

Bonding and aging mechanisms of polymers on titanium alloys

Miriam Löbbecke, Jan Haubrich

German Aerospace Center (DLR)
Institute of Materials Research
Linder Hoehe
D-51147 Cologne

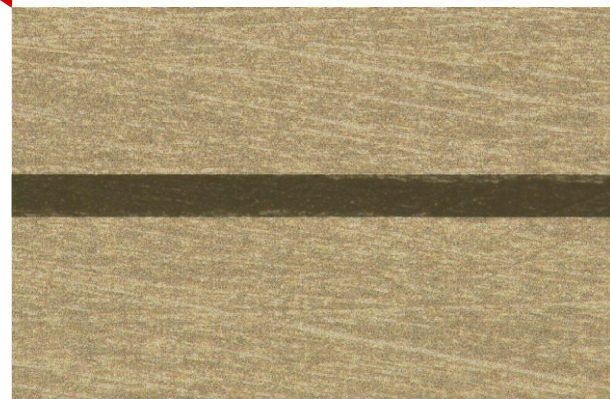
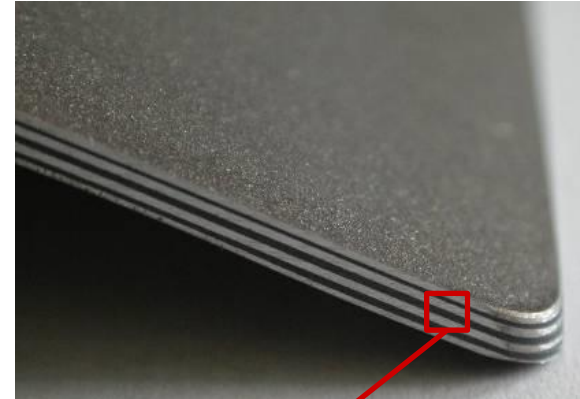
Miriam.Loebbecke@dlr.de



Knowledge for Tomorrow



Motivation



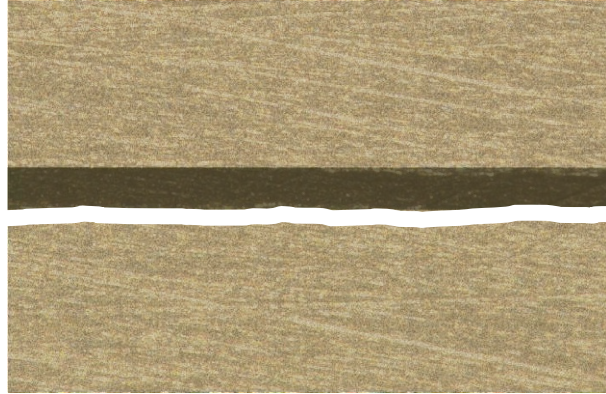
Titanium or CFRP

Polymer

Titanium



Strength and failure of adhesively bonded joints



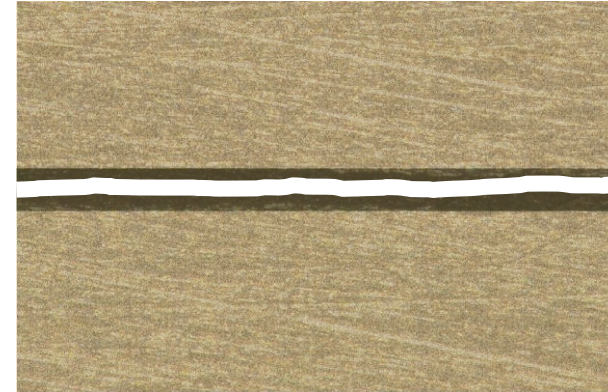
adhesive fracture

adhesive strength < cohesive strength

Titanium

Polymer

Titanium

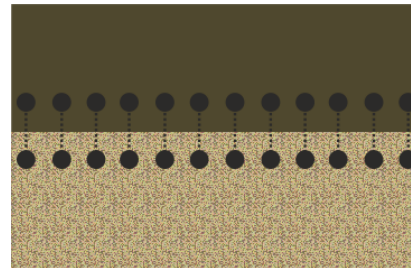


cohesive fracture

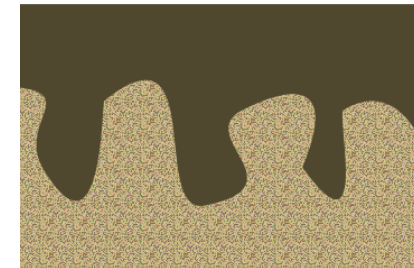
adhesive strength > cohesive strength



Possible bonding mechanisms:

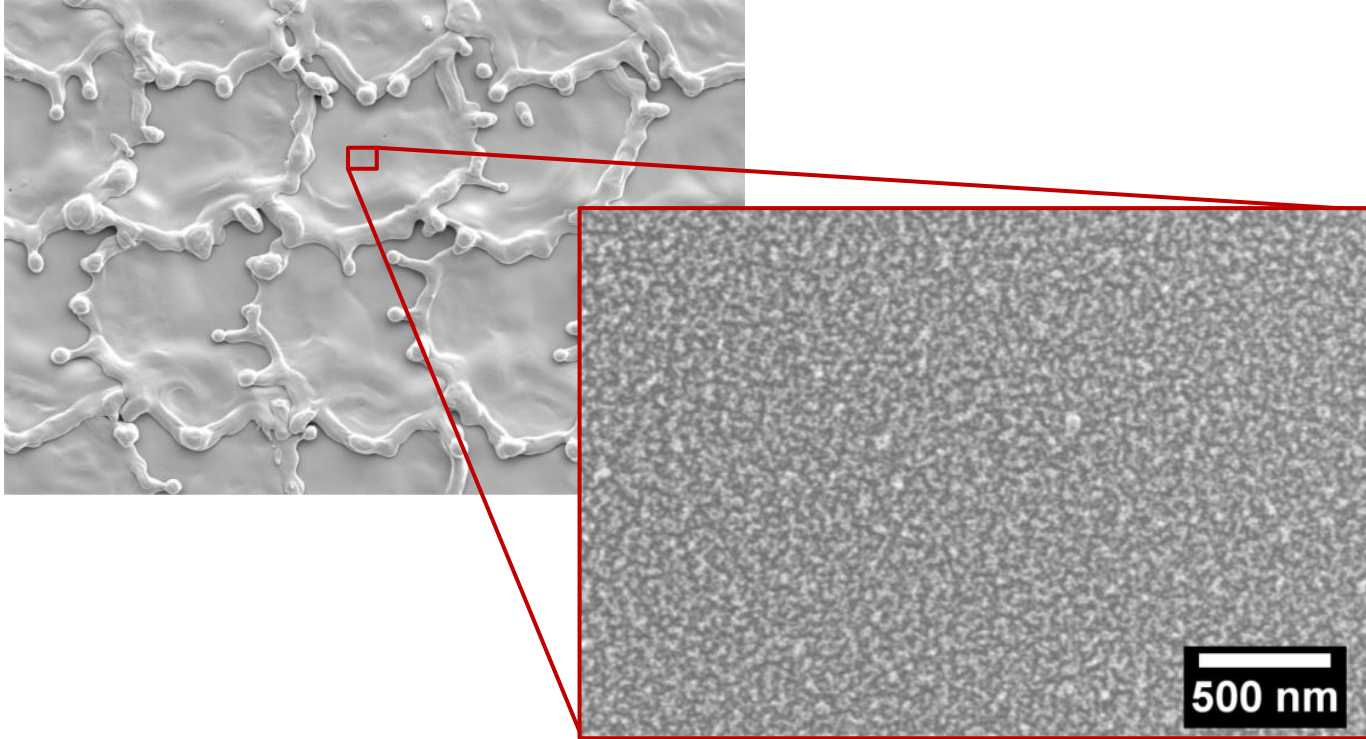


chemical interactions

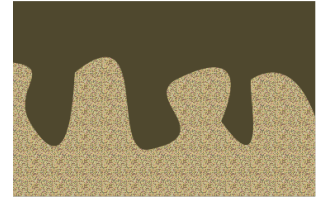


mechanical interlocking

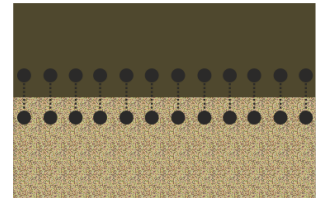
Laser surface treatment



- structuring on different scales



- chemical modification

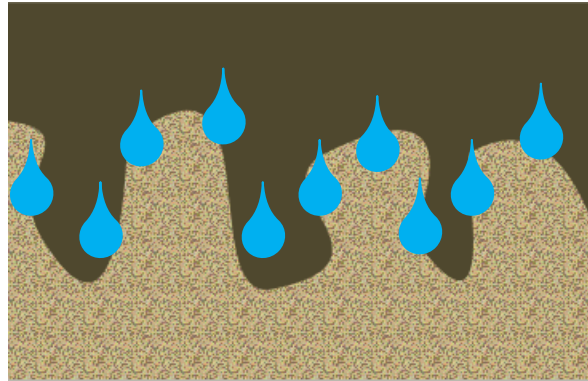


- high bonding strength possible
- long-term stable

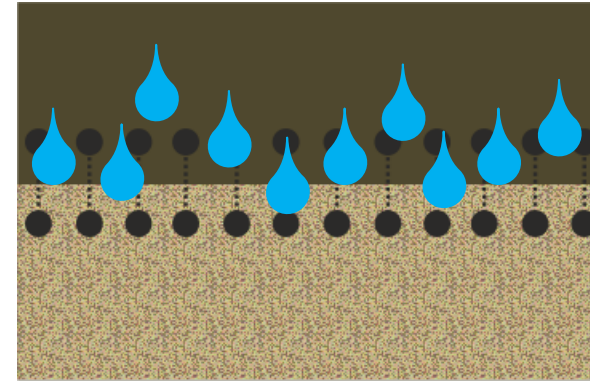
Main research questions

Why does a laser treatment cause high bonding strengths?

Why does a laser treatment cause long-term stable bonds?



?



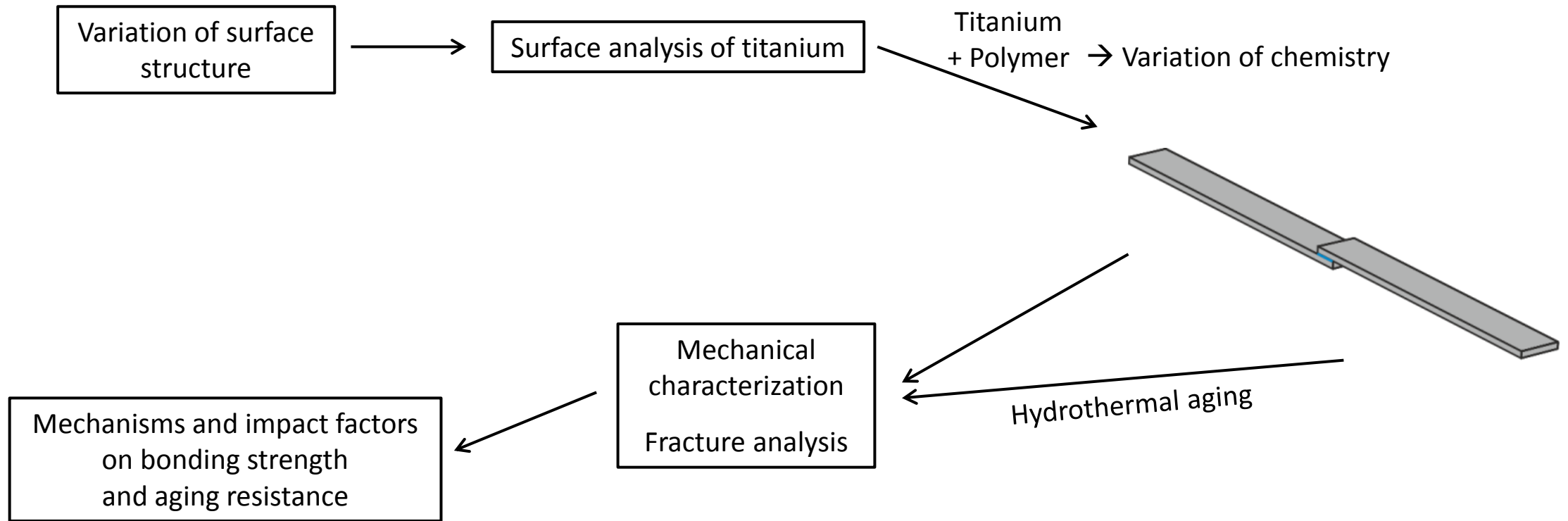
Structure



Chemistry

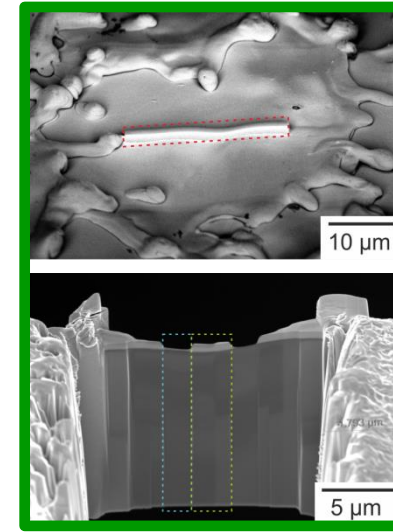
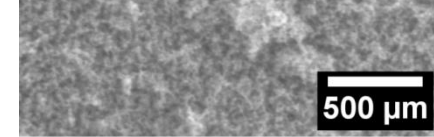
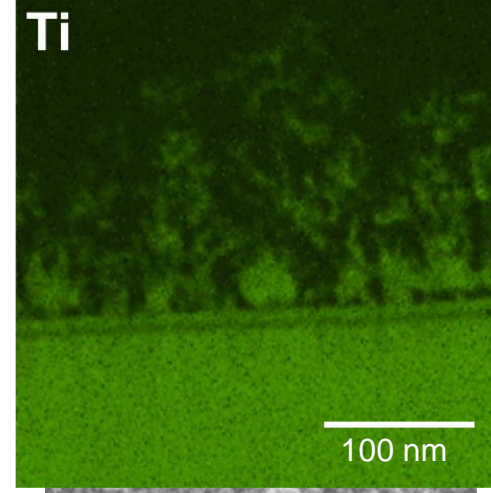
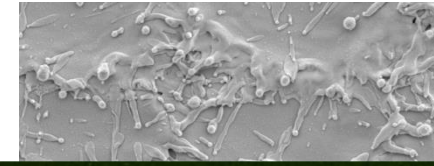
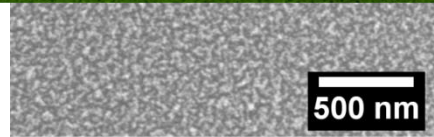
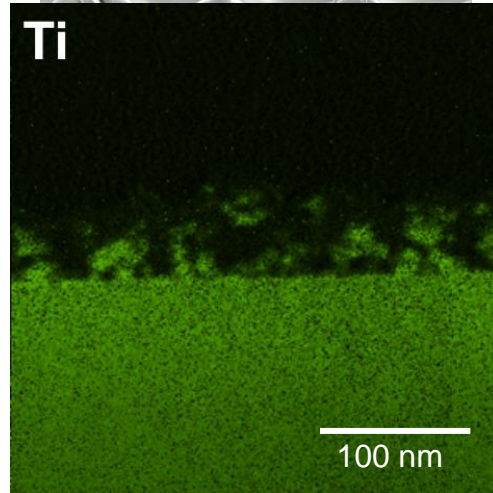
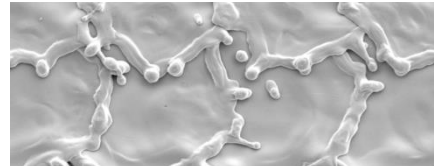
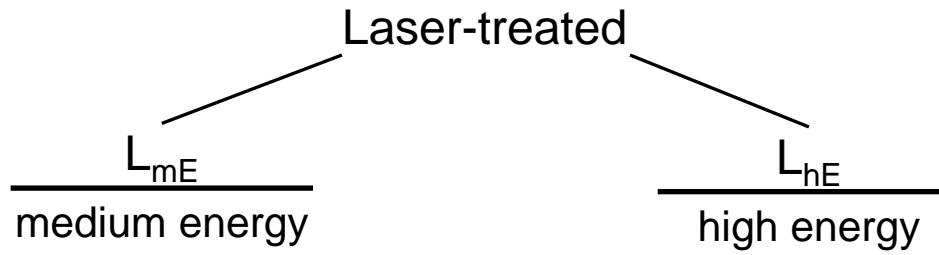
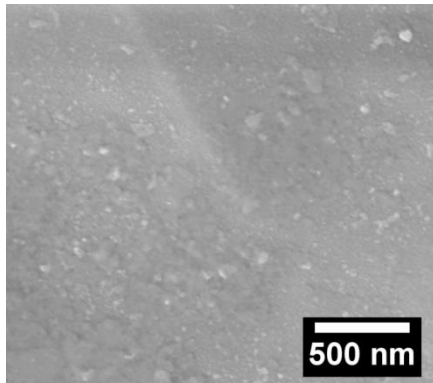
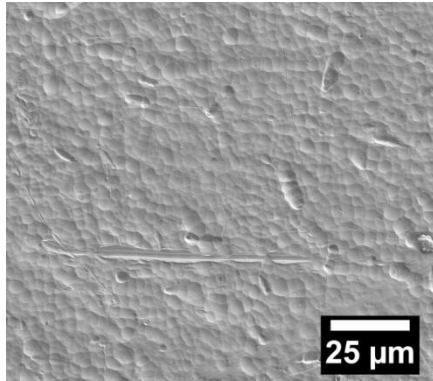
What is important for long-term stable adhesively bonded metal joints?

Materials and methods



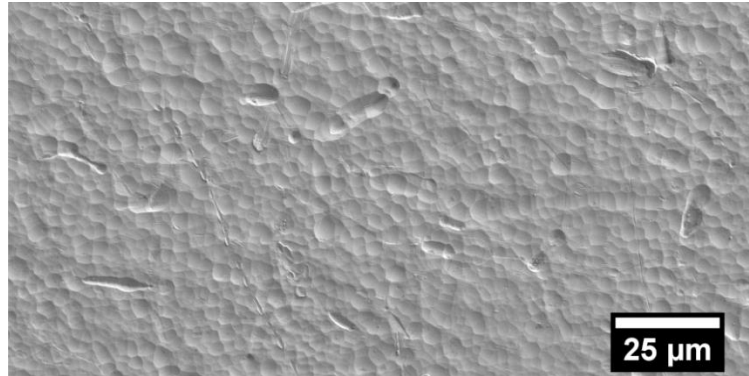
Surface treatments and analysis

U
untreated



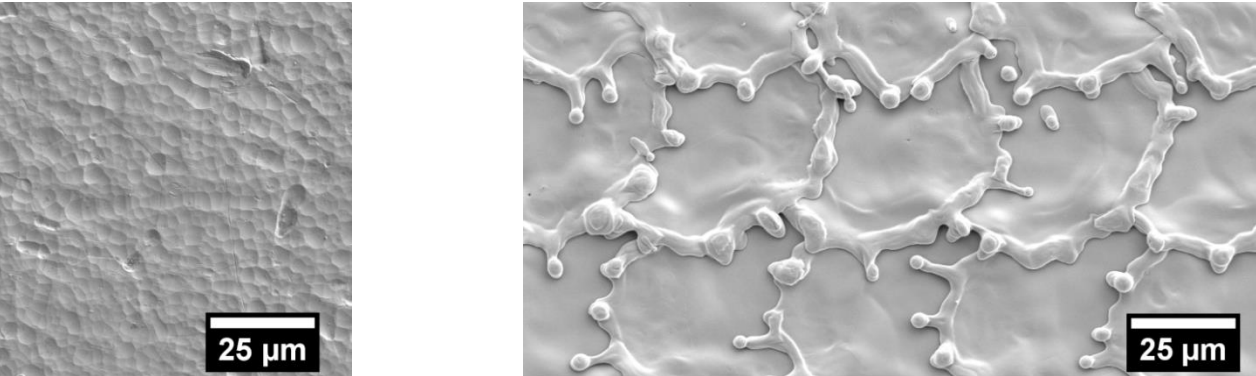
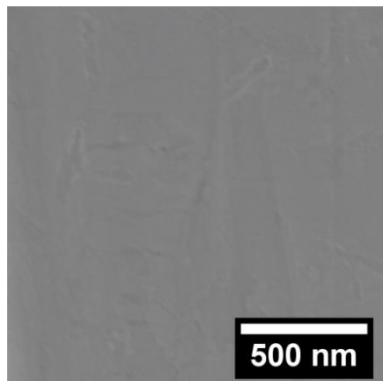
TEM

Surface treatments and analysis



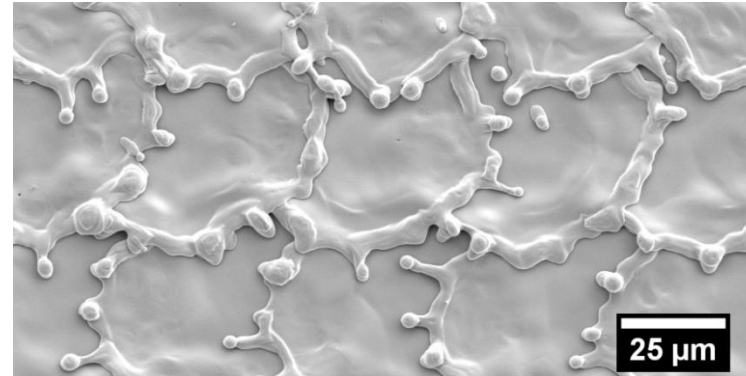
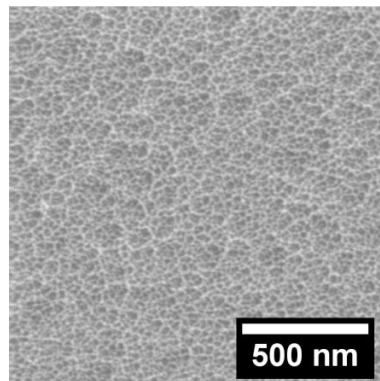
$U-E_{Kell}$

no
nanostructure



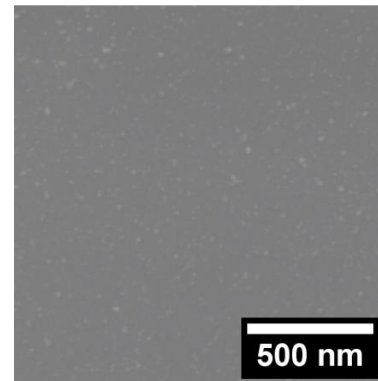
$U-E_{KOH}$

changed
nanostructure



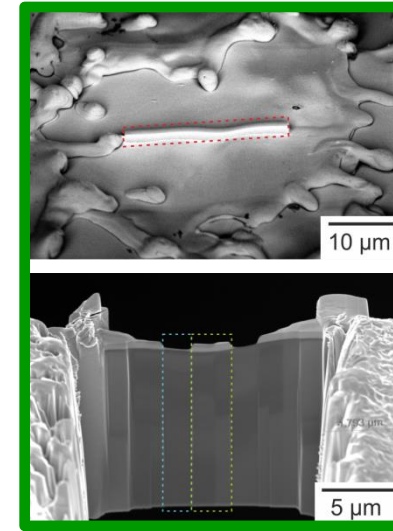
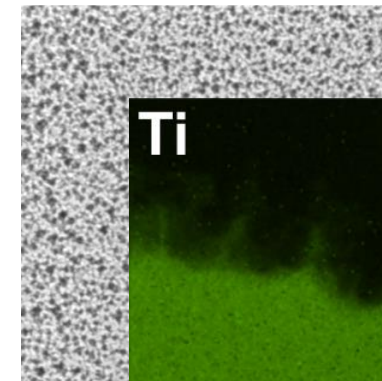
$L_{mE}-E_{Kell}$

no
nanostructure



$L_{mE}-E_{KOH}$

changed
nanostructure



TEM

Ti

100 nm

Mechanical characterization

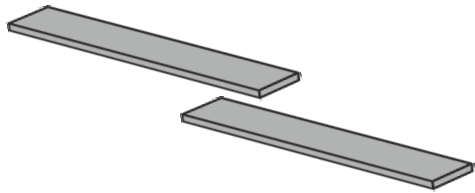
Metal

+

Polymer



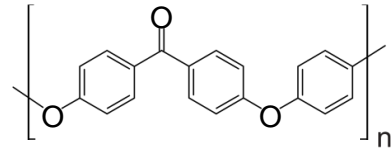
Lap-shear samples



Titanium Ti15-3
(surface pretreated)

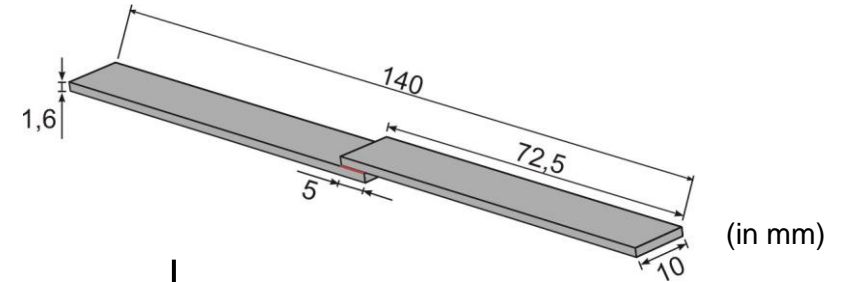
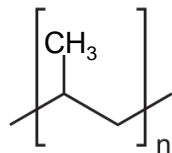
Polyetheretherketone (PEEK)

- high chemical resistance
- low water uptake
- slightly polar

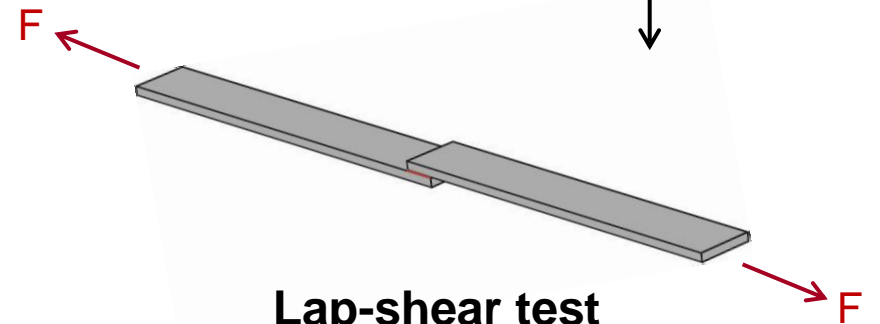


Polypropylene (PP)

- high chemical resistance
- low water uptake
- nonpolar

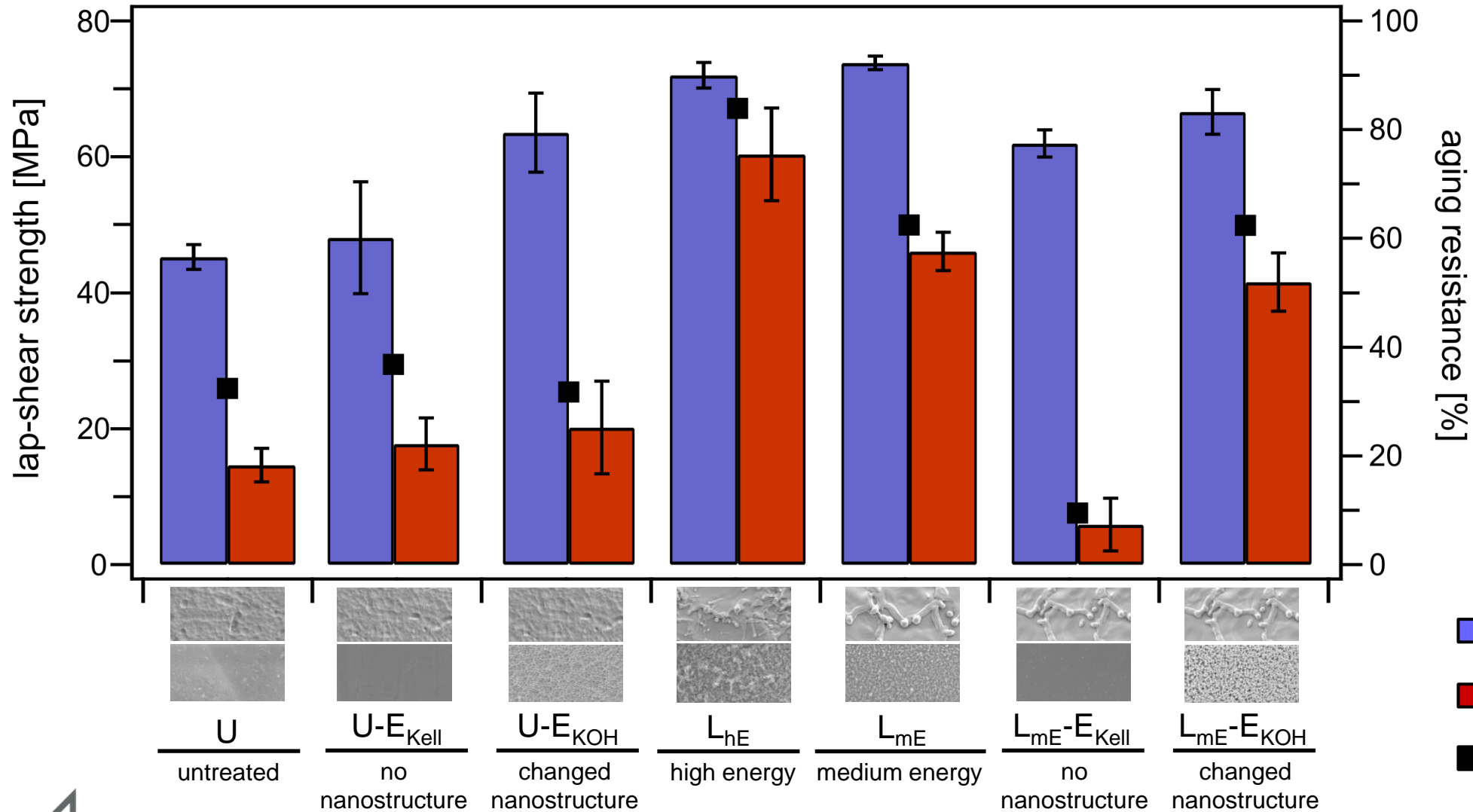
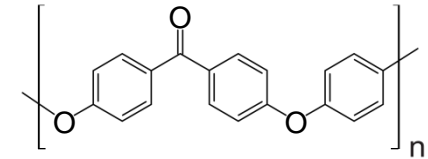


Hydrothermal
aging
(80 °C, 7 days)



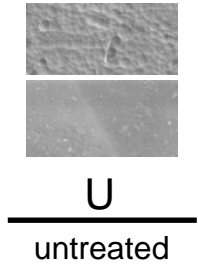
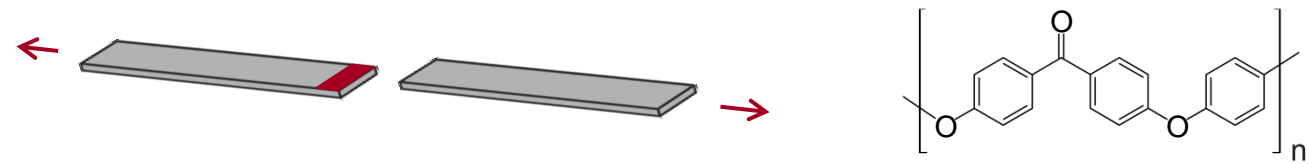
Lap-shear test

Mechanical characterization – Ti15-3/PEEK

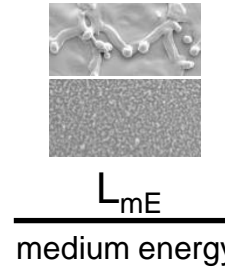
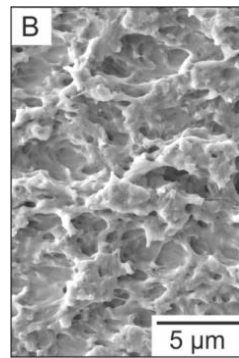
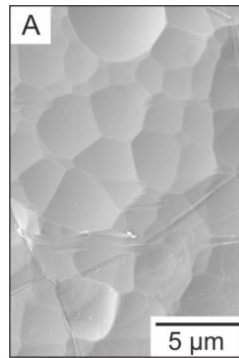
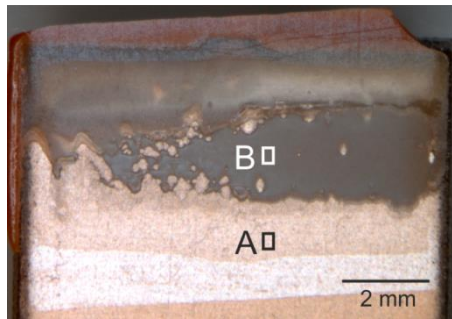


- Strength initial
- Strength after aging (7 d)
- Aging resistance

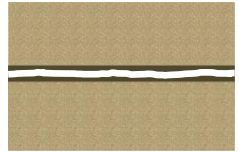
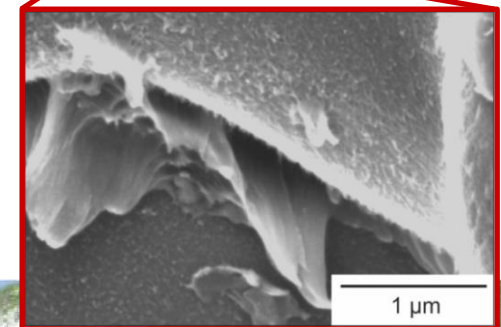
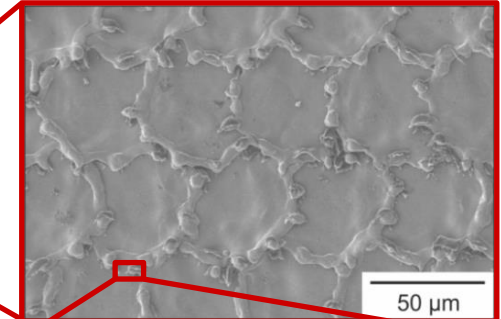
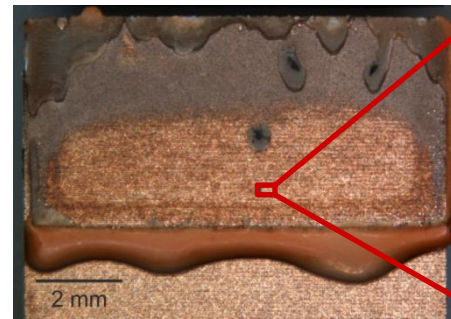
Fracture analysis Ti15-3/PEEK



U
untreated



L_{mE}
medium energy

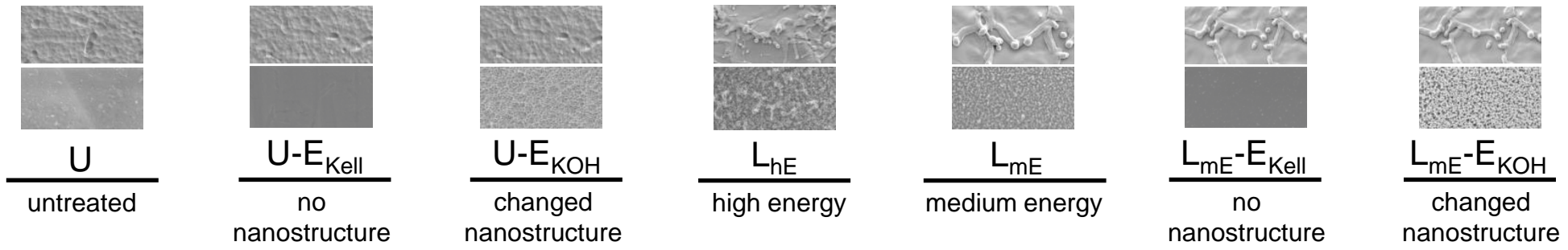
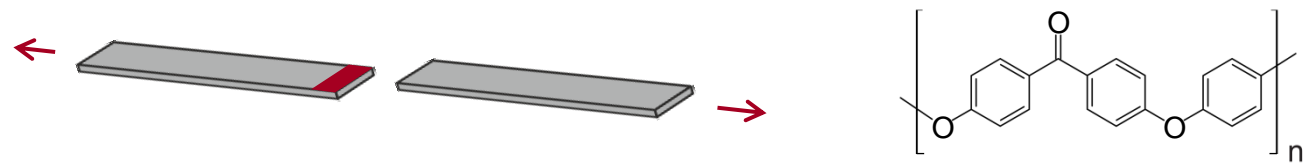


cohesive

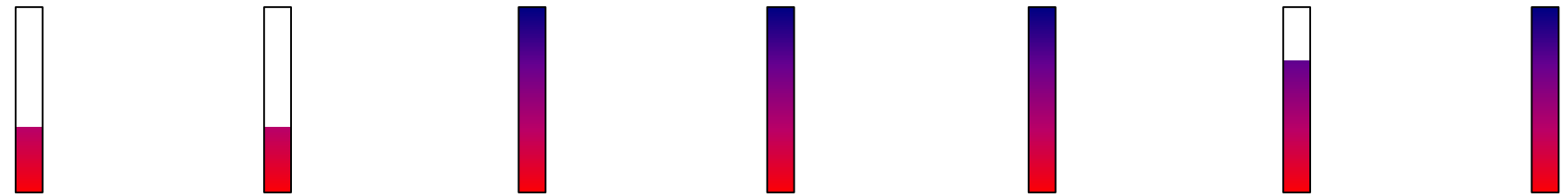


adhesive

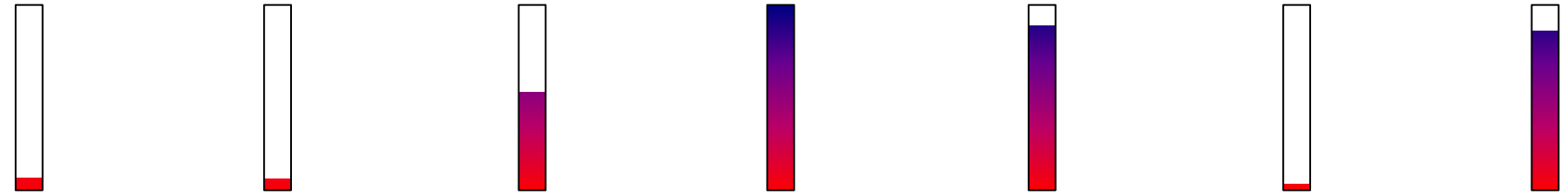
Fracture analysis Ti15-3/PEEK



initial



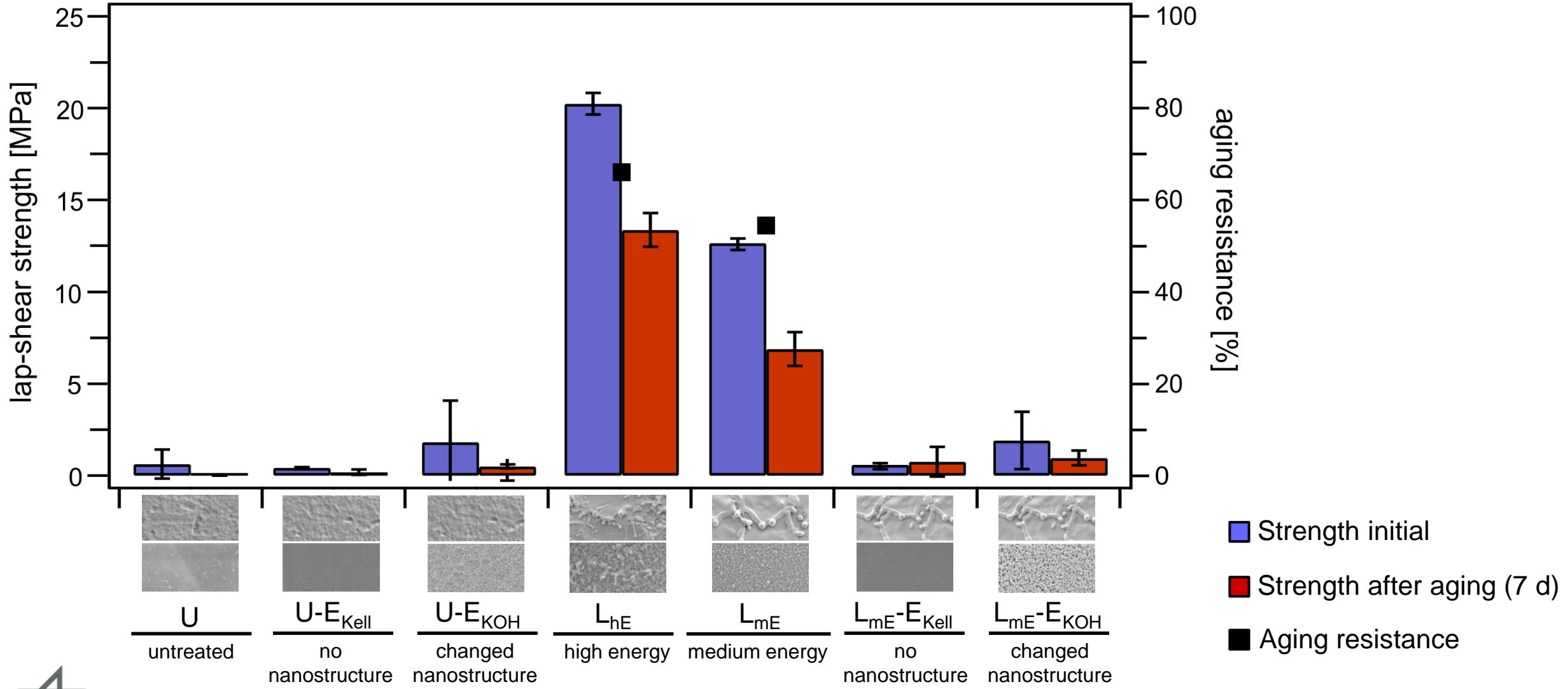
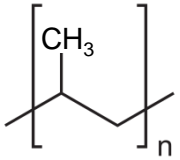
aged



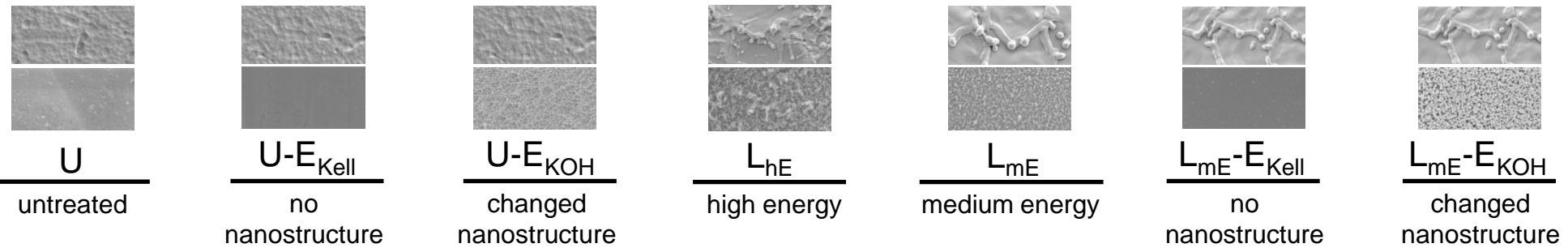
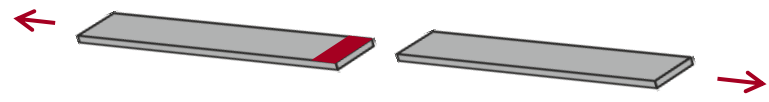
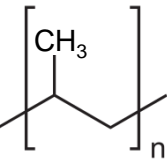
cohesive
adhesive



Mechanical characterization – Ti15-3/PP



Fracture analysis Ti15-3/PP



initial

aged



Conclusions

***Why does a laser treatment cause long-term stable bonds?
What is important for long-term stable adhesively bonded metal joints?***

Structure

- mechanical interlocking possible
- surface enhancement: number of potential binding sites
- crucial: size and morphology
 - macrostructure for initial strength
 - shape of nanostructure key for long-term stability

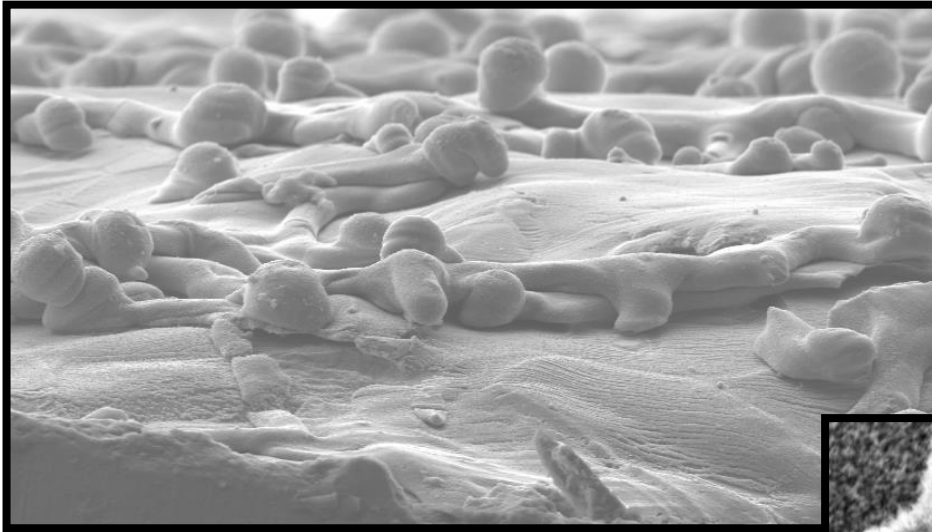
- nanomechanical interlocking due to pronounced, open-porous, branched nanostructure
- role of macrostructure in combination with nanostructure?

Chemistry

- affects wetting, infiltration and magnitude of interactions
- chemical interactions can promote/support high bonding strength
- when infiltration and stability of materials ensured: influence of chemistry less significant than influence of structure

- mechanical interlocking is more stable than chemical interactions!

Thank you for your attention!



Dr.-Ing. Miriam Löbbcke
(Miriam.Loebbecke@dlr.de)

German Aerospace Center (DLR)
Institute of Materials Research
Linder Höhe
D-51147 Cologne

