures (not too fine though)
- Hydrodynamic shadow

PEP of complex parts: influence of initial surface topology. Examples

Titanium butterfly. Solutions:

- Mount the part in slightly tilted position

Titanium joint. Solutions:

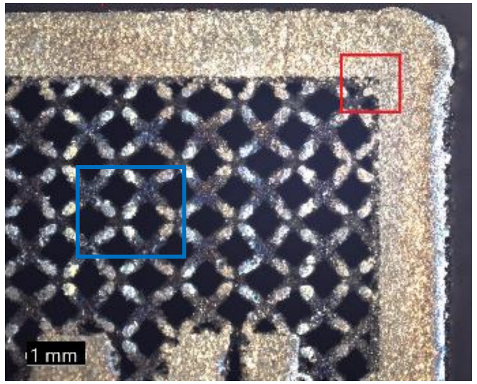
- Multiple PEP steps with part rotation in between them

! Red circle shows the presence of the hydrodynamic shadow during the PEP process.

Titanium part (AM). Solutions:

- Multiple PEP steps with part rotation in between them

PEP of complex parts: influence of initial surface topology. Examples



AM titanium grid-like structure.
Challenge:

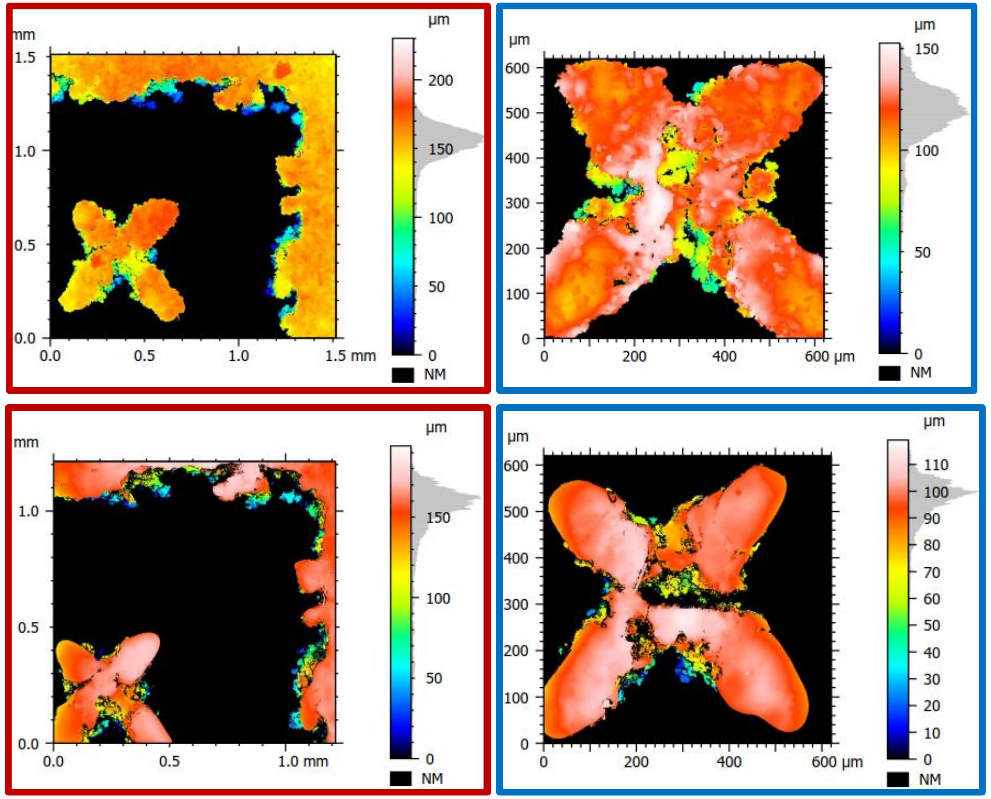
- Very fine grid structure

PEP goal:

- Remove the remaining powder

Solution:

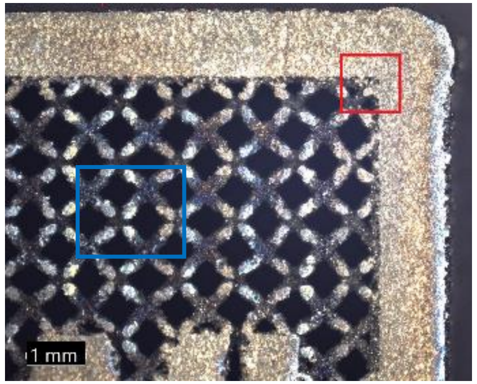
- Horizontal part positioning
- Induced electrolyte stream



Surface topology before PEP

Surface topology after PEP without induced electrolyte flow

PEP of complex parts: influence of initial surface topology. Examples



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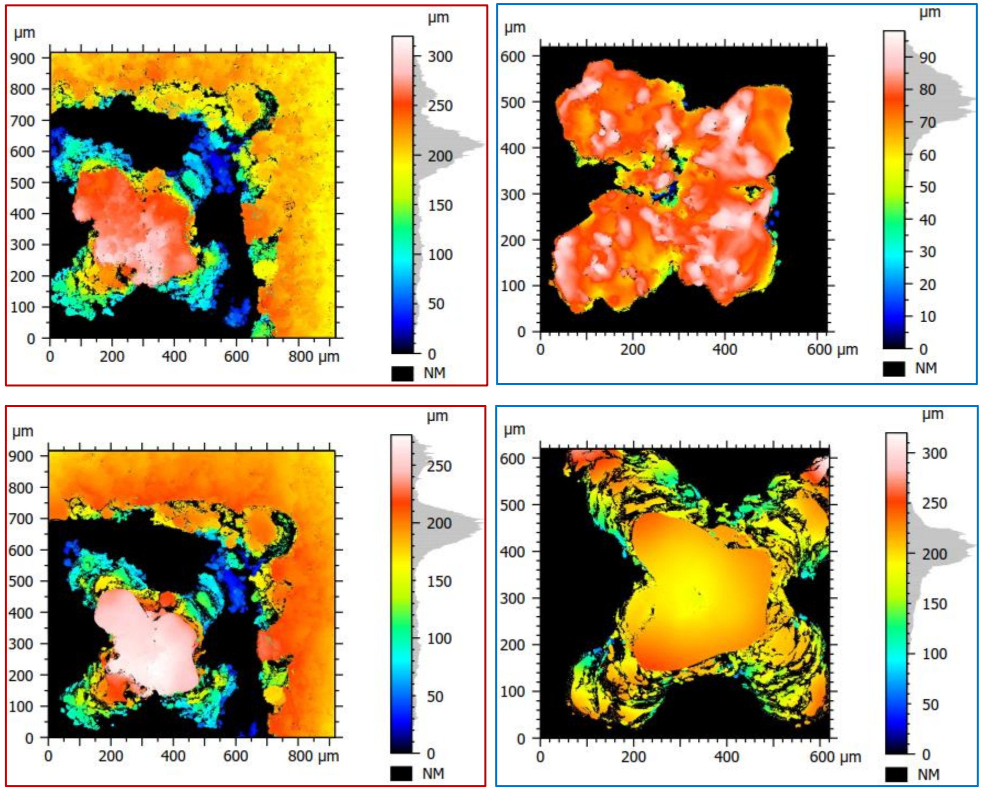


Surface topology before PEP

Surface topology after PEP with induced electrolyte flow

! Induced electrolyte flow enables PEP of fine grid-like structures. However, care should be taken not to overexpose the part to the PEP process so the fine structures would not be dissolved.

PEP of complex parts: influence of initial surface topology. Examples

AM complex titanium tensile part. Challenge:

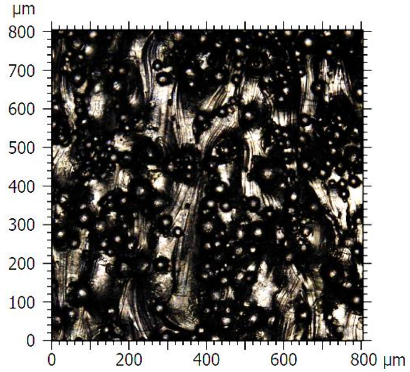
- Hydrodynamic shadow cast at critical part areas

PEP goal:

- Fine surface quality for increased service life under tension

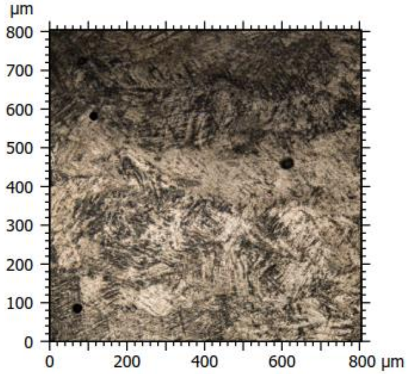
Solution:

- Multiple PEP steps and part rotation in between



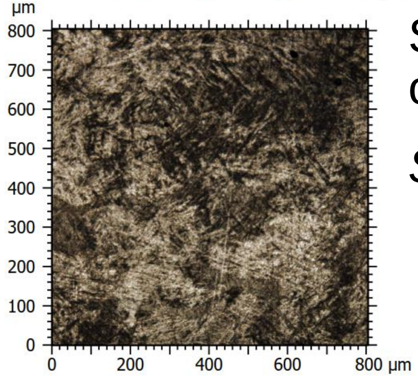
Surface topology before PEP

Sq = 19.2 µm



Surface topology after 45 min of particle blasting and 24 min of PEP

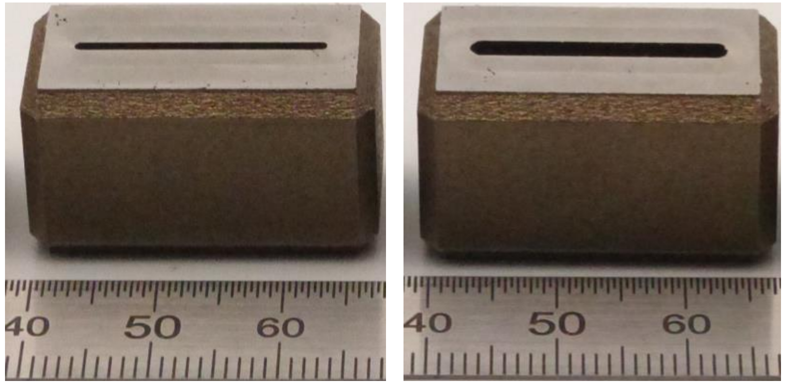
Sq = 0.7 µm



Surface topology after 32 min of PEP

Sq = 0.5 µm

PEP of complex parts: influence of initial surface topology. Examples



AM maraging steel parts for polymer extrusion with 1 mm opening (left) and 2 mm opening (right).
Challenge:

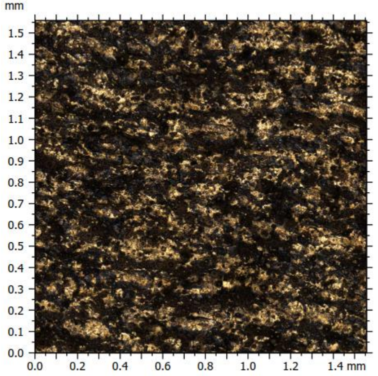
- Polishing of inner surfaces

PEP goal:

- Smoothening of inner surface throughout the part

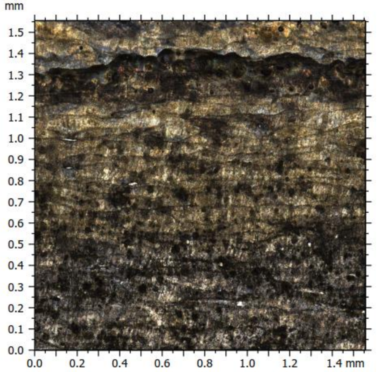
Solution:

- Induced electrolyte flow directed to the inner surface



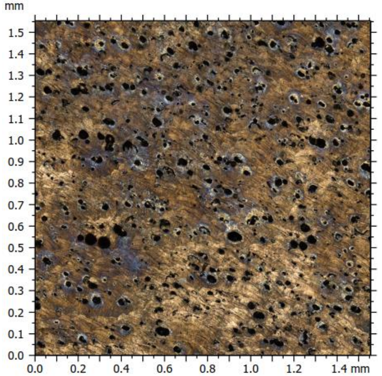
Characteristic surface topology before PEP

Sq = 8.8 µm



Surface topology after 10 min of PEP of the part with 1 mm opening

Sq = 7.4 µm

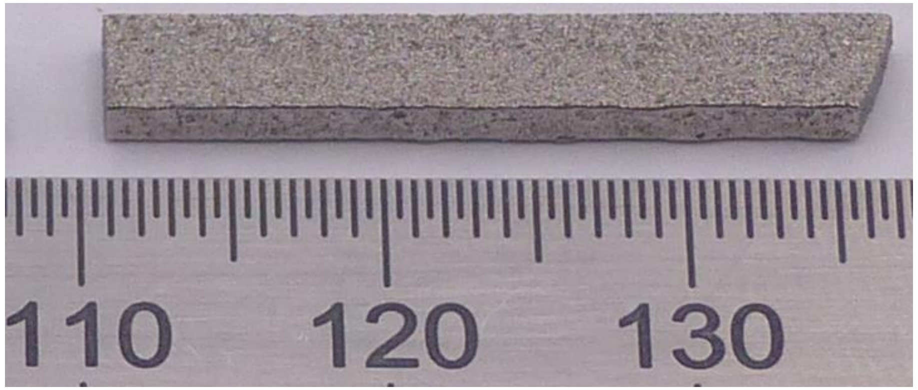


Surface topology after 10 min of PEP of the part with 2 mm opening

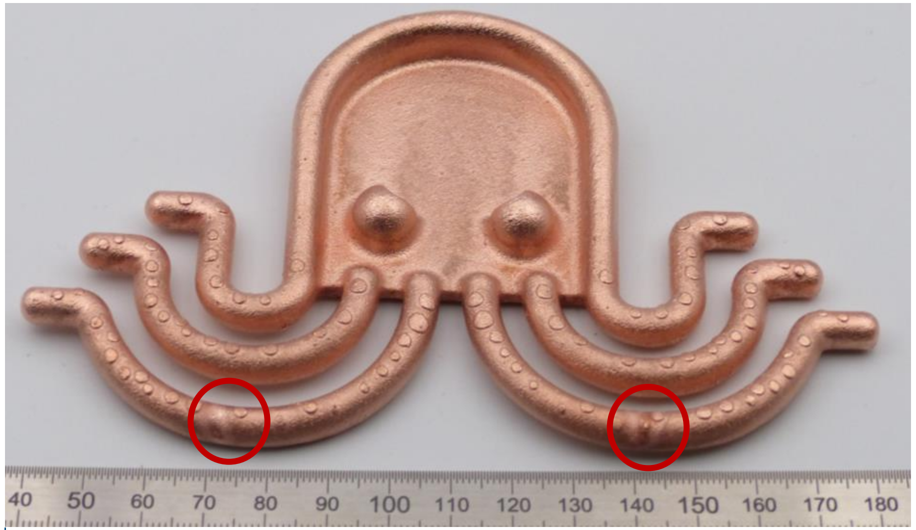
Sq = 2.0 µm

Part geometry/shape, orientation in PEP and part mounting

A part shape/geometry defines the part orientation in the PEP process as well as its mounting.



An AMZ4 beam. To achieve homogenous polishing over the whole surface, it must be oriented vertically or horizontally with the narrow edge facing down. The part must be rotated by 180° to polish top and bottom sides evenly.



A copper part after PEP. It was hanged on a holder at the areas highlighted in red circles and immersed head down.

Part geometry/shape, orientation in PEP and part mounting

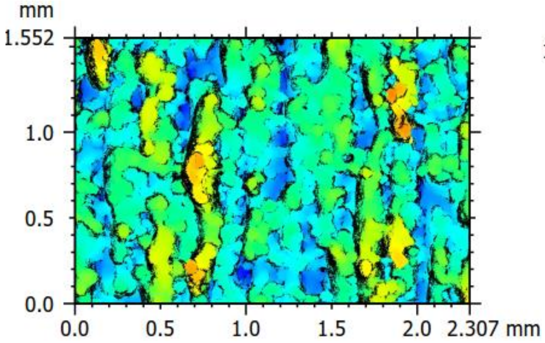
The rotation angle, especially when standing-wave-PEP is used, is very important for good polishing results.

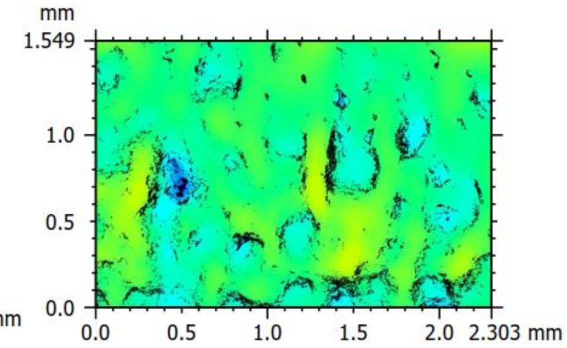
Austenitic steel part in as-built condition

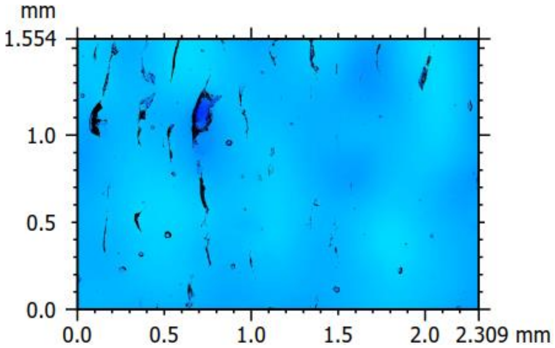
After standing-wave-PEP. Rotation angle was θ = 180°

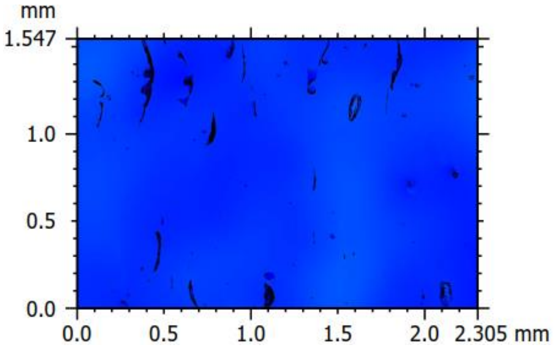
After standing-wave-PEP. Rotation angle was θ = 120°

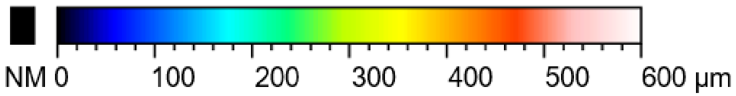
After standing-wave-PEP. Rotation angle was θ = 90°











Part geometry/shape, orientation in PEP and part mounting

For running an **effective PEP process**, a **part** must be **firmly electrically contacted as an anode**. Ideally a parts' holder/clamping system would be made out of the same material as the part.

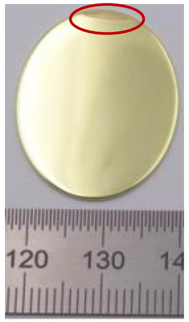
Most frequently used holder materials:

- Thick copper wire for copper-based alloys
- Stainless steel for almost everything else

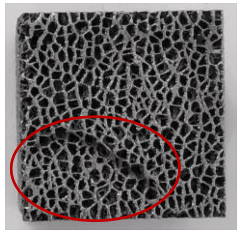
A **Nitinol plate** was clamped with **inappropriate holder** for the PEP process. Thus, a part of it was **coated with copper** (that was in chemical composition of the holder) as it is highlighted in the read circle.

A holder must be:

- Electrically well conducting
- Mechanically stable in PEP process, e.g. shape memory alloys with transformation temperature in the range of the PEP process temperatures cannot be used as holders because they would not keep the required form



A brass disc after PEP. Highlighted in red is a mark left by the stainless-steel holder.



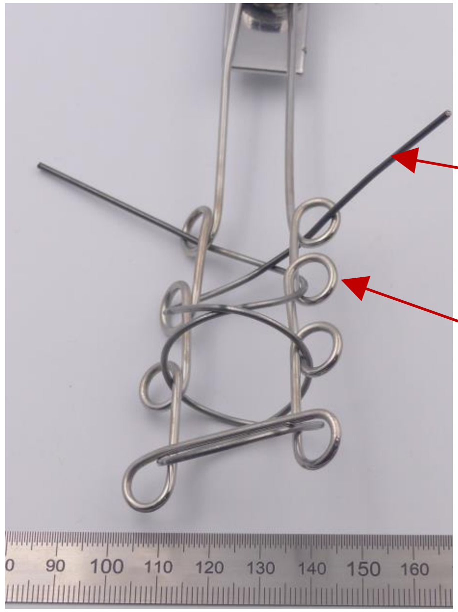
A Nitinol cube after PEP. Highlighted in red is a mark left by the stainless-steel holder.

Part geometry/shape, orientation in PEP and part mounting

Parts can be:

- Clamped within a holder
- Hanged on the holder
- Screwed on the holder
- Mounted within a holder (for specific purposes)

An aluminium holder for aluminium cubes.



A Nitinol wire within a stainless—steel holder.

Nitinol wire

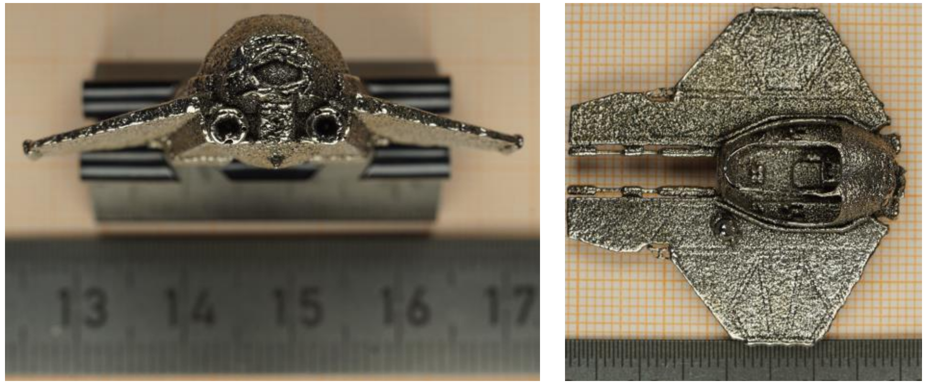
Stainless-steel holder

A stainless-steel plate hanged on a stainless—steel holder.

Part mounting. Quiz

How to mount these parts? Which type of holders to use?

A titanium part. A side view (left) and bottom view (right)



A invar aeroplane. A front view (left) and top view (right)