Multiscale post-processing of metal additive manufactured parts by electro-polishing technology

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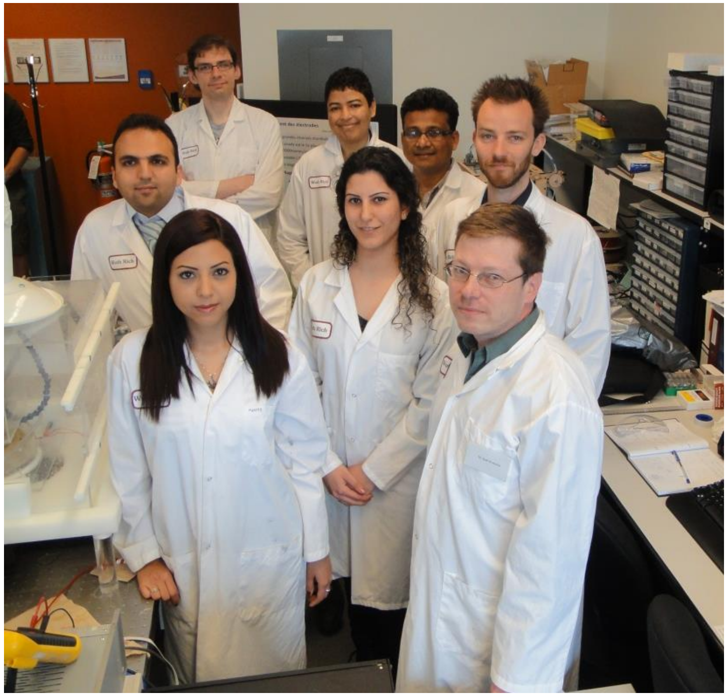
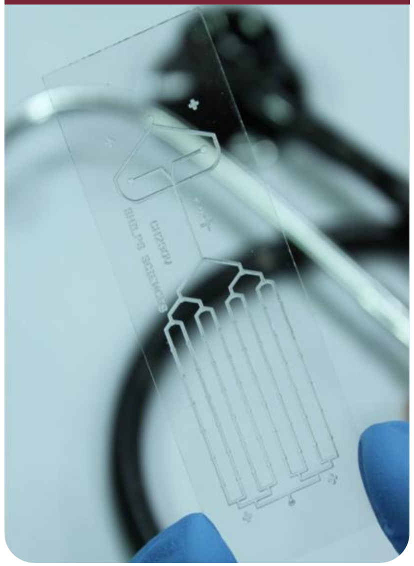
Our Mission

Develop green advanced manufacturing technologies meeting the demand of the fourth industrial revolution



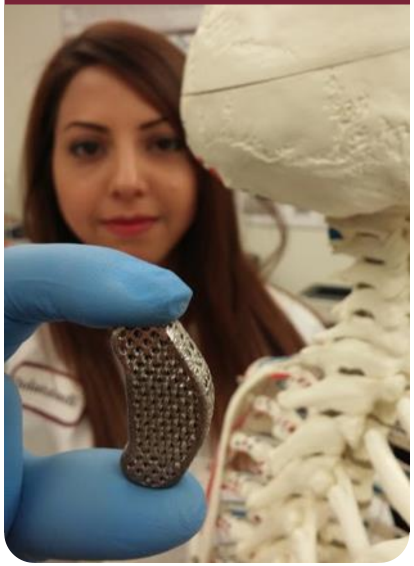
Our Expertise

Glass Machining



- Lab-on-Chip
- Multilayer chips
- Micro- to Macro-world interfaces

Post-Processing

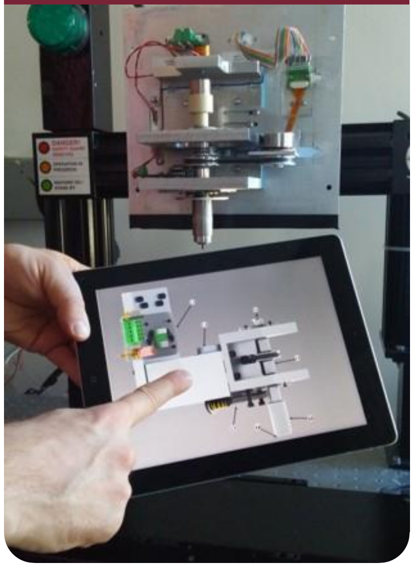


- Multiscale electro-polishing
- Down to Ra of 50nm
- Broad range of materials including Titanium

Coating

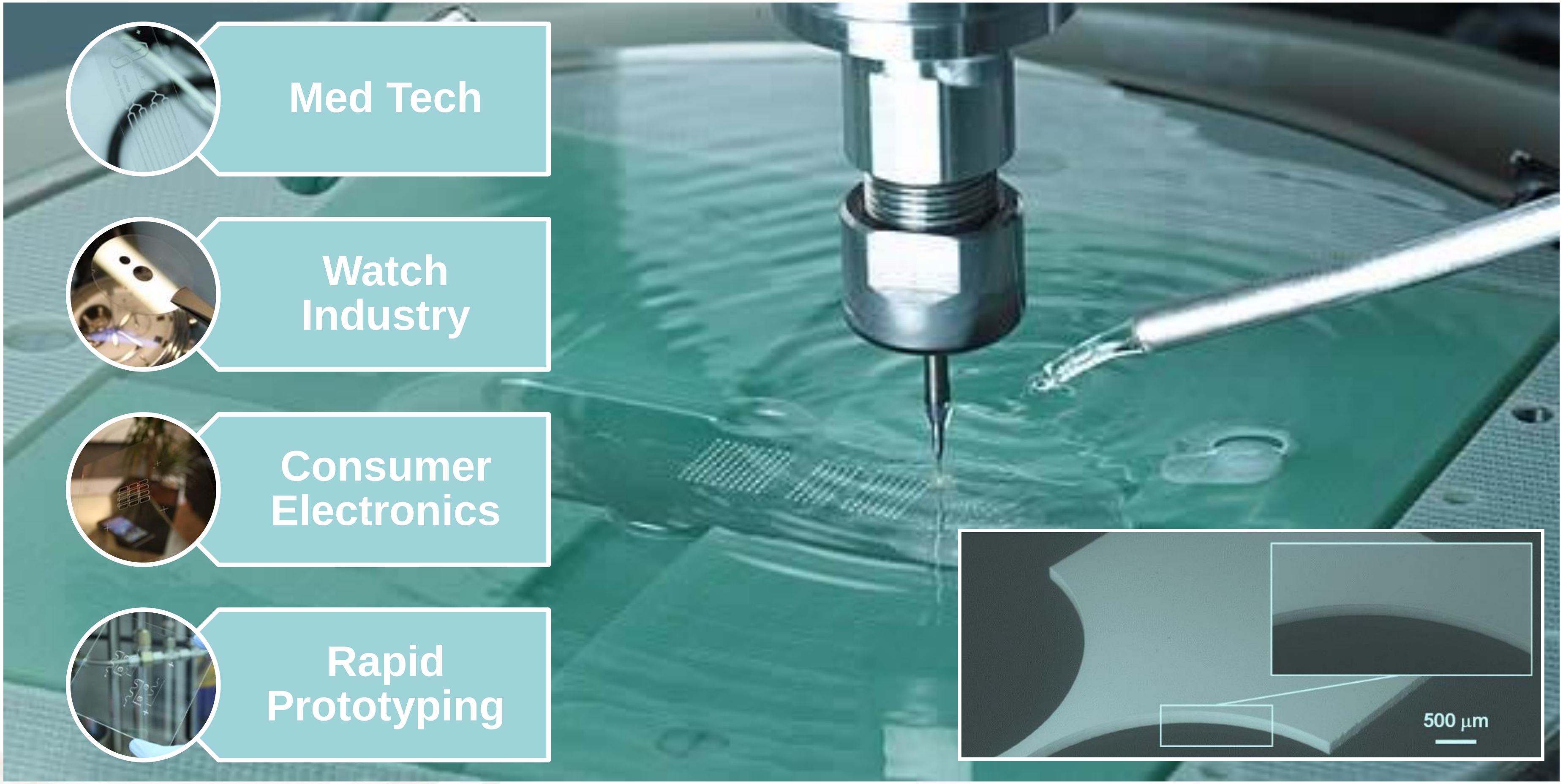
- Complex parts
- Wide range of substrate materials
- Tuning surface wettability

Industry 4.0

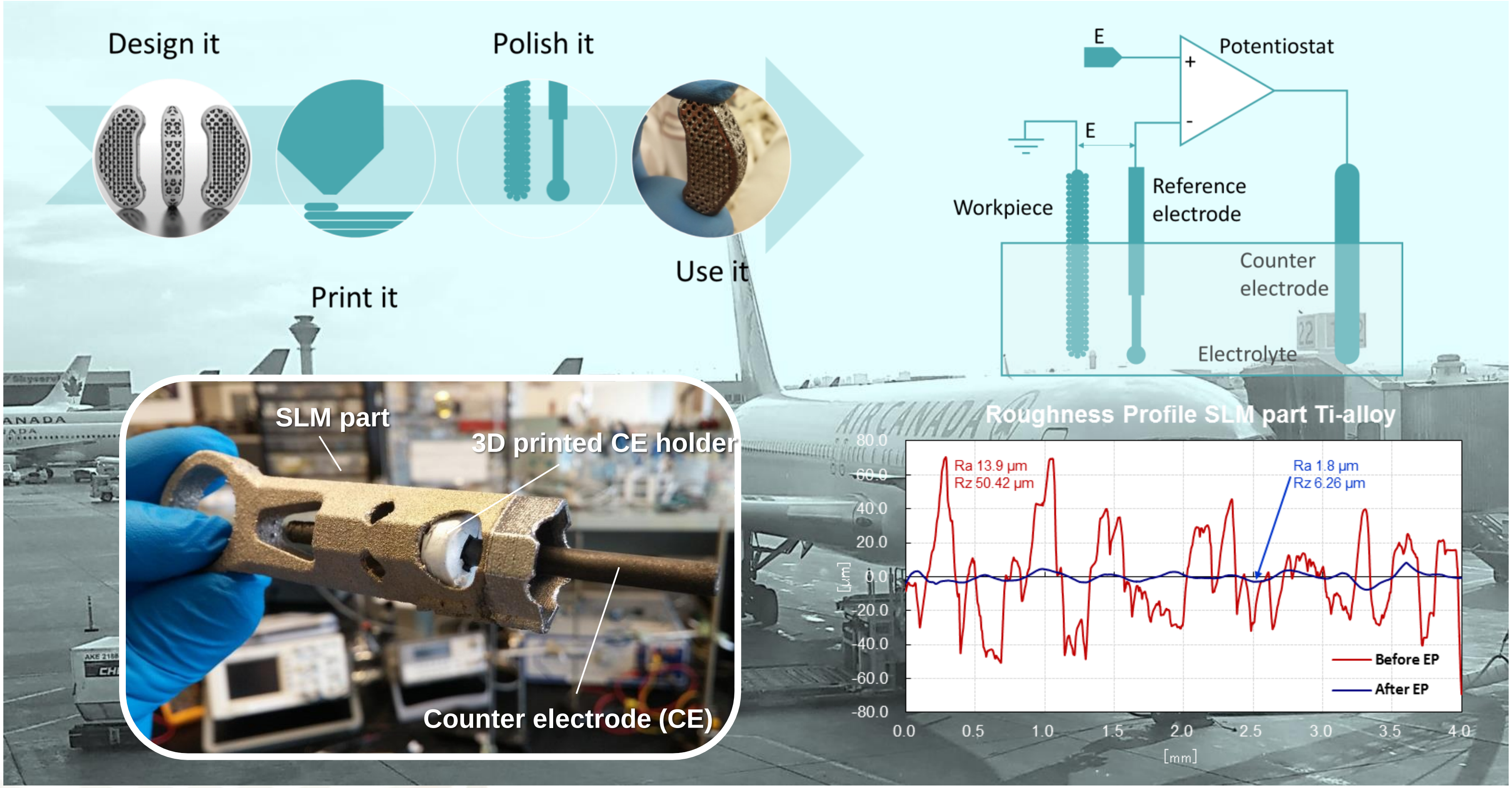


- Batch Size 1 production
- Internet of Things (IoT)
- Ultra low-cost tooling

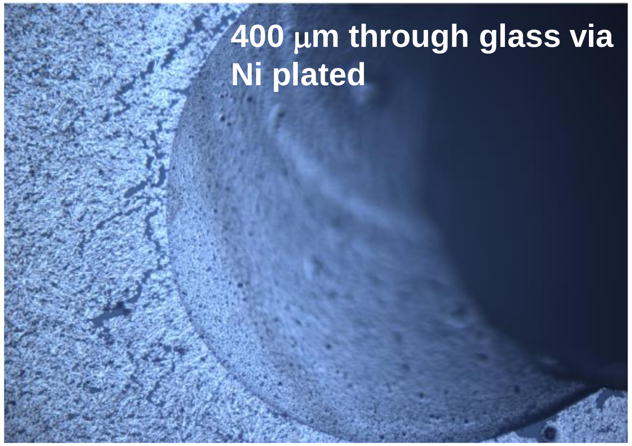
Glass Micromachining

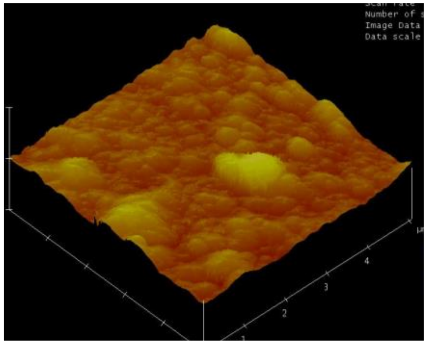


Electropolishing

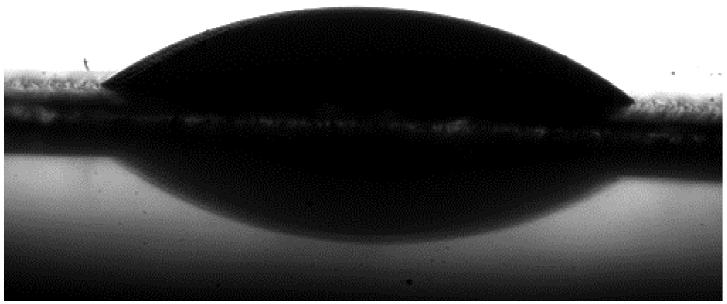


Room Temperature Nanocoating

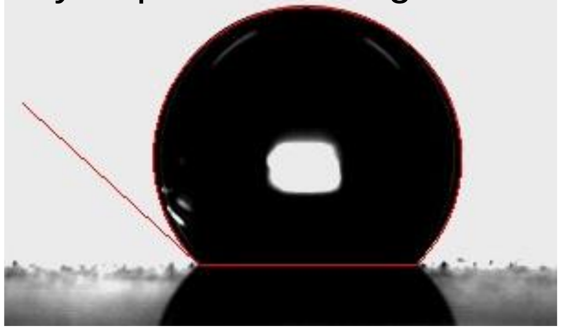




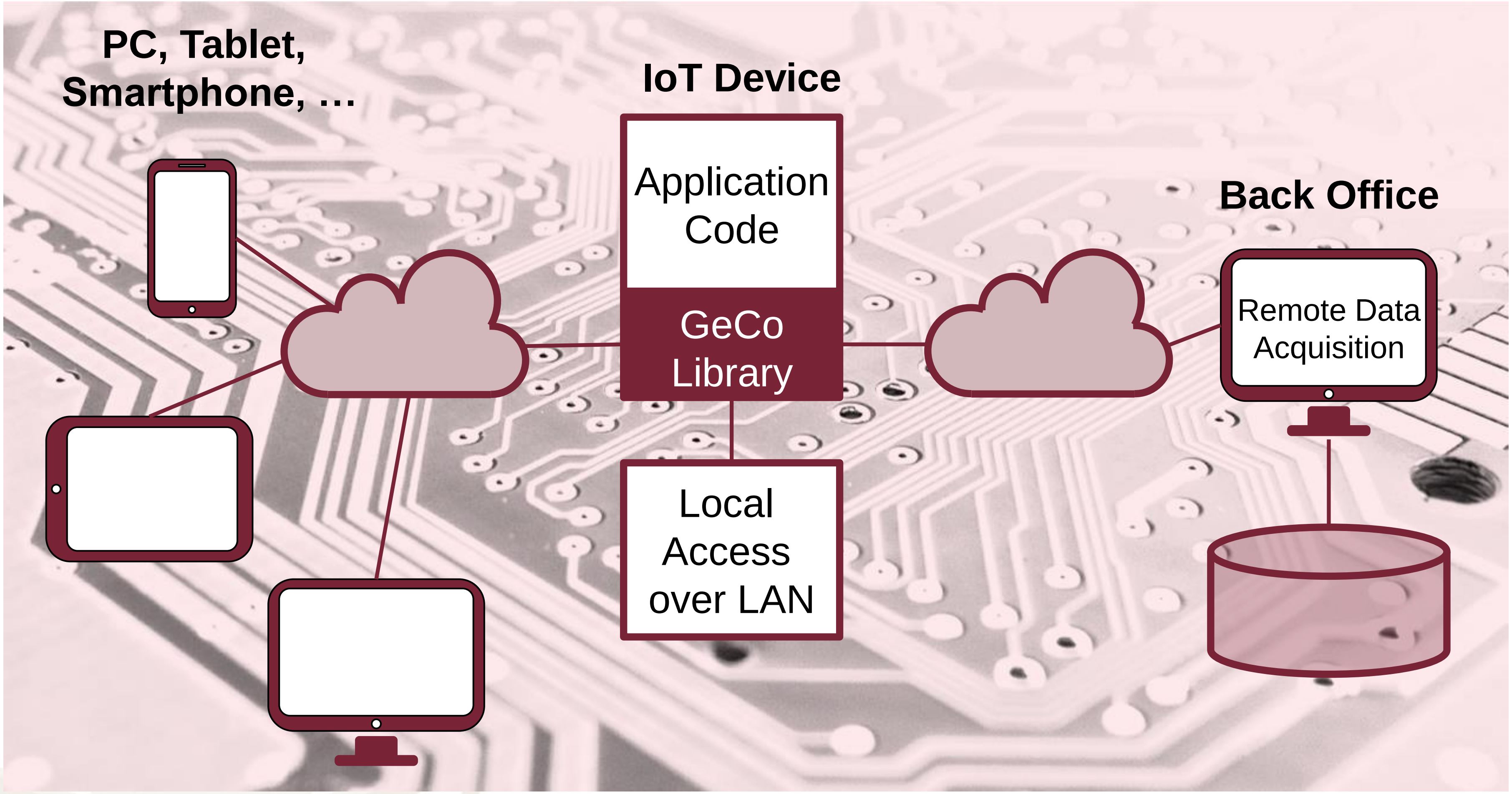
Hydrophilic coating



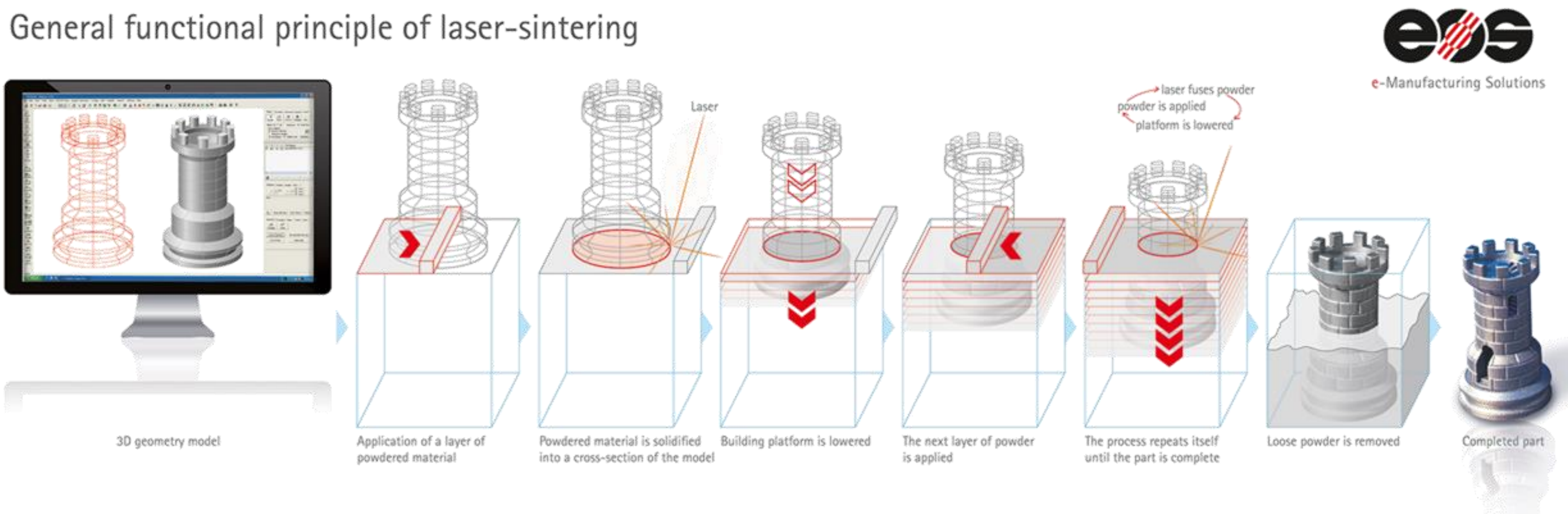
Hydrophobic coating



Internet of Things



Additive Manufacturing



Typical metals

- Aluminium alloys
- Cobalt Chrome alloys
- Maraging Steel
- Nickel alloys
- Nickel Chromium alloy
- Stainless steel
- Titanium alloys

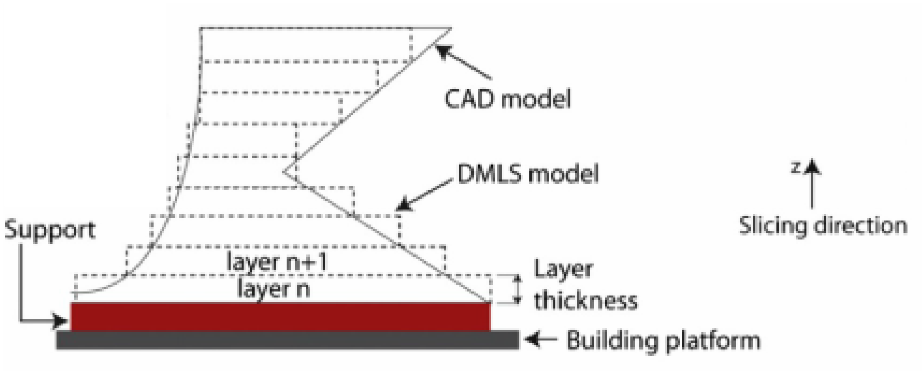
Applications

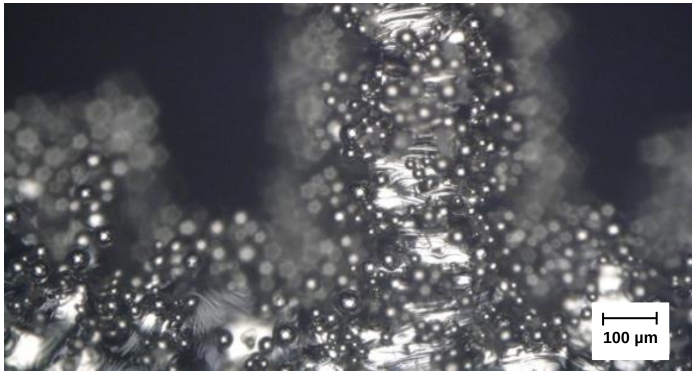
- Aerospace
- Medical
- Automotive
- Lifestyle
- Tooling
- Rapid Prototyping

Additive Manufacturing: Limitations

Staircase effect & semi-melted beads

- Surface quality (1 – 100 µm R_a)
- Geometrical accuracy
- Surface defects decrease performance





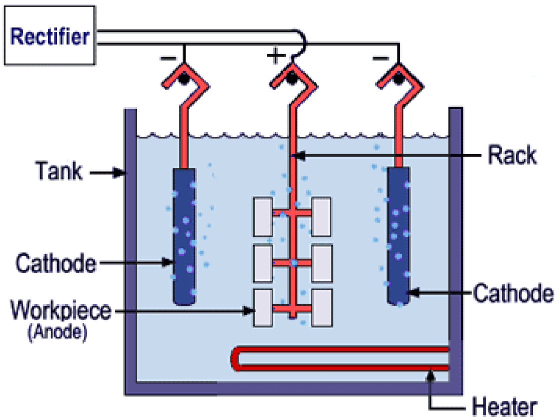
Solutions to overcome limitations:

- Process control (e.g. re-melting, finer powder)
- Post-processing:
  - **Electropolishing** →
    - ✓ Selective surface smoothing
    - ✓ control of micro- and nano-roughness
  - Mechanical polishing
  - Abrasive flow polishing

Electropolishing Principle

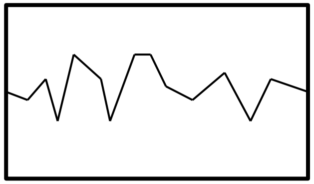
- Workpiece immersed in electrolyte (e.g. sulphuric acid)
- Anodic dissolution of workpiece

$$\mathrm{M(s)} \leftrightarrow \mathrm{M}^{+n} + \mathrm{ne}^{-}$$

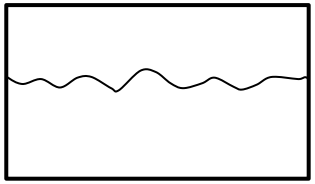


Mass transport mechanism:

- Peaks diffuse at higher rates than recesses
  → anodic leveling
- Random removal of atoms from surface
  → surface brightening



Surface profile before electropolishing



Surface profile after electropolishing

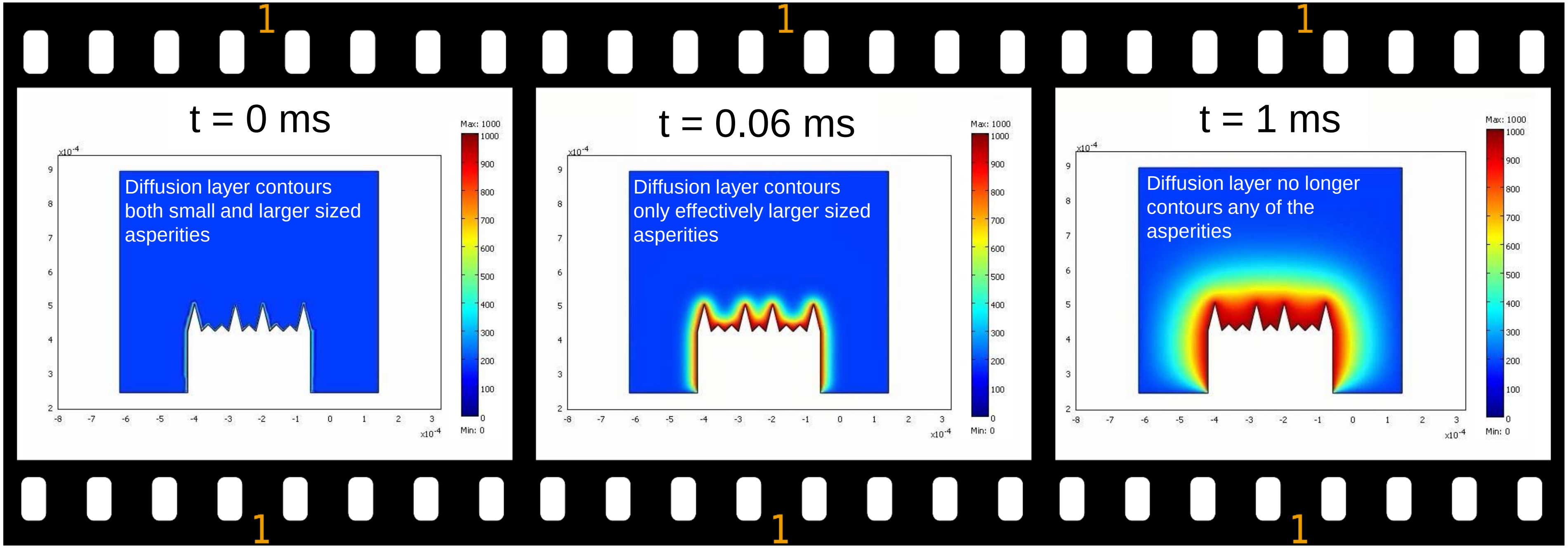
Electropolishing Limitations

- Acts only on microprofiles (=> requires low initial surface roughness)
- Aqueous acidic solution limits removal of metal species
  → forming TiO_2 layer → stopping removal process
- Acidic electrolytes are very hazardous

Method to overcome limitations

- Pulse Technology → control Nernst diffusion layer
- Water-free electrolytes

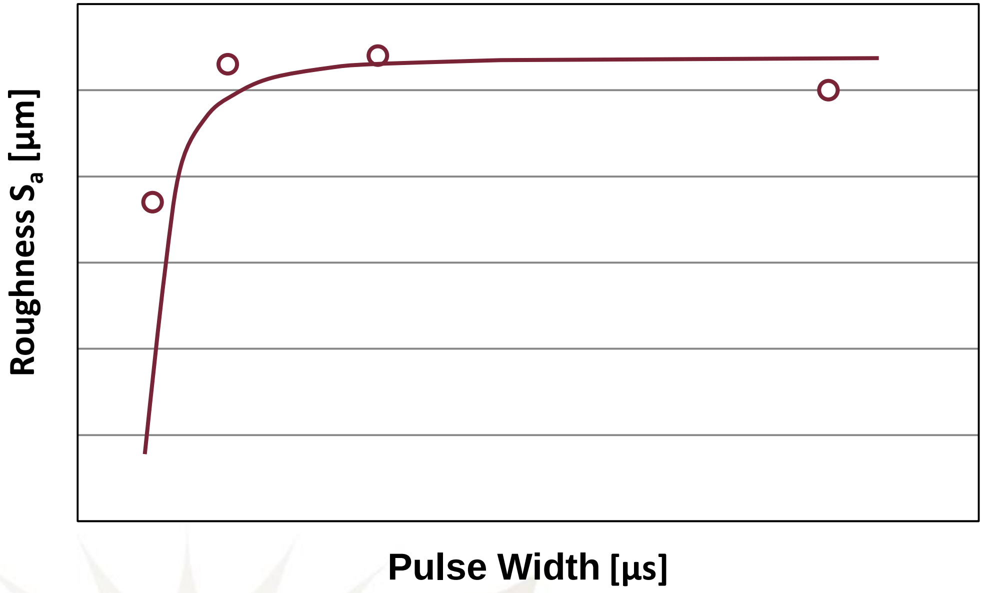
Nernst Diffusion Layer Evolution

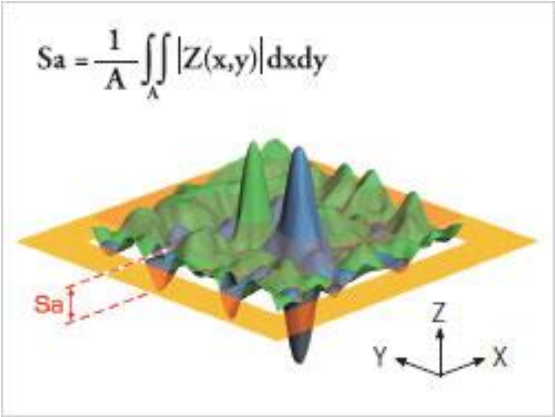


Nernst diffusion layer control by pulsed current

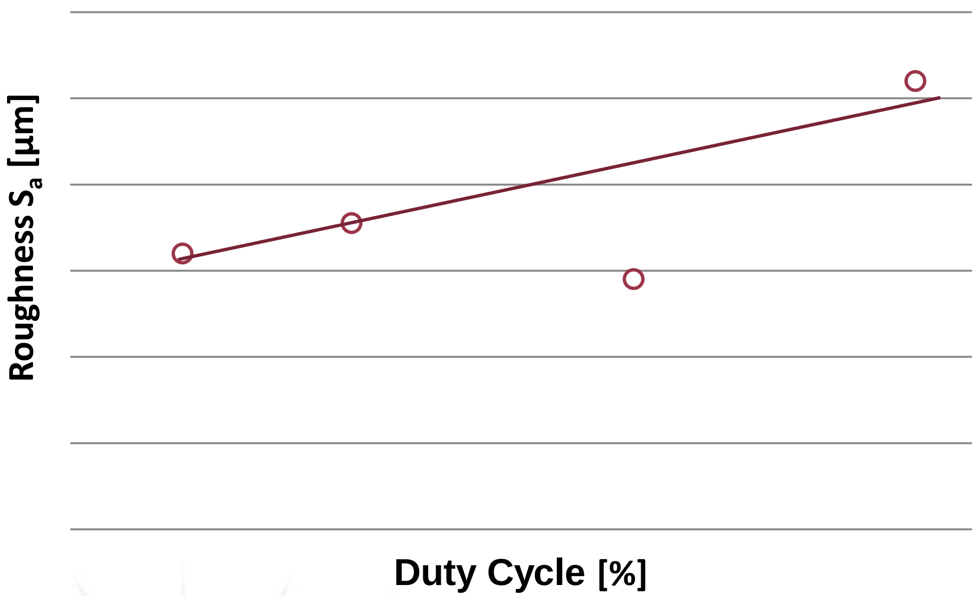
- Short pulses → reducing large asperities (> 100 µm)

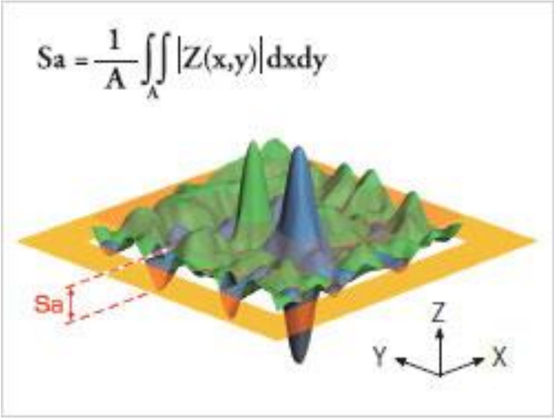
Pulse Technology
Effect of Pulse Width



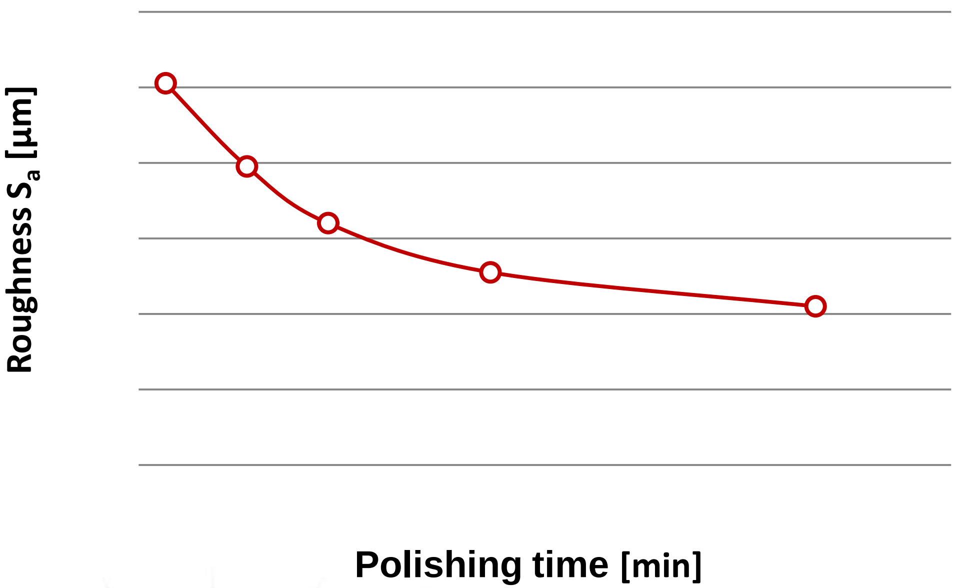


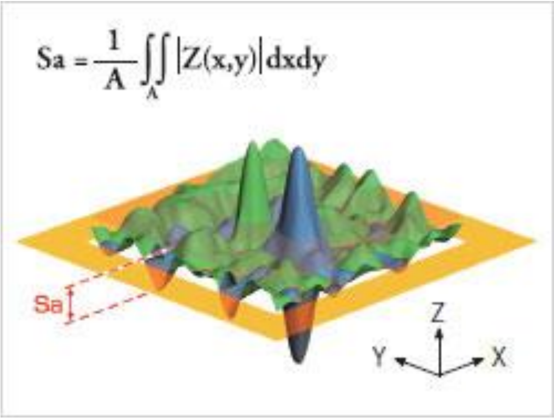
Pulse Technology
Effect of Duty Cycle variation



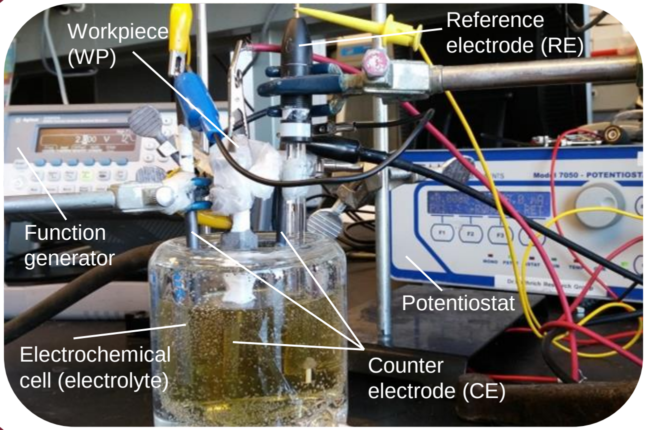


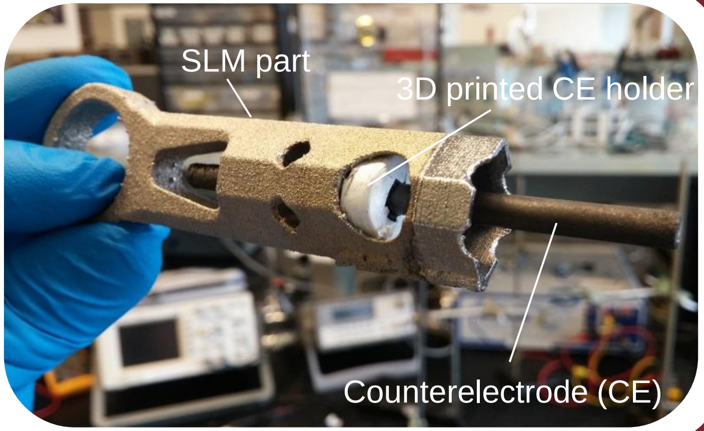
Pulse Technology
Effect of Polishing Time

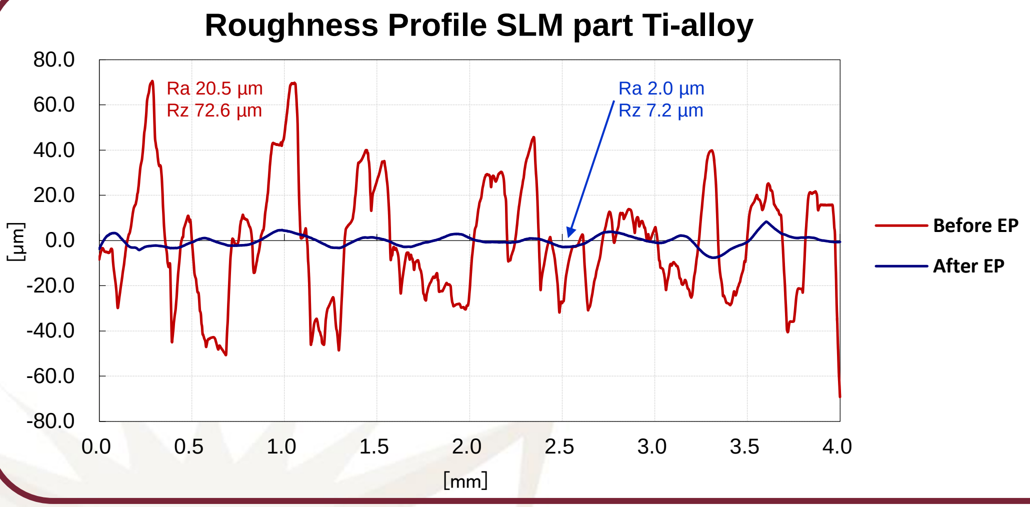


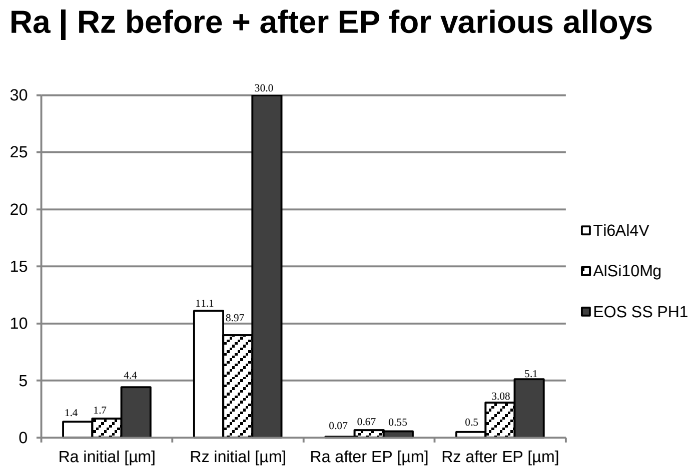


Post-process Metal AM Parts



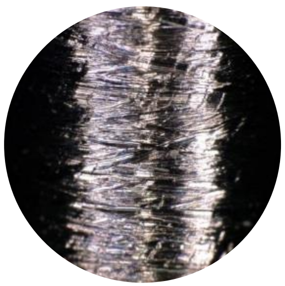




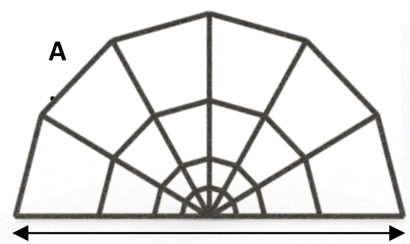


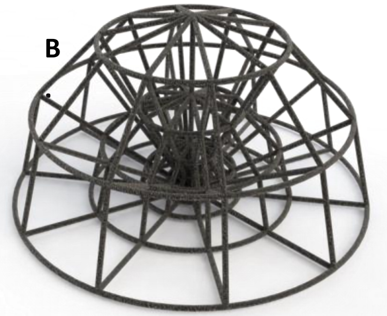
Case Study Roughness Control

1. Titanium rod
2. 'Spider-web' SLM fabricated Ti-6Al-4V parts



Ra=1.2μm

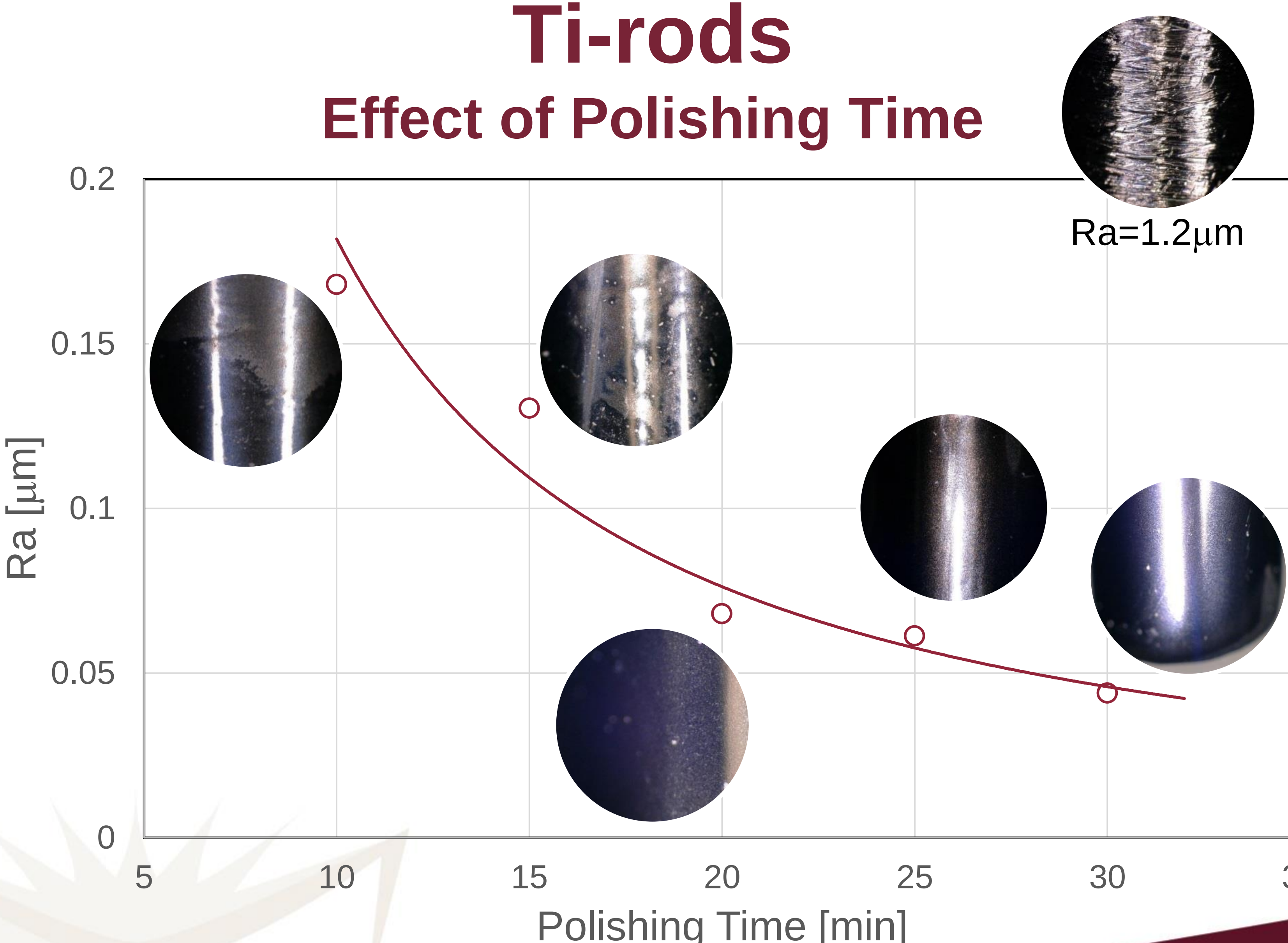




Goal: 1. reduce semi-melted beads (50 μm - 100 μm)
2. understand global reduction in strut thickness
3. optimize parameters for control of roughness and process time

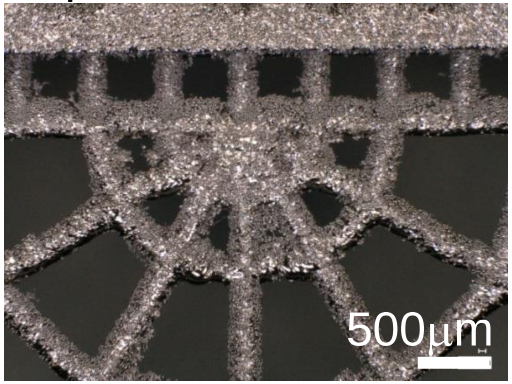
Ti-rods

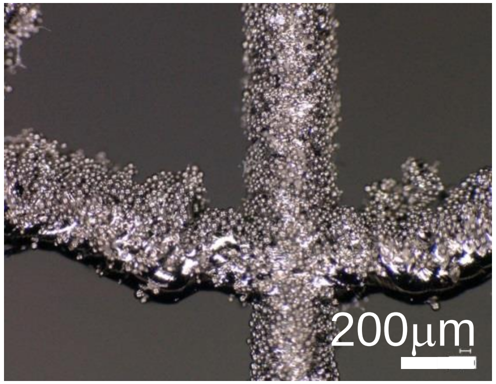
Effect of Polishing Time

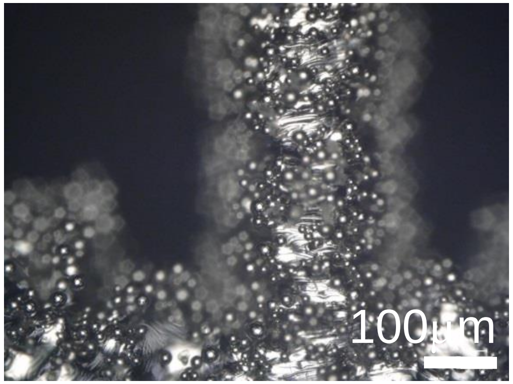


Ti-Spider Web
Effect of EP on Bead Removal

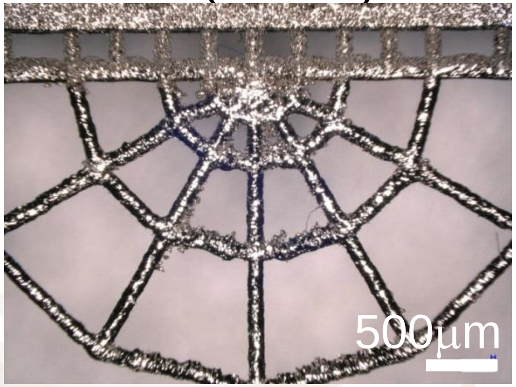
Unpolished

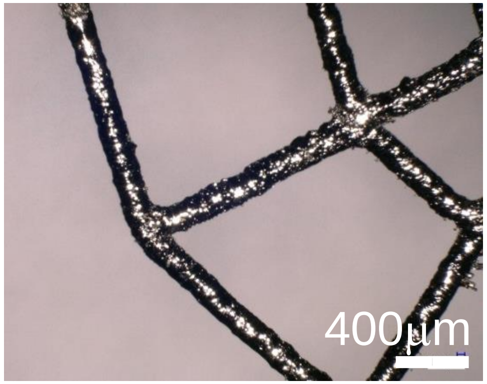


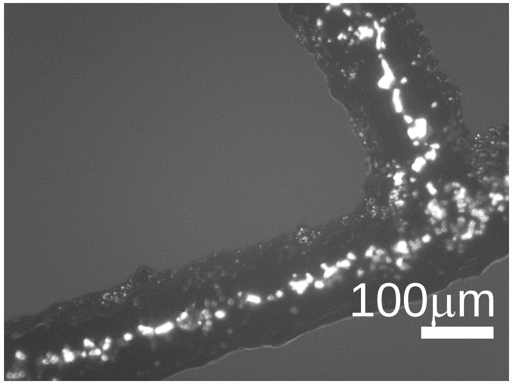




Polished (35 min)

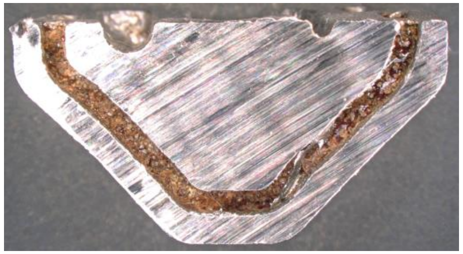


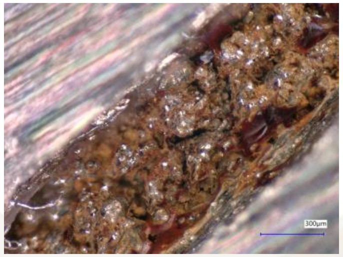


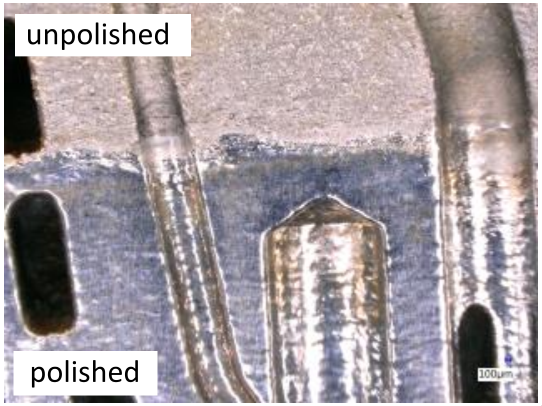


Polishing of Inner Surfaces

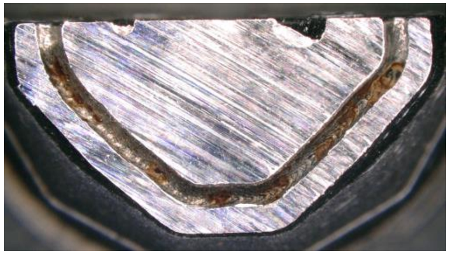
Unpolished

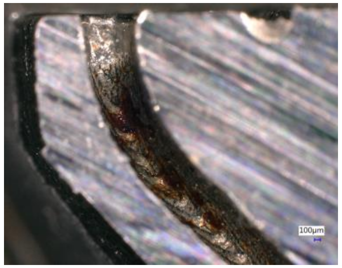


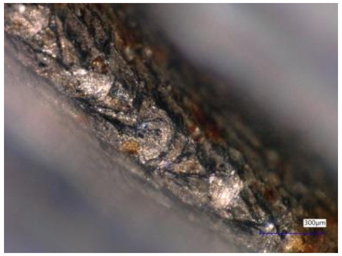




Polished







Conclusions

- Pulse technology is an effective tool to eliminate surface asperities on AM parts
- Surface roughness is reduced typically by a factor 10-20
- Possible to tune the final roughness
- Possible to polish complex shapes
- Possible to polish inner surfaces

Current industrial partners

posalux
SWISS MADE

FlowJEM
Polymer Microfluidic Technology

micronit
MICROFLUIDICS
15th Anniversary

PASSIVE ACTION

RÉSEAU QUÉBEC 3D

AXIS
PROTOTYPES

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TERRAGON
Environmental Technologies Inc.

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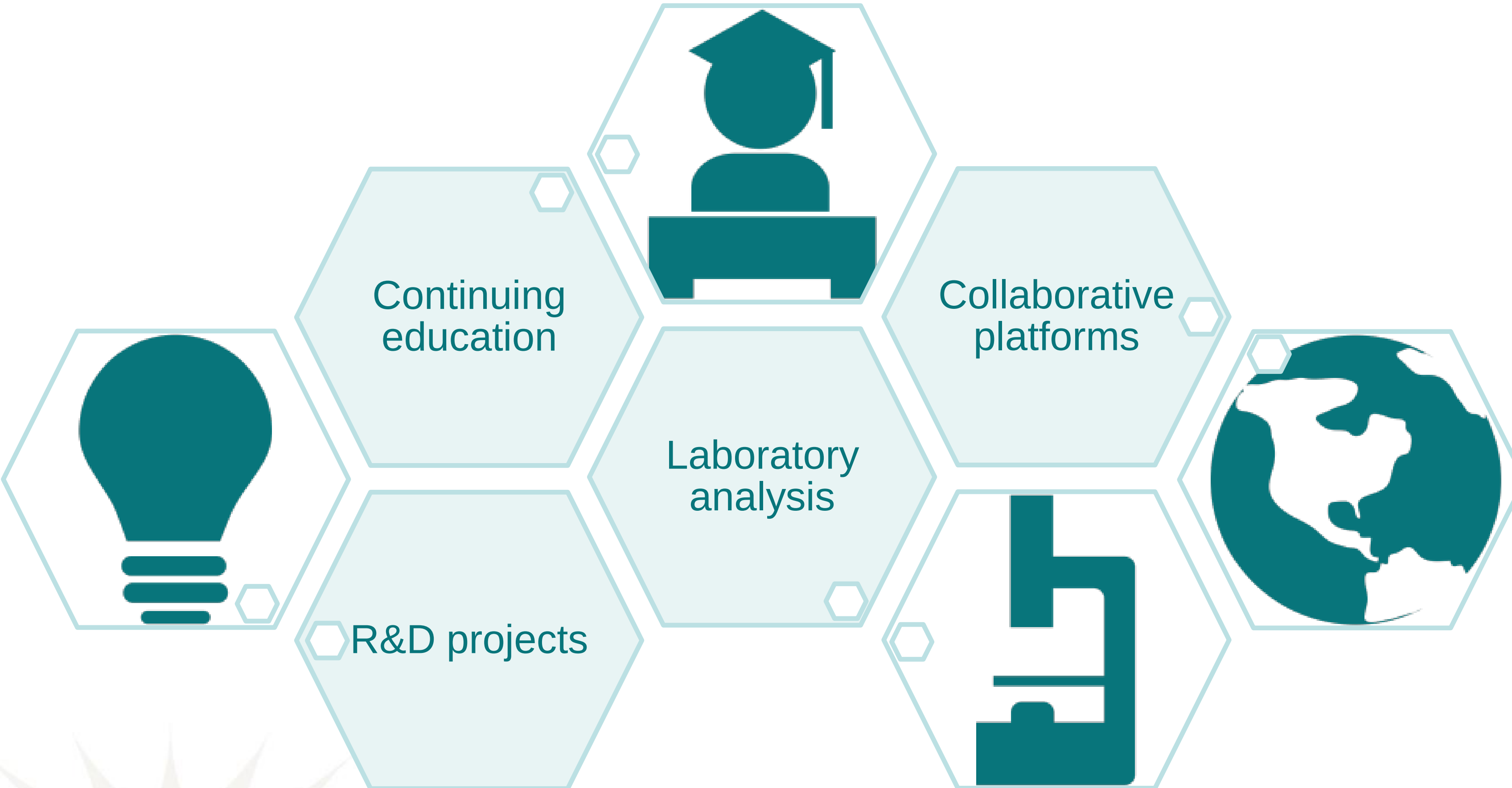
What we offer



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