

# Influence of manufacturing conditions on the surface quality of stainless steels in sensitive industrial applications

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# Manufacturing of components for sensitive applications

## Applications

- containers and drums for transportation and storage
- vessels for processes (tempering, mixing, separating, deposition,...)

## Industries

- Pharmaceutical products
- Food industry
- Chemical industry



# Manufacturing of components for sensitive applications

## Wanted surface features

- no contamination / no corrosion
- chemical resistance
- easy to clean

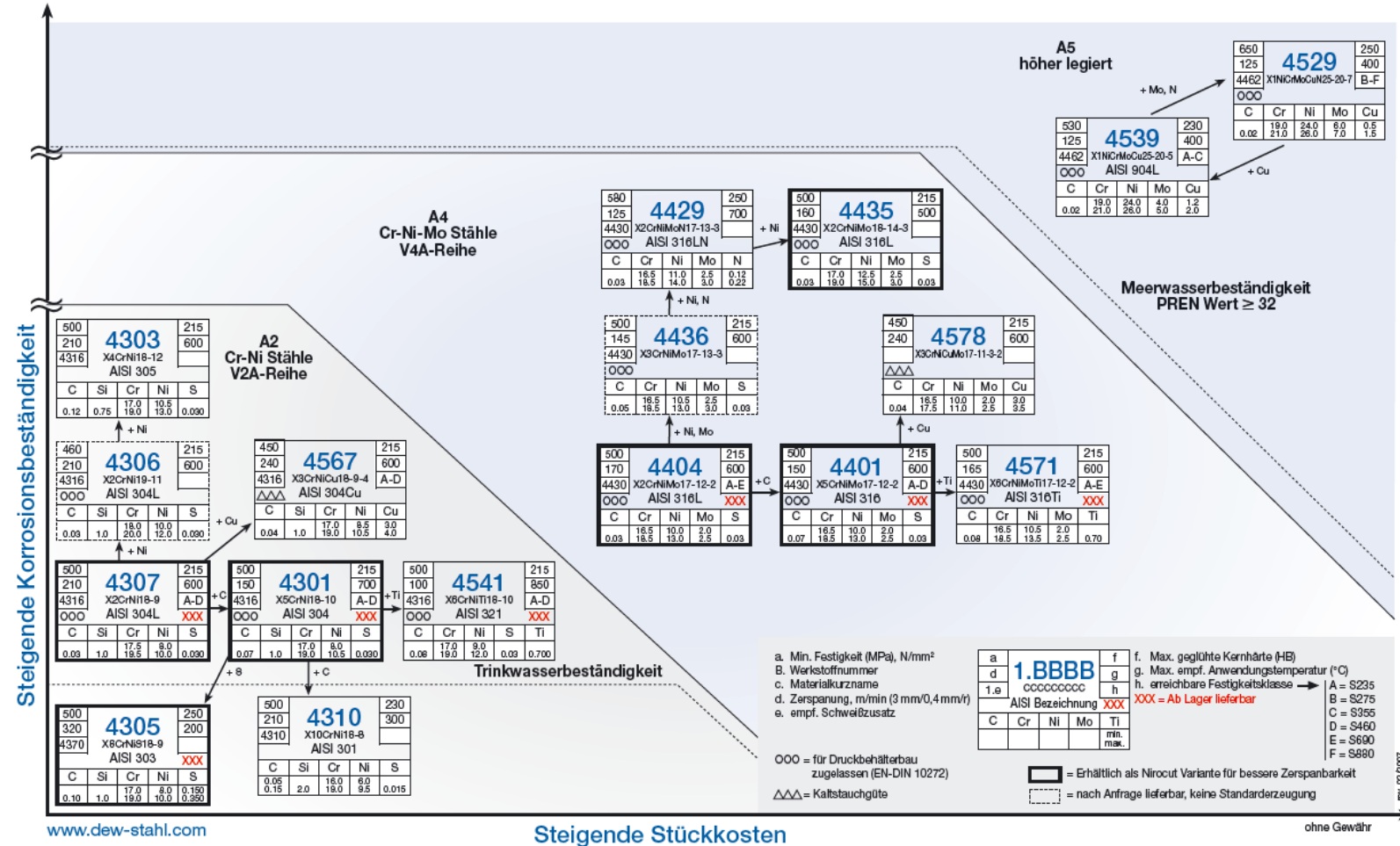
## After cleaning / after use

- no contamination left
- no corrosion / no transfer of material

## Materials

### stainless steel

- mostly Ni & Mo content
- mostly austenitic steels



## Standards and regulations

ISO 14159:2002 Safety of machinery – Hygiene requirements for the design of machinery

EN 1672:2 Food processing machinery – Basic concepts – Part 2: Hygiene and cleanability requirements

Directive 2008/37/EC of European Parliament and of the council

EHEDG Document

- No. 8: Hygienic design principles
- No. 32: Materials of construction for equipment in contact with food

### Summary of statements

- smooth - surface that **meets hygiene requirements** and **no surface defects**
- surface roughness according ISO 21920 less than  **$Ra = 0.8 \mu m$**
- surface easy to clean
- homogenous surface
- ...

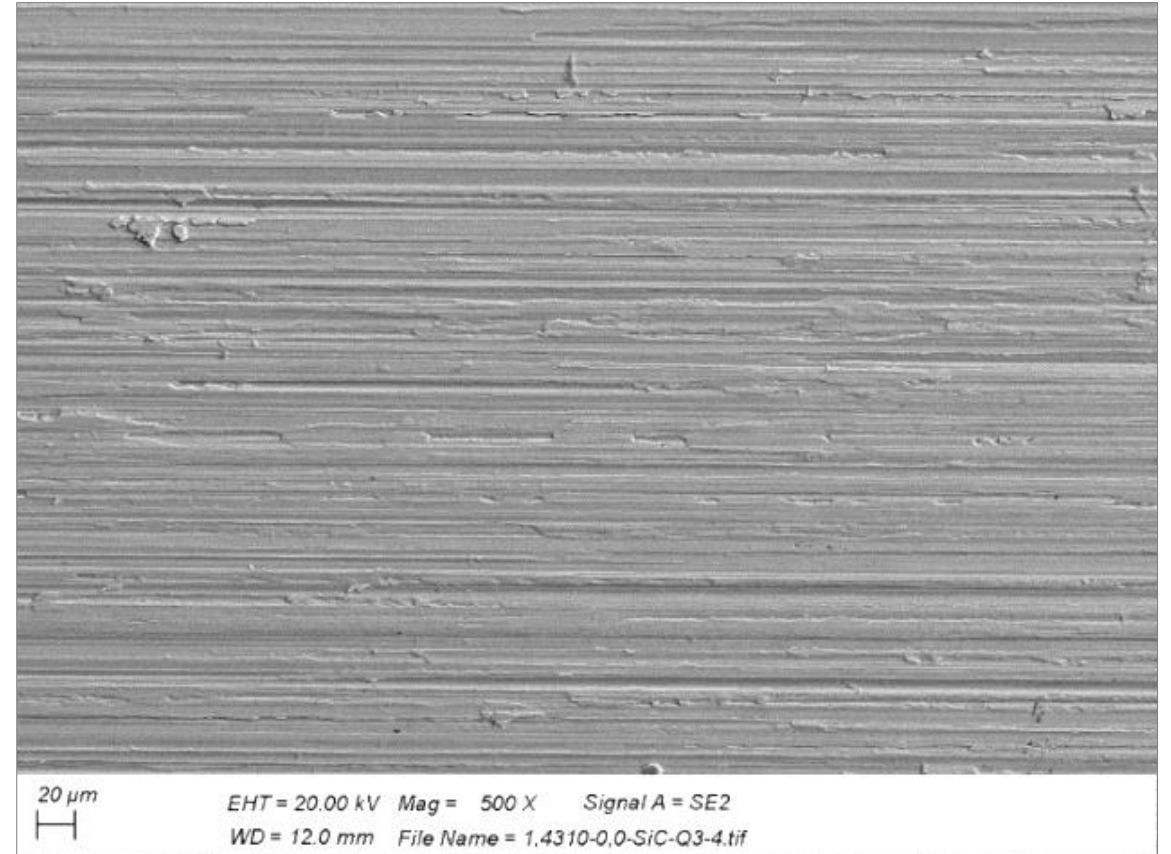
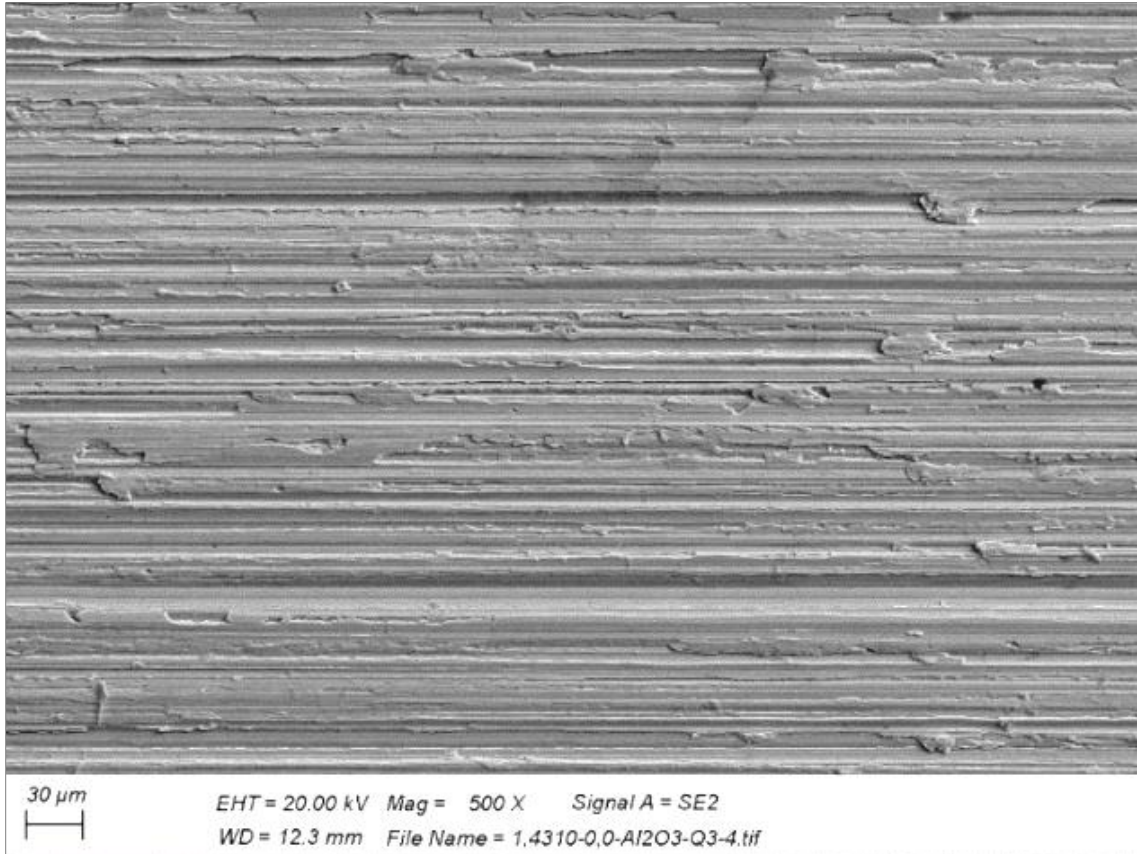
## Influencing Factors

Factors that affect the properties of the surface and it's interaction with the product

- Product / pre-product, molecular structure ...
- Process parameter / temperature, pressure, humidity, flow velocity ...
- Material / chemical composition of the stainless steel
  
- Surface
  - surface roughness
  - surface topography
  - uniformity of the surface
  - chemical composition of the surface

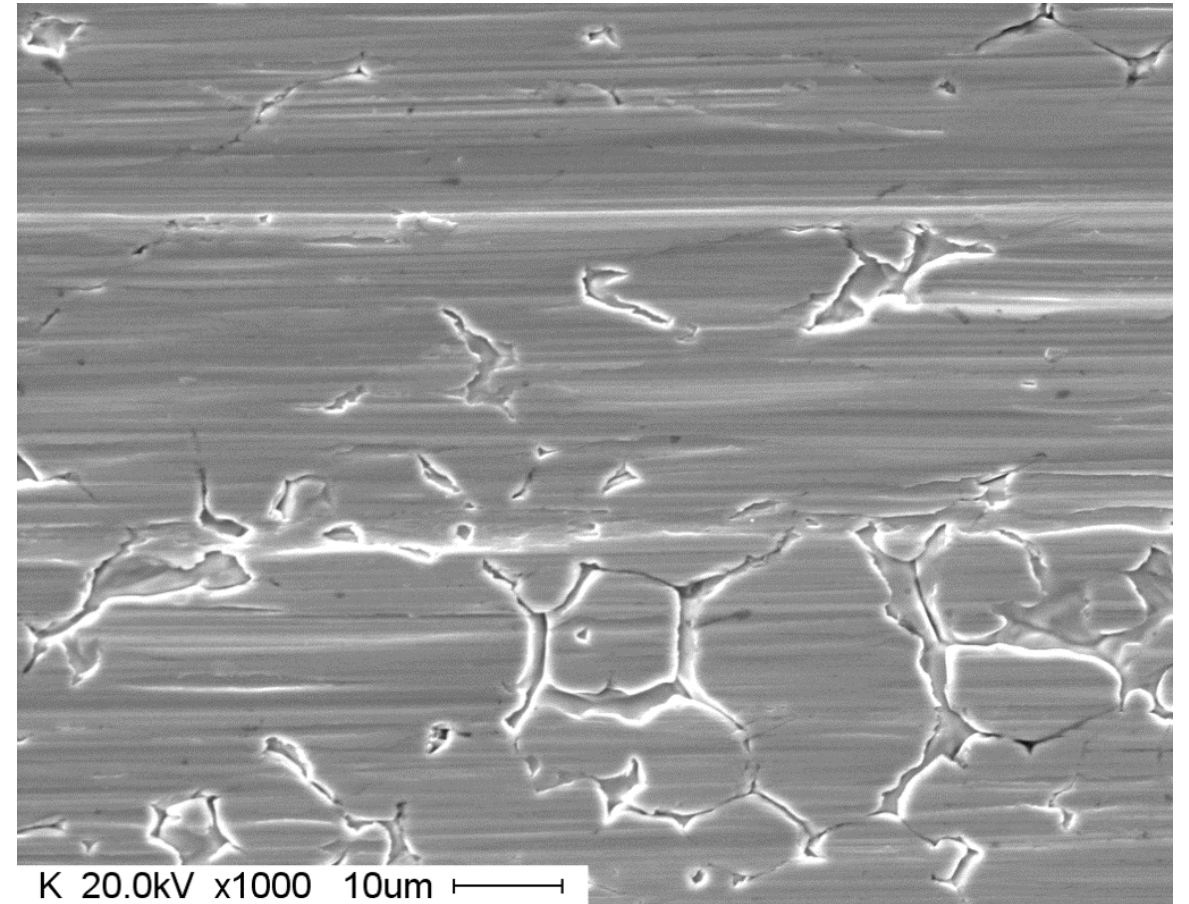
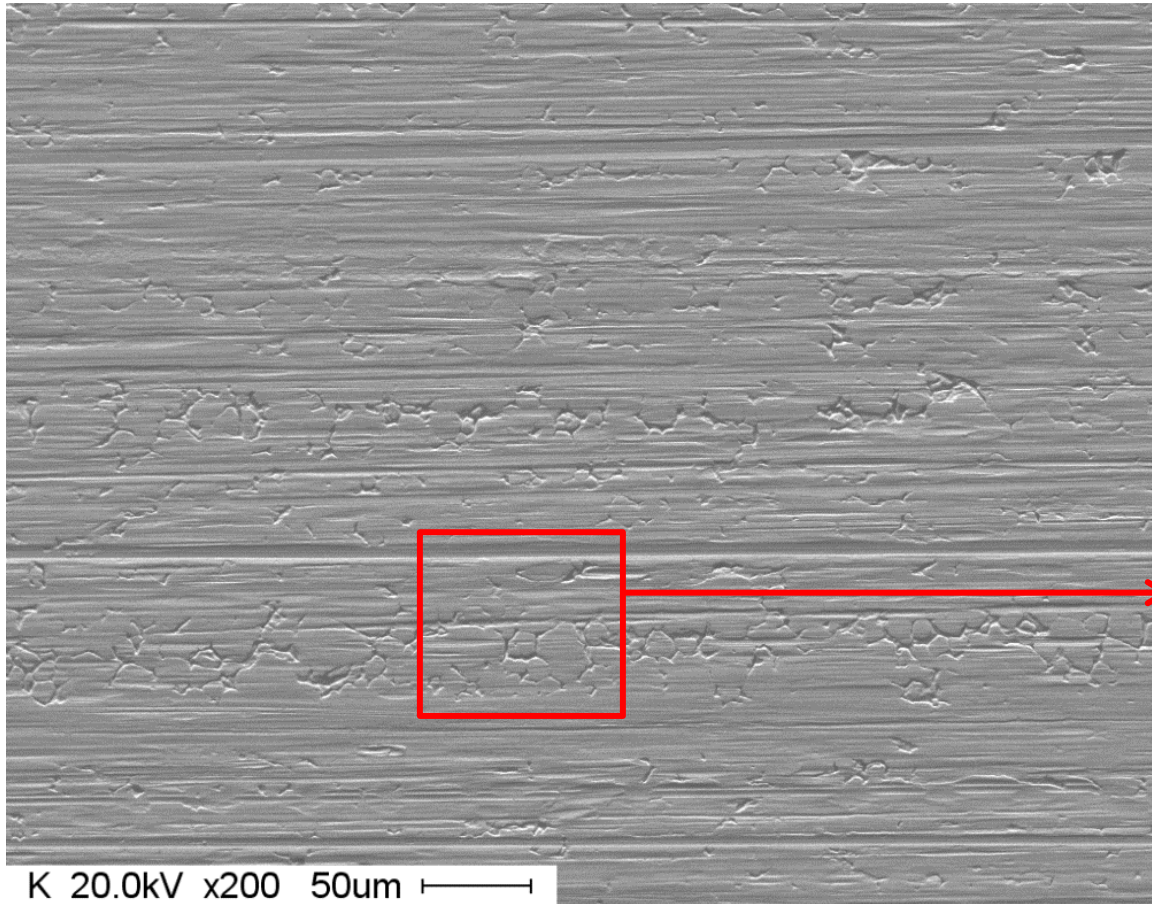


# Surface topography



Stainless steel 301 – industrial ground

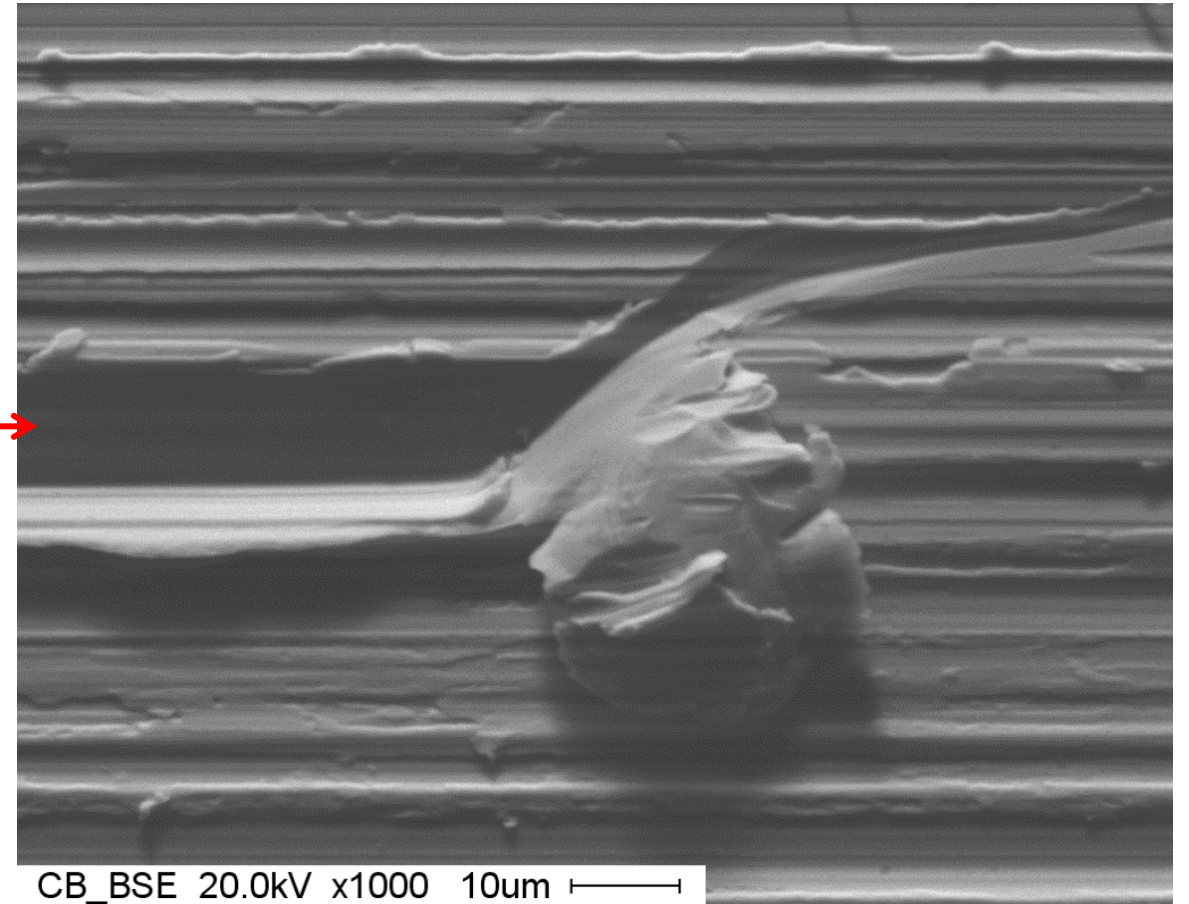
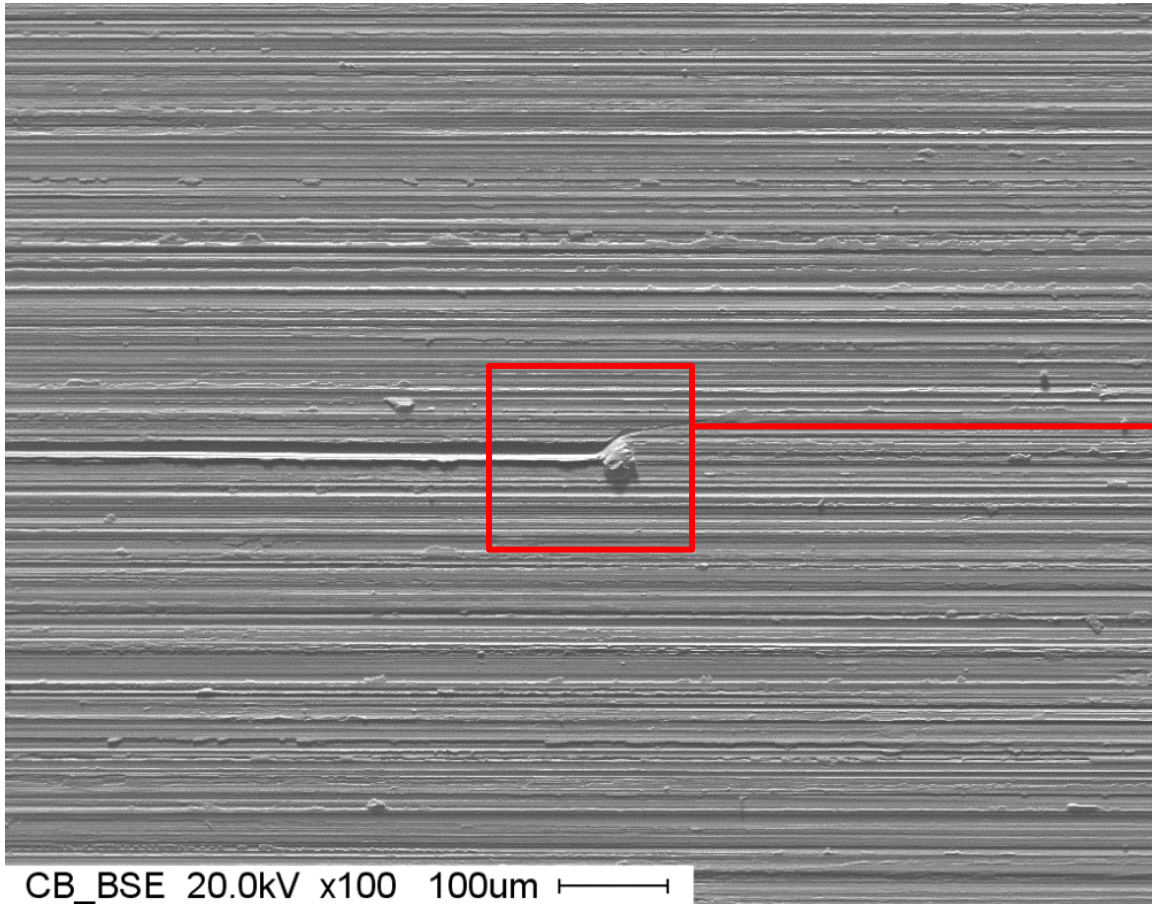
## Surface topography



Stainless steel 304 - Initial surface 2B according EN 10088: subsequently industrially brushed



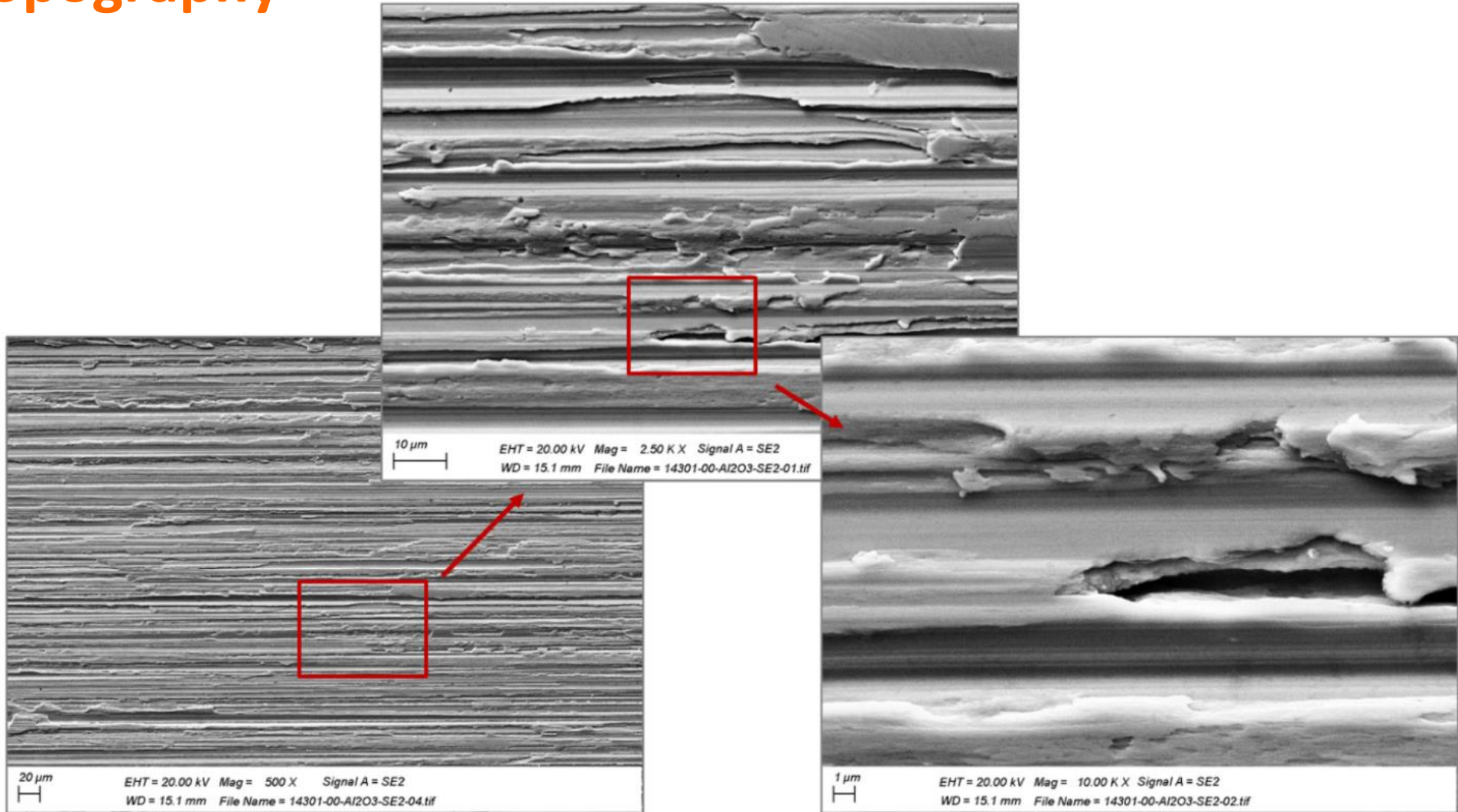
## Surface topography



Stainless steel 304 – industrial ground, grain size 220

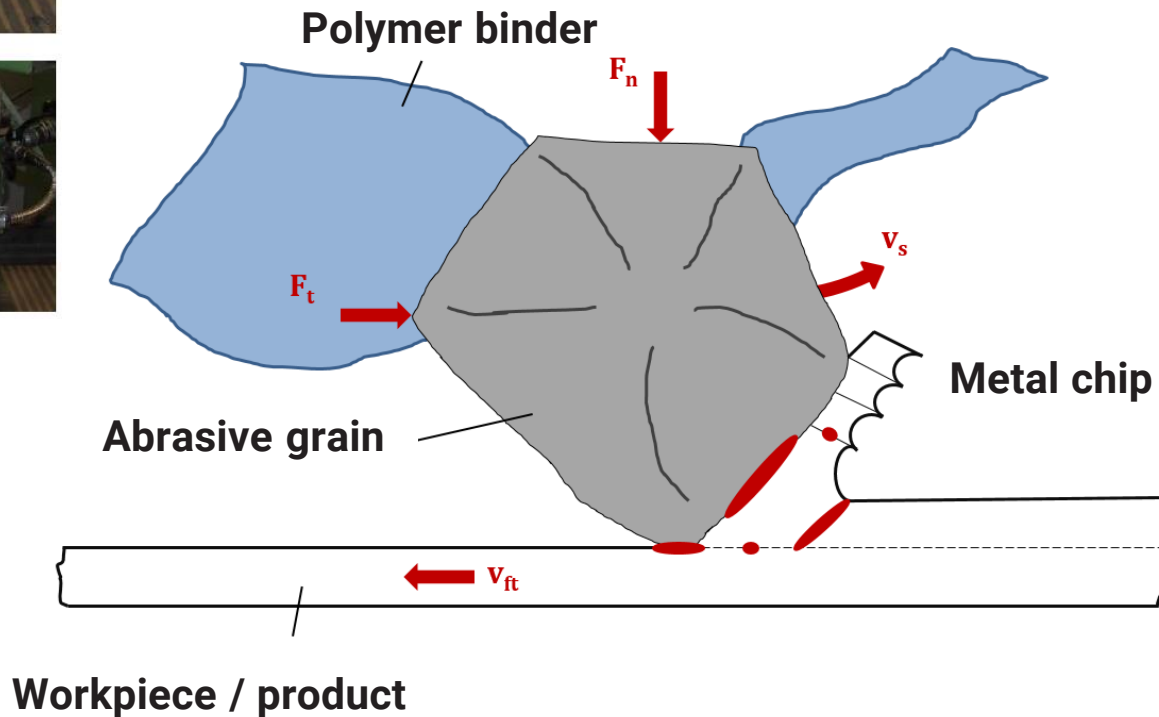
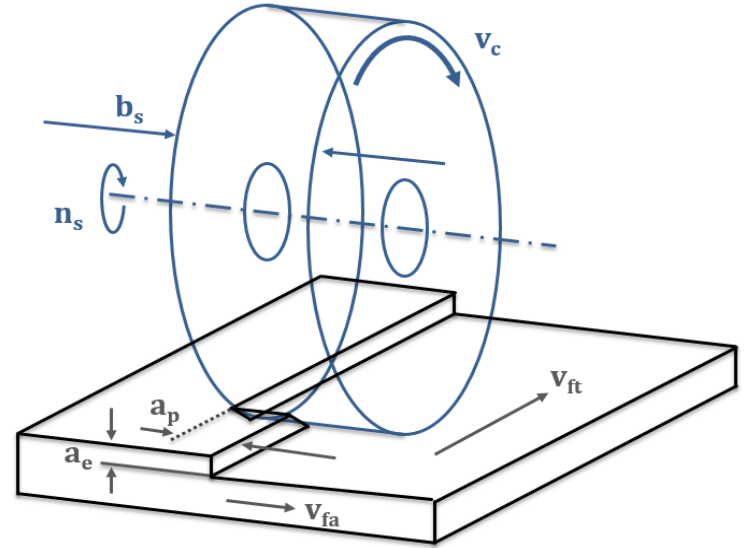
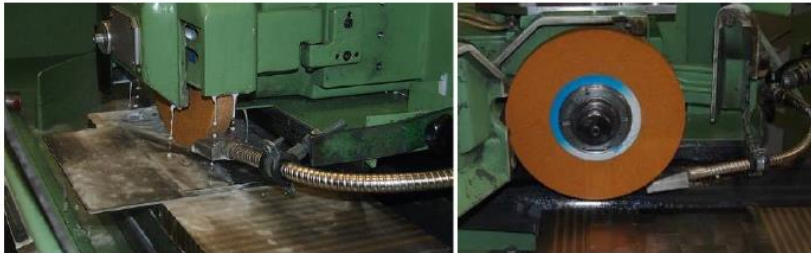


# Surface topography

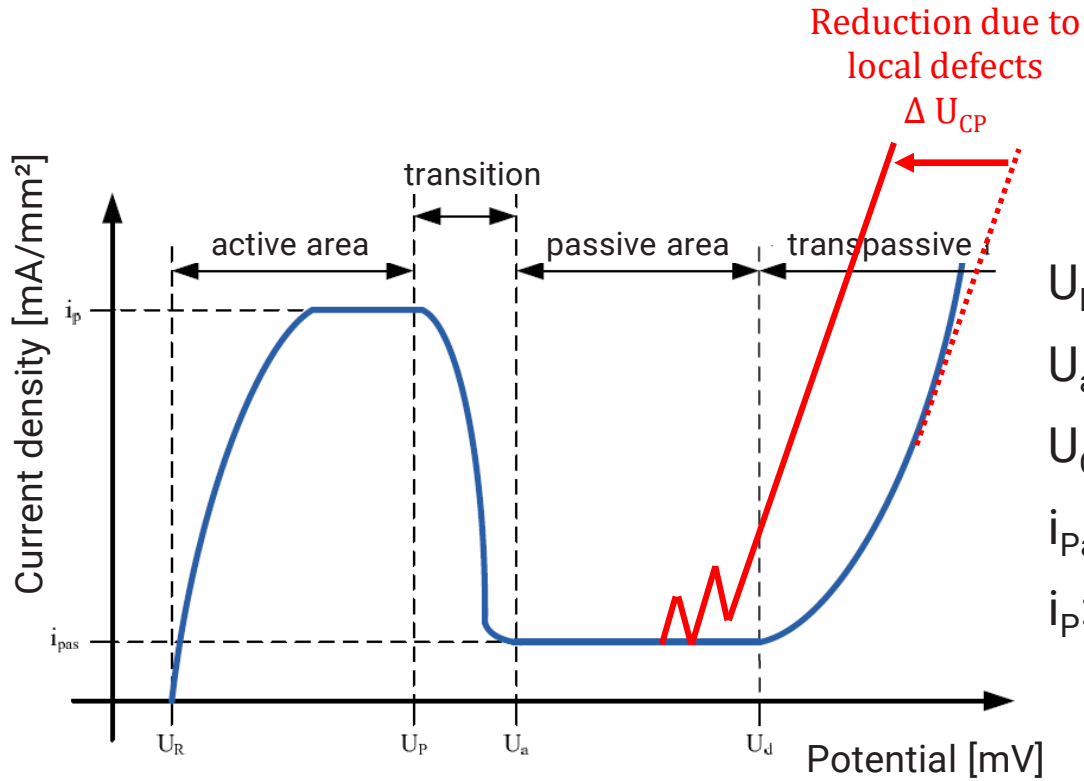


Stainless steel 304 – industrial ground

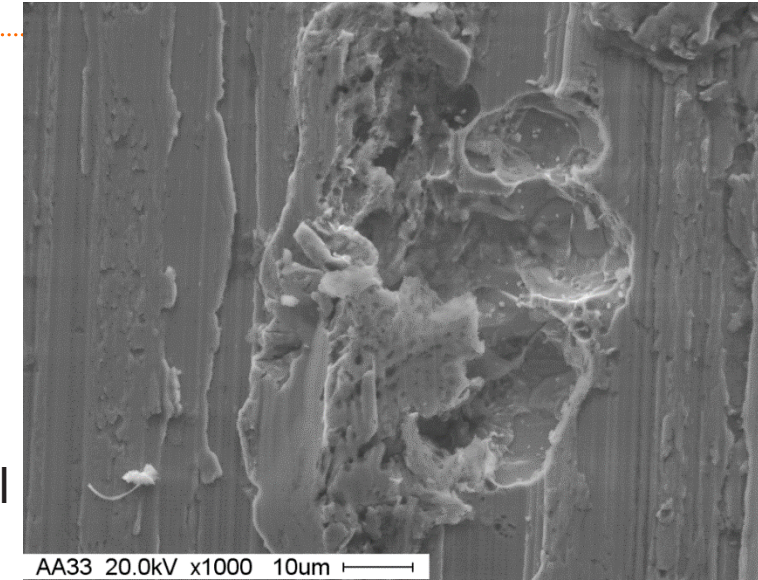
# Surface topography / grinding



# Corrosion resistance



- $U_P$ : passivation potential
- $U_a$ : activation potential
- $U_{CP}$ : critical pitting potential
- $i_{Pas}$ : passive current density
- $i_p$ : passivation current density



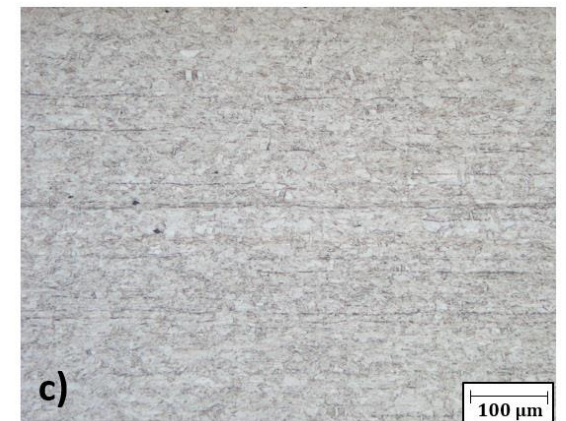
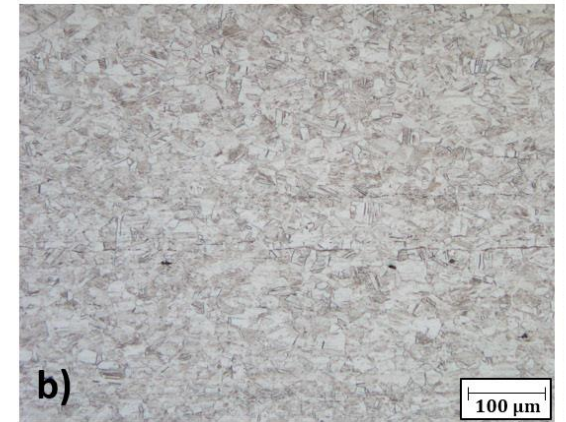
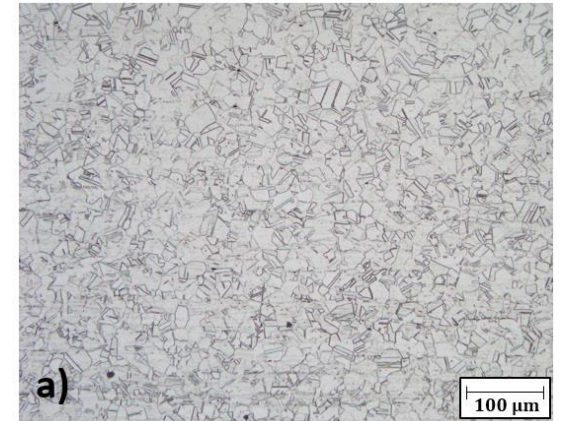
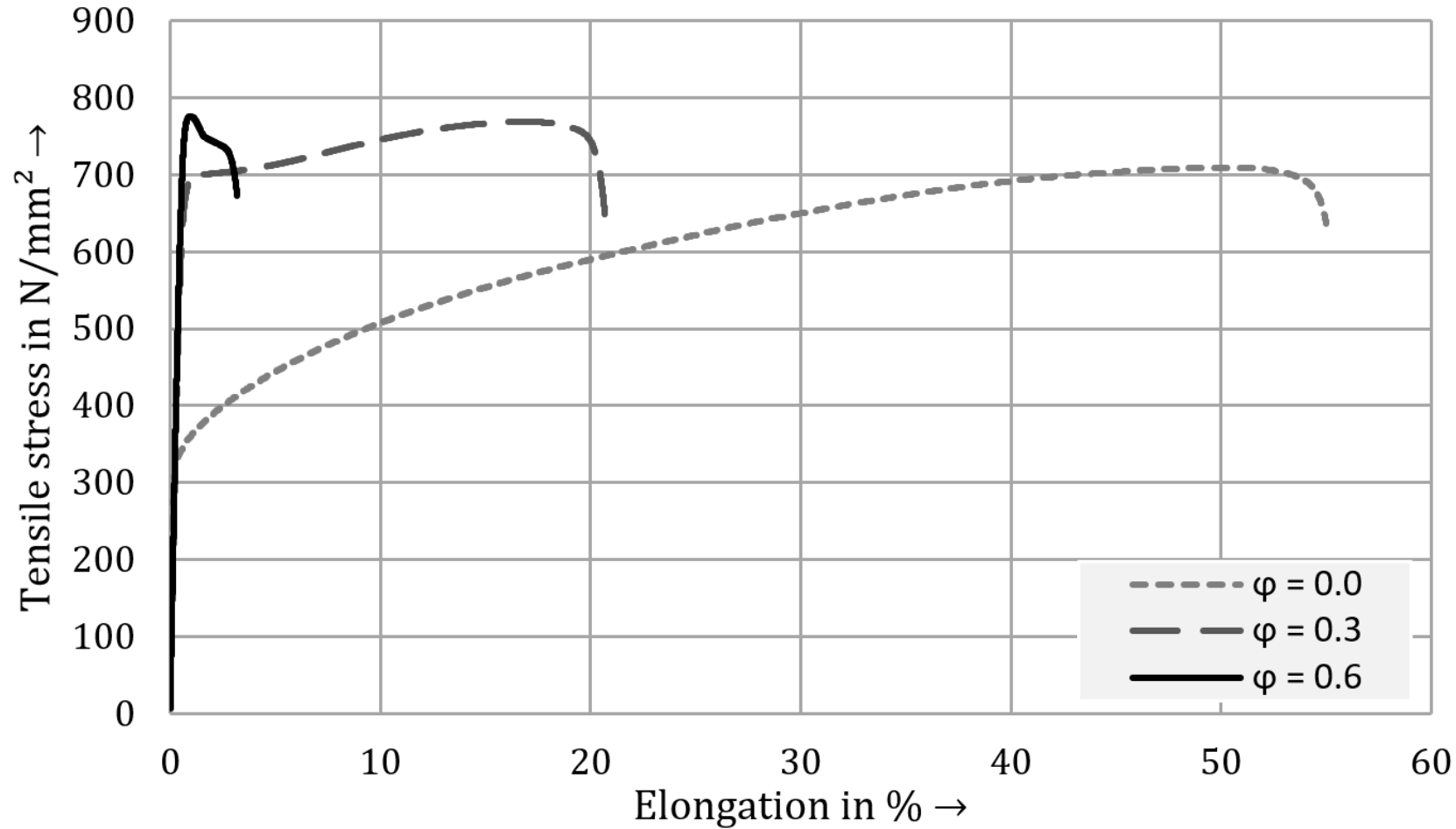
Schematic representation of the current density-potential curve of a stainless steel in sulphuric acid

Imperfections in the passive layer reduce the corrosion resistance and thus also the breakdown potential using the example of the electrochemical current density-potential curve!



# Mechanical properties / deformation

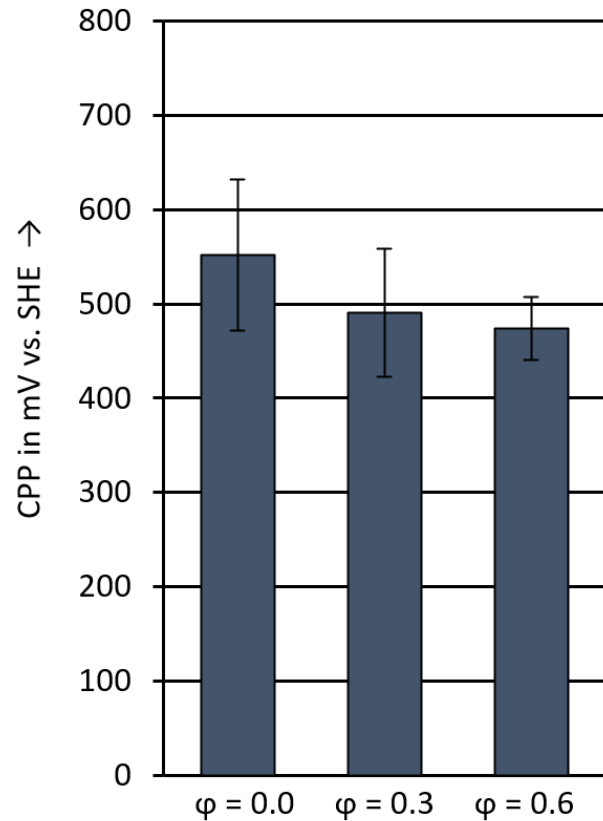
cold rolled stainless steel 304



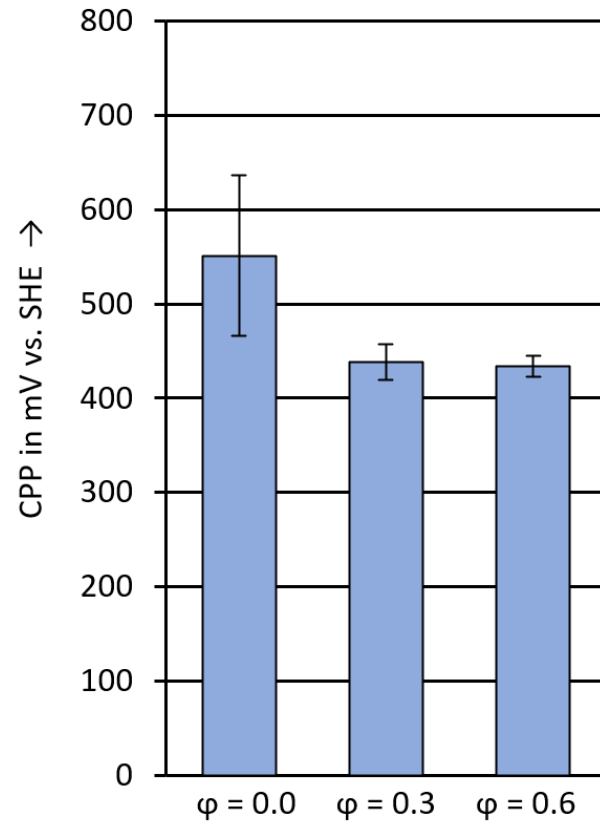
# Corrosion resistance

cold rolled stainless steel

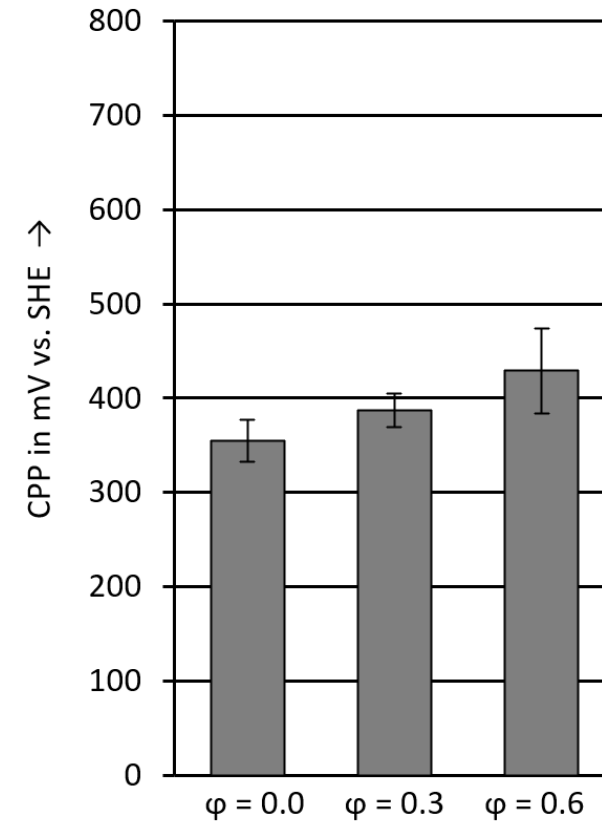
metallographically polished  
with diamond suspension



electropolished



metallographically ground  
by hand



## Modifying grinding process

Conventional process for sensitive applications

- pretreated surfaces according EN 10088
- production process (cutting, forming, welding)
- **hand-guided machine grinding (angel grinder)**
- electropolishing

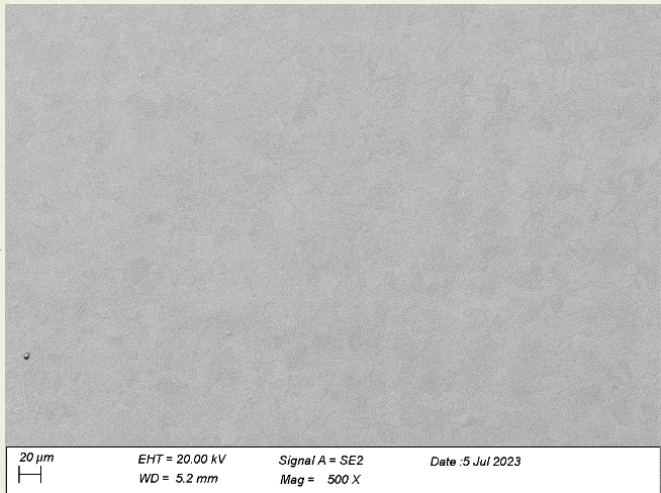
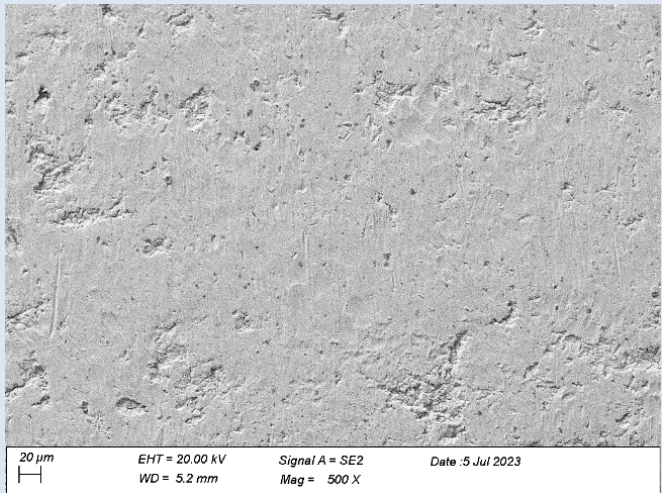
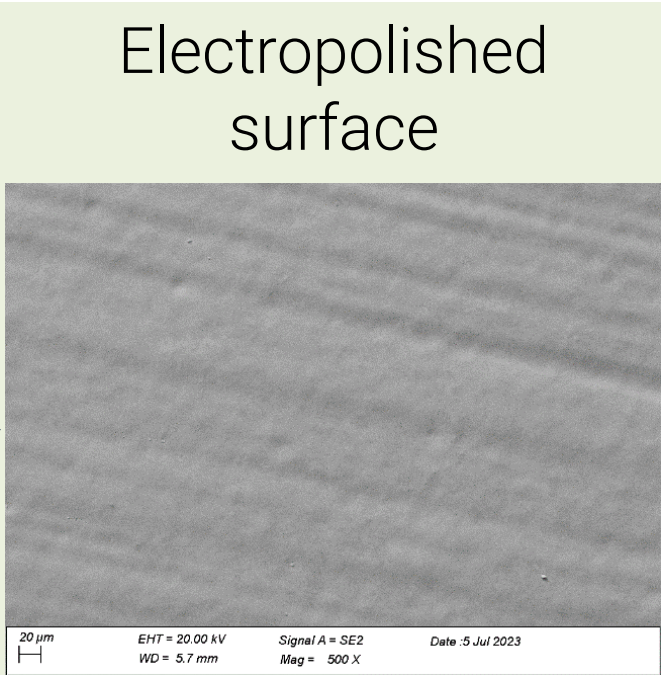
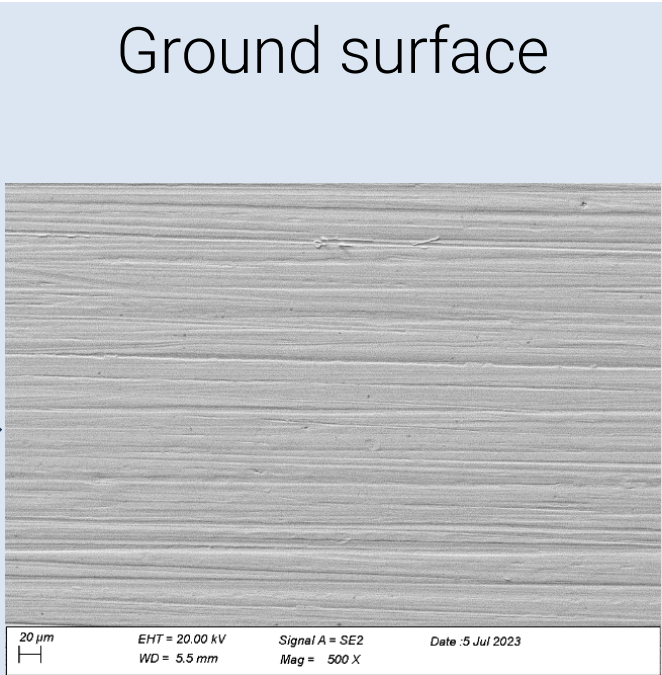
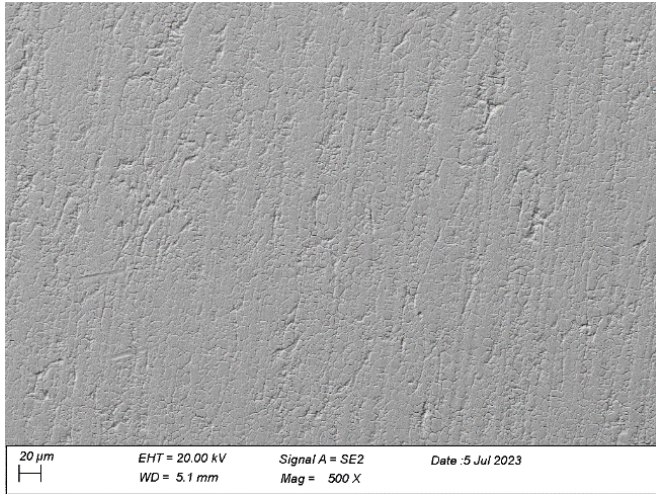


Modification

- **replacement of the hand-guided grinding process with an automated process**
  - > automated vibration grinding: abrasive: ceramic bonded corundum ( $\text{Al}_2\text{O}_3$ )
  - > called OGF / optimized grinding finish

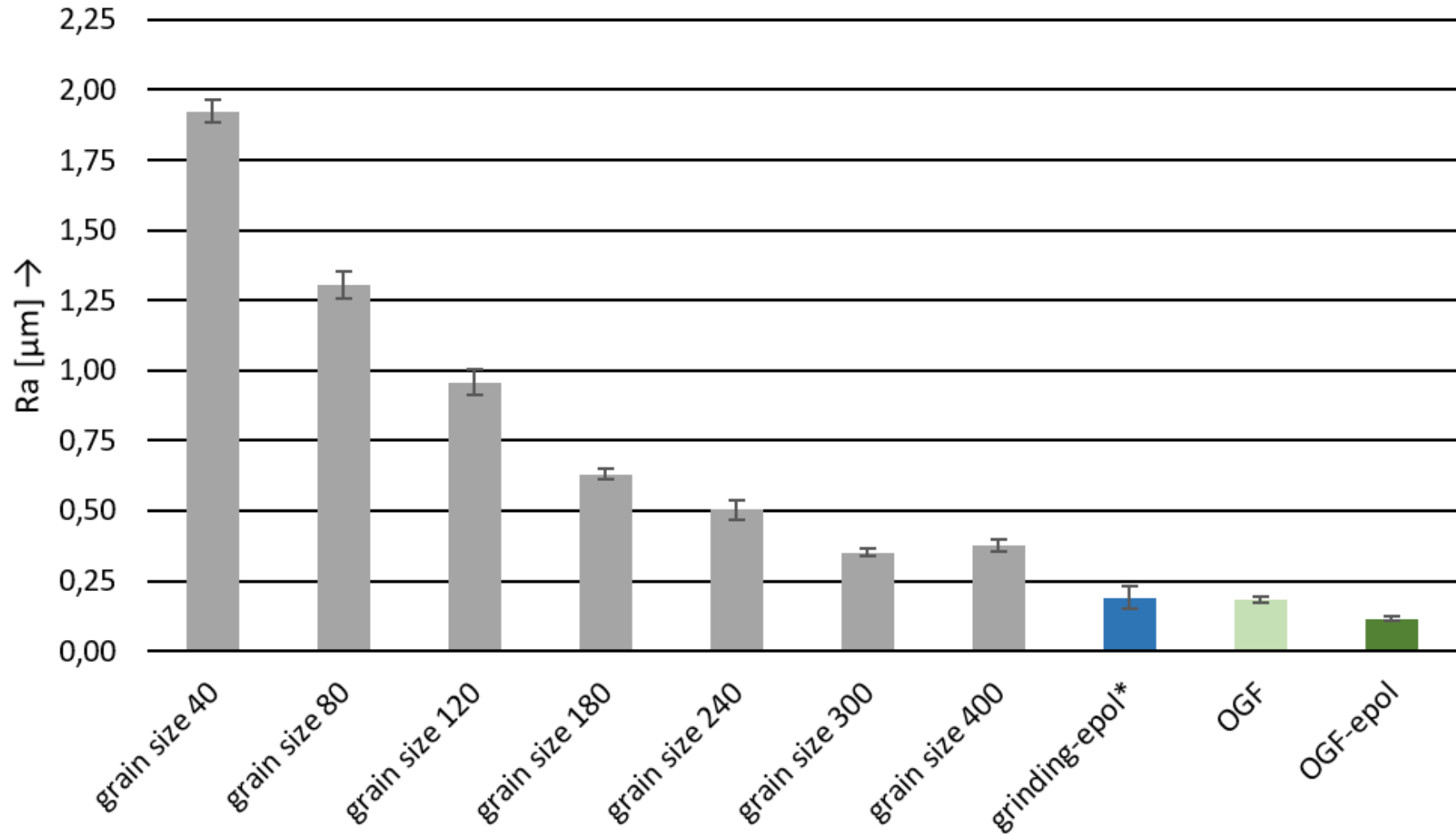


# Results



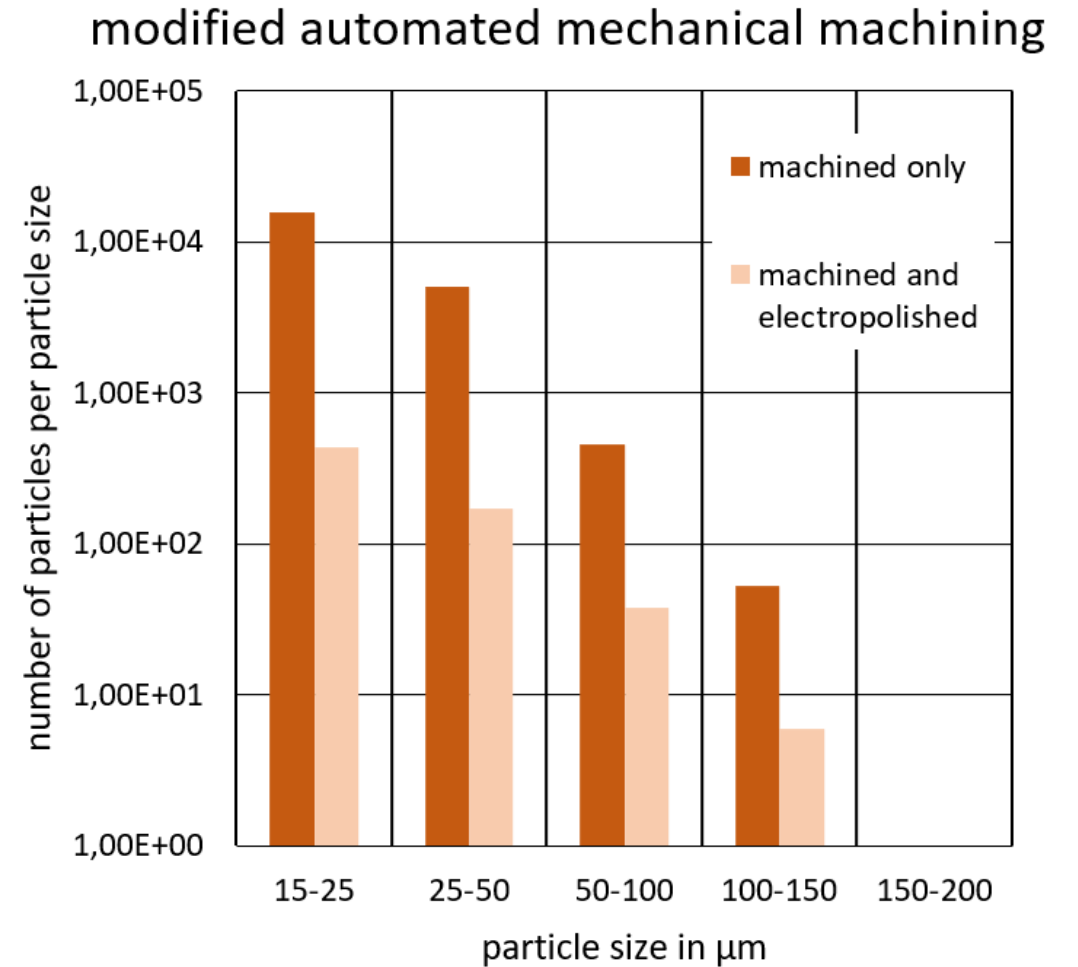
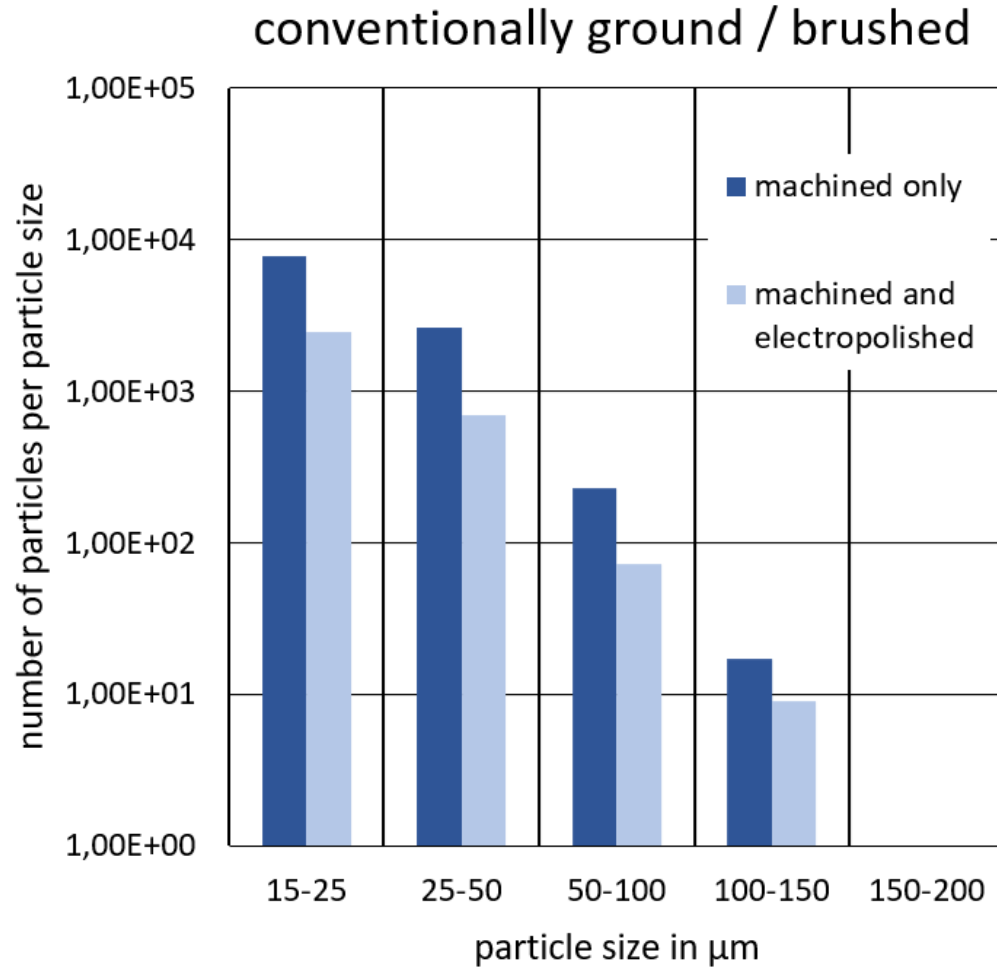
# Results

Surface roughness: Comparison depending on the surface preparation



# Results

Cleanability according to ISO 16232 for differently machined surfaces





## Conclusion

- reduction of mechanical influences by modified grinding process / OGF (optimized grinding finish)
  - > leads to an even **more homogeneous surface after grinding**
  - > **less local imperfection**
  - > improvement in surface properties with regard to **cleaning behavior** (in combination with E-Pol)
- post processing like electropolishing is increasing the surface properties
  - > removal of imperfections on the surface
  - > leads to a more homogeneous surface
  - > limited in depth
- strong mechanical influences on the material are retained
  - > furthermore, an influence on the technical properties of the surface / cleanability is given

**Not only the surface influences the properties, but also the area below the surface!**

## Acknowledgments

to all project partners for the good, fast and uncomplicated cooperation

the Central Innovation Program for SMEs (ZIM), financed by the German Ministry of Economics

