TECHNISCHE UNIVERSITÄT CHEMNITZ

Institute of Joining and Assembly
Chair of Welding Engineering
Prof. Dr. Peter Mayr

PROFESSUR SCHWEISSTECHNIK

In-line surface treatment and diffusion bonding

A novel approach for joining challenging materials

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Symposium of World Experts in Diffusion Bonding

Milton Keynes, 20th of June 2017

SFB 692 - HALS

Where is Chemnitz located?

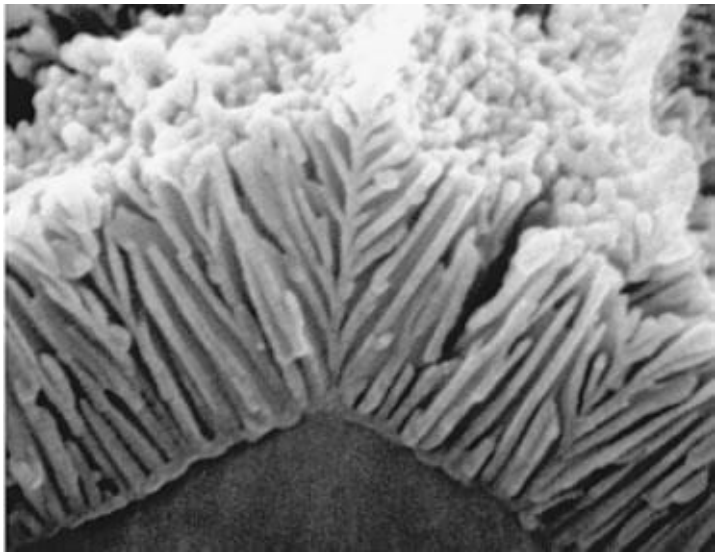
Chair of Welding Engineering

What are the limiting factors of weldability?

limiting factors on weldability

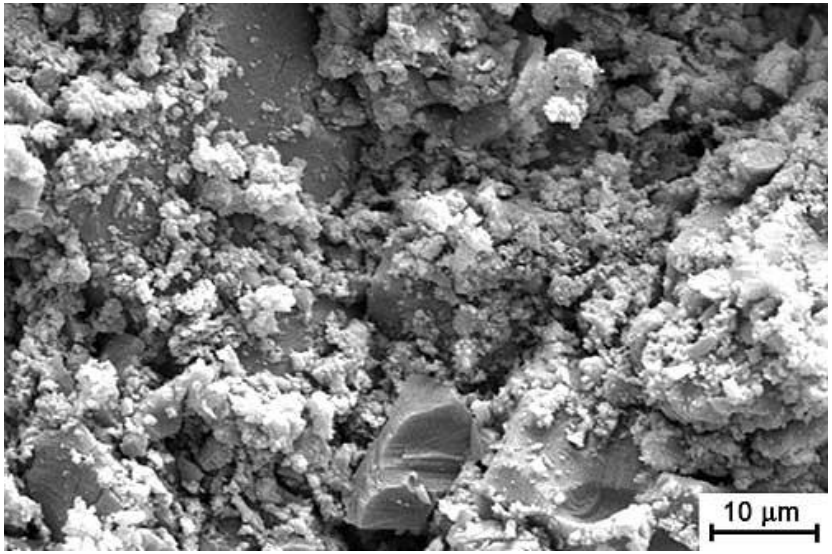
1. oxide layer on joining surface, e.g. of aluminium and magnesium alloys

amorphous structure of the Al-oxide layer (≈ 20 nm)



source: alumatter.co.uk

oxide layer on magnesium surface

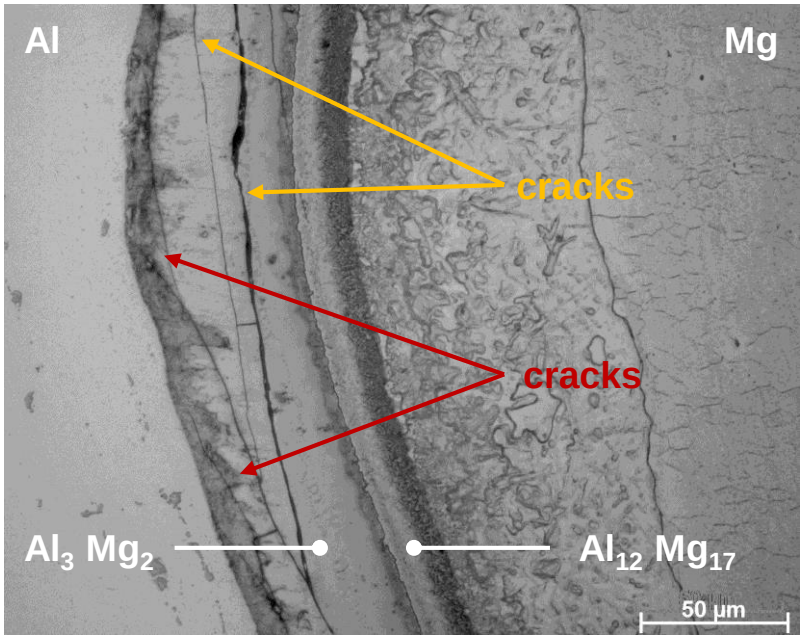


source: Brevier

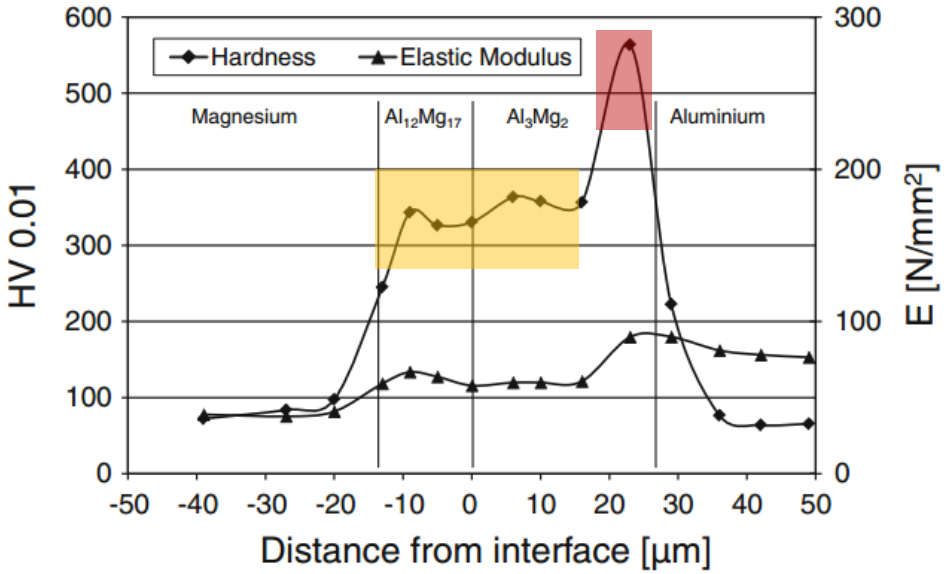
limiting factors on weldability

1. oxide layer on joining surface, e.g. of aluminium and magnesium alloys
2. formation of brittle intermetallic compounds along the interface

interface of an Al-Mg-joint



hardness profile of Al-Mg-interface

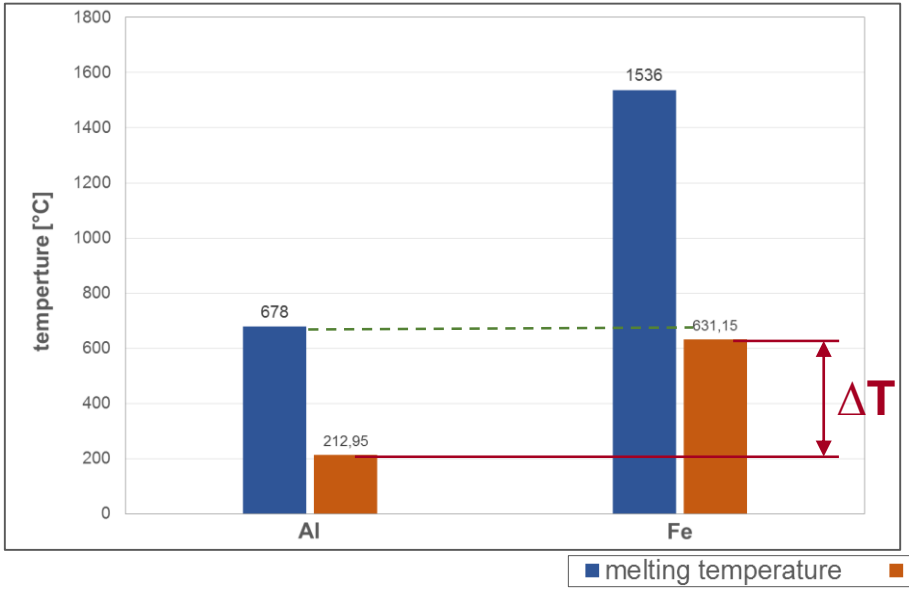


source: J Mater Sci (2011) 46:357–364

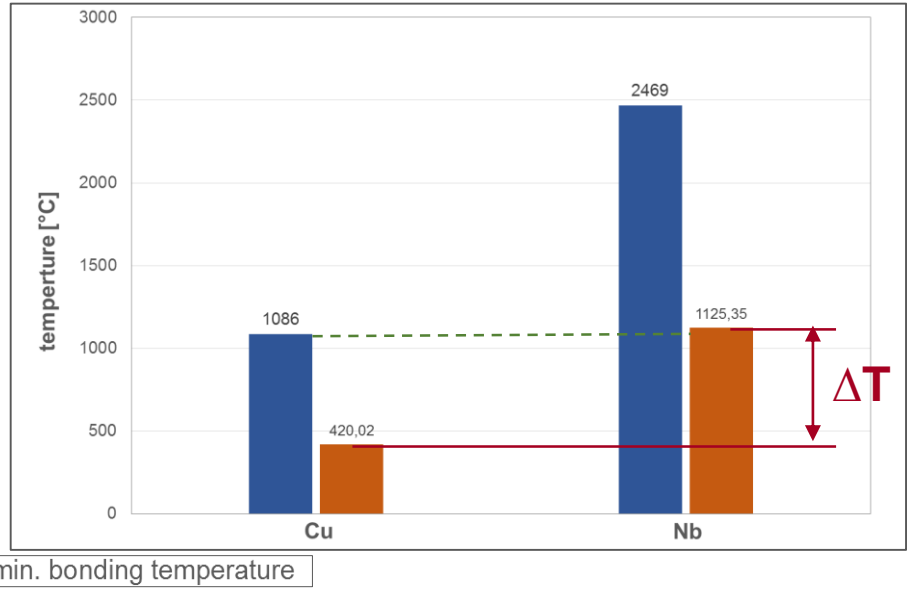
limiting factors on weldability

1. oxide layer on joining surface, e.g. of aluminium and magnesium alloys
2. formation of brittle intermetallic compounds along the interface
3. different physical properties, e.g. melting temperature

Al and Fe diffusion bonding



Cu and Nb diffusion bonding

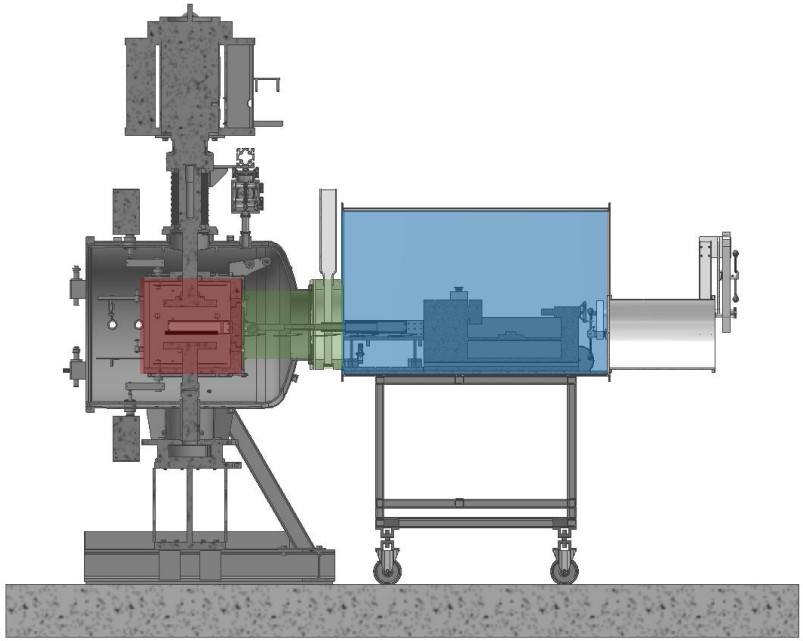


How to improve the weldability of challenging materials for diffusion bonding?

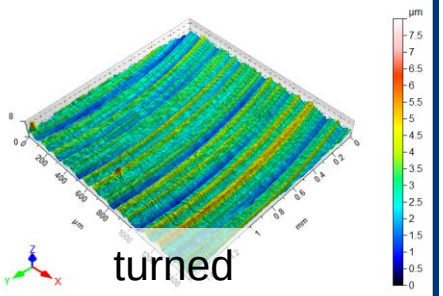
In-line surface treatment and diffusion bonding

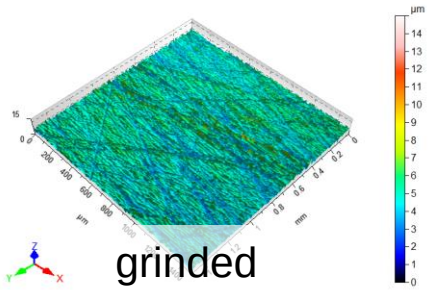
In-line surface treatment and diffusion bonding

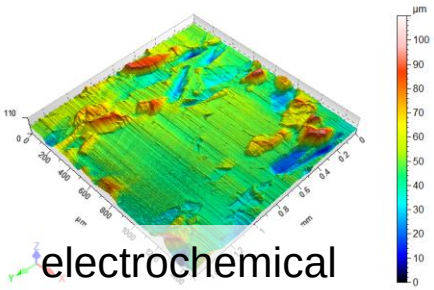
diffusion bonding

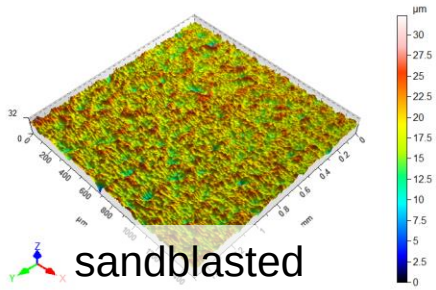


possible surface treatments in a glovebox and their effects


turned


grinded


electrochemical


sandblasted

initial surface state

increasing surface roughness

Increasing surface energy

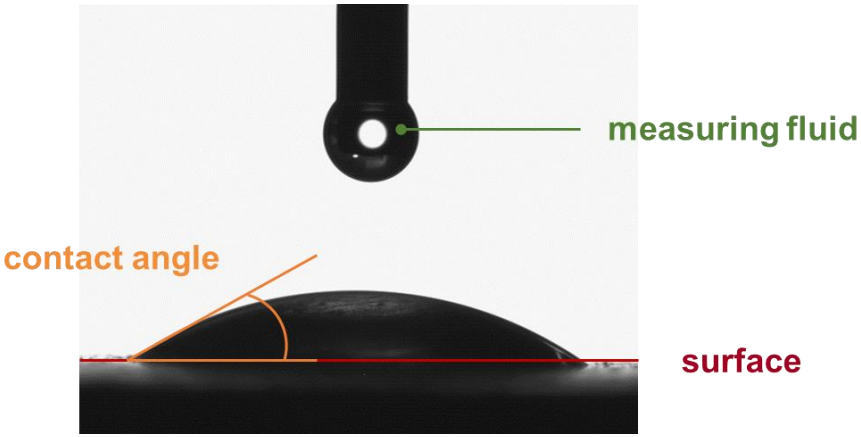
influencing bonding parameter

How does the surface treatment influence the condition of the joining surface?

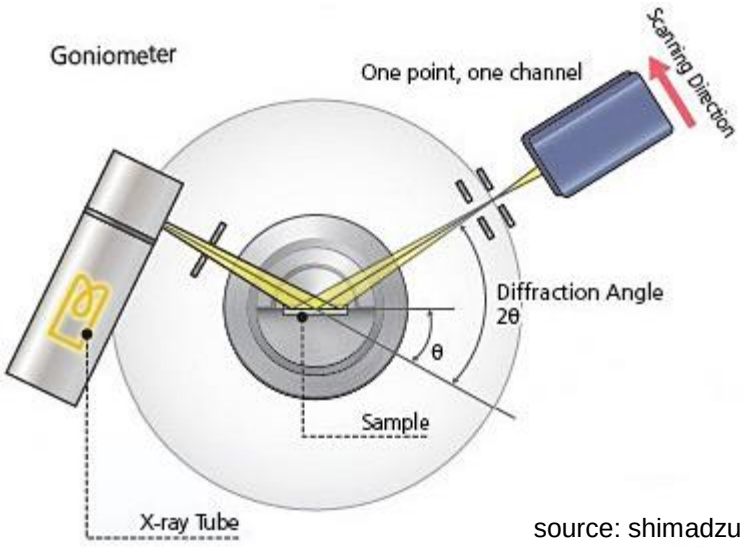
surface treatment vs. surface condition

determination of the surface condition

static contact angle measurement (Owens-Wendt-method)

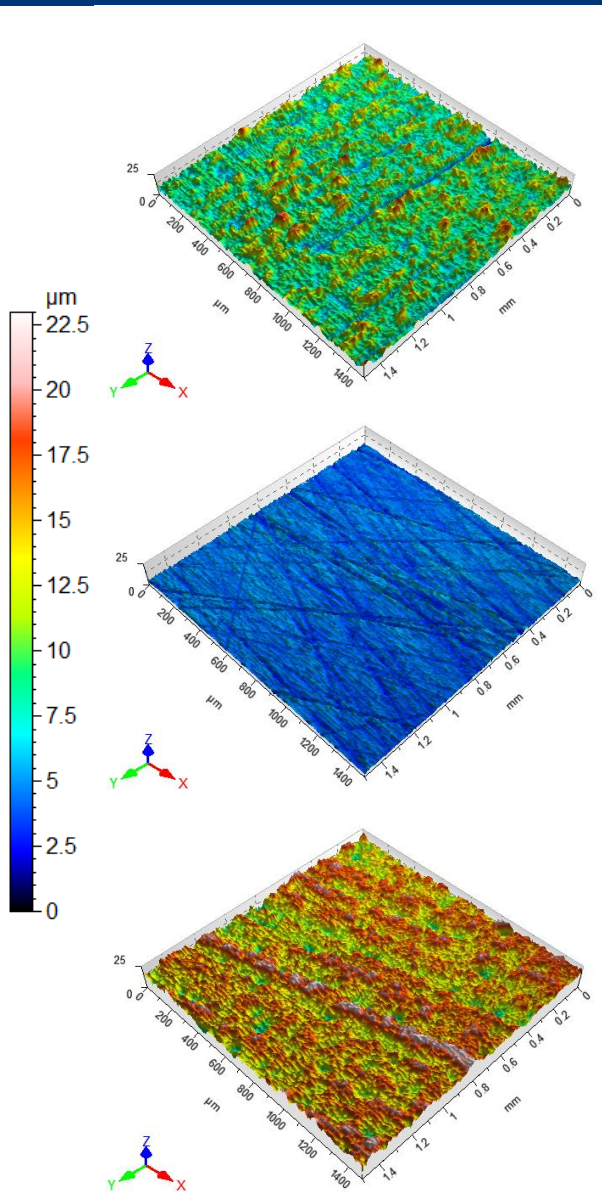


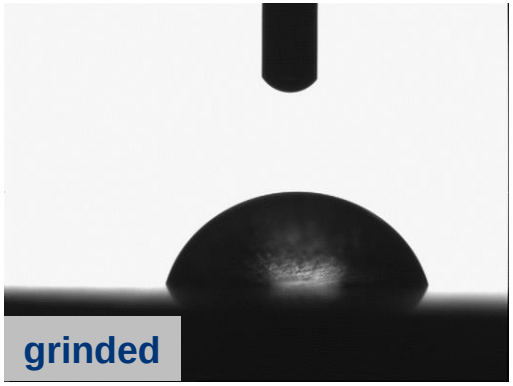
X-ray diffraction

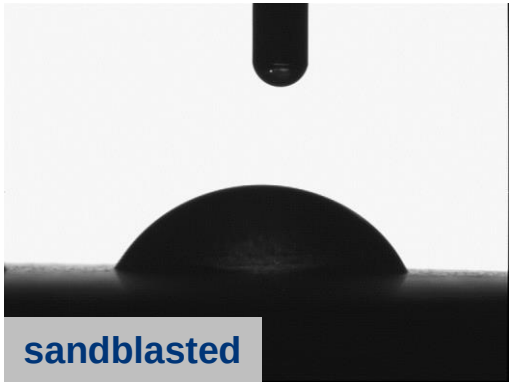


source: shimadzu

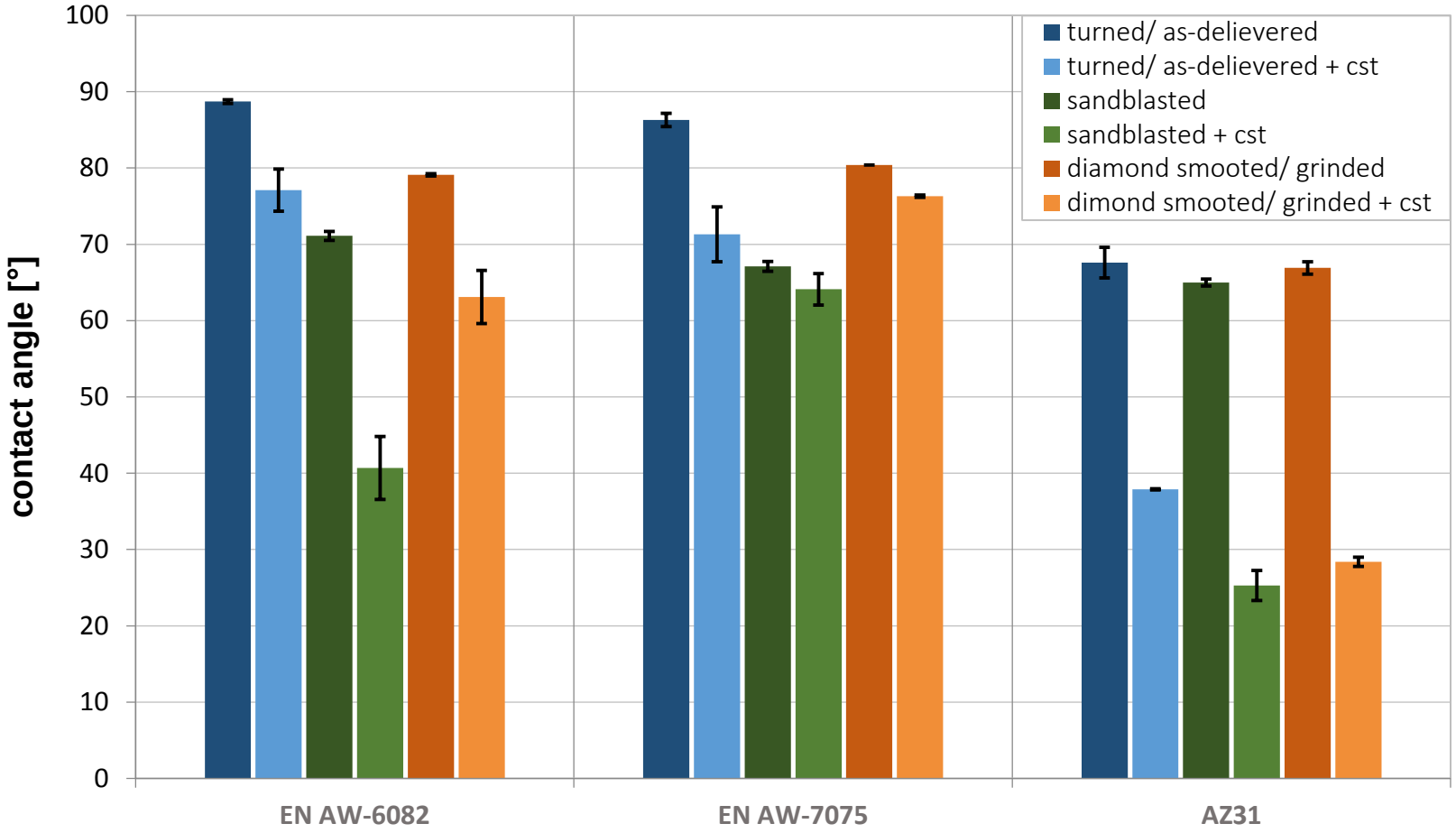
influence of surface treatment on the contact angle of AZ31





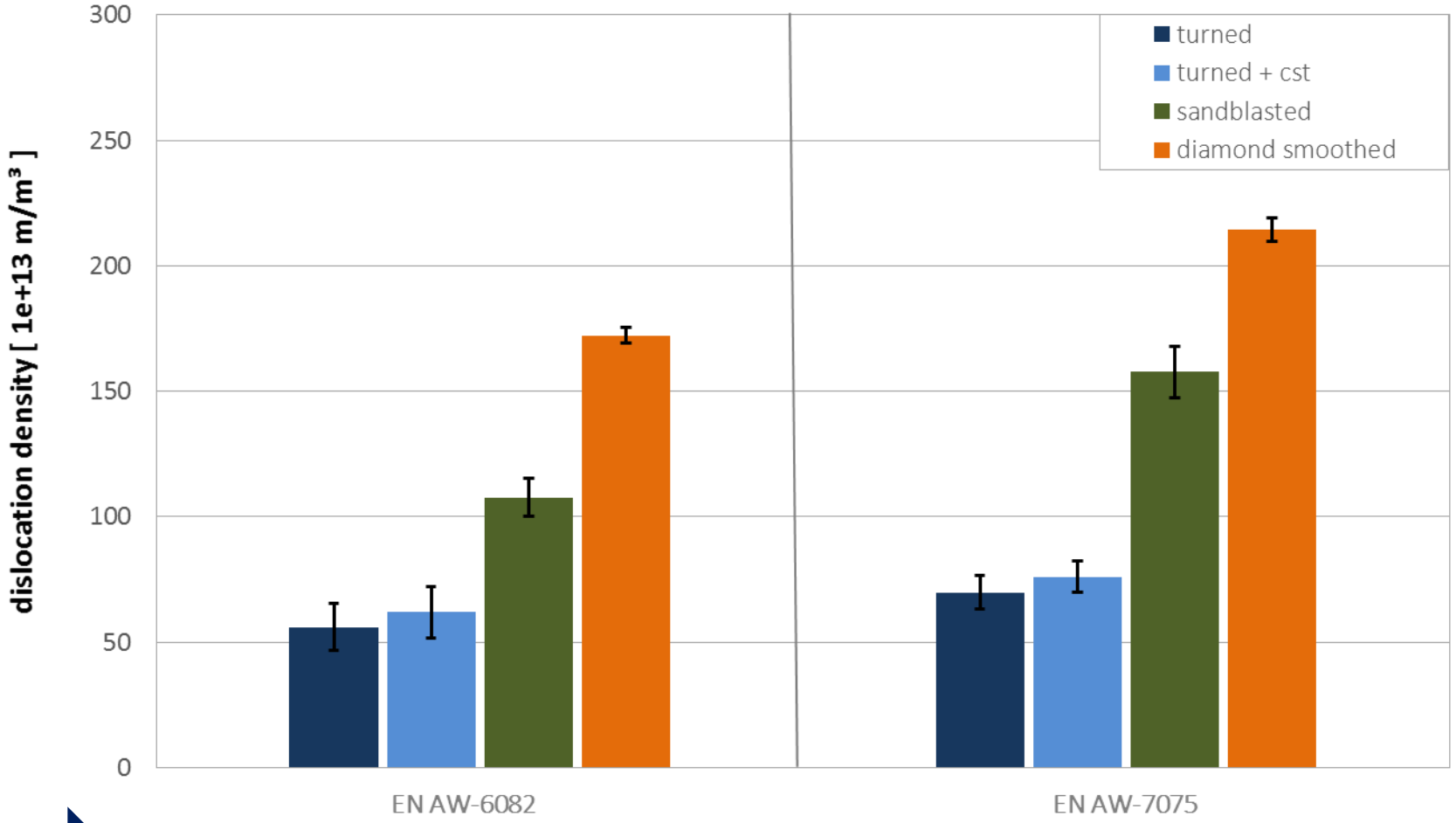


influence of surface treatment on the contact angle (measuring fluid: water)



- sandblasted surfaces show lowest contact angle
- chemical surface treatment reduces the contact angle

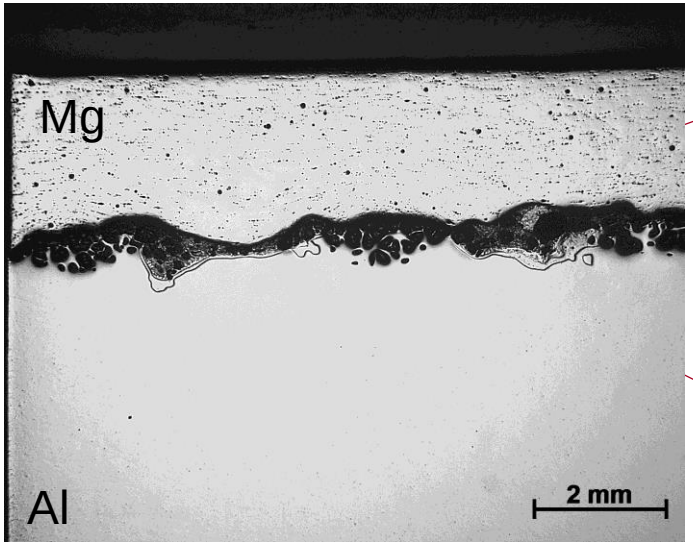
effect of the different surface treaments on the dislocation density of the prevailing aluminium alloys

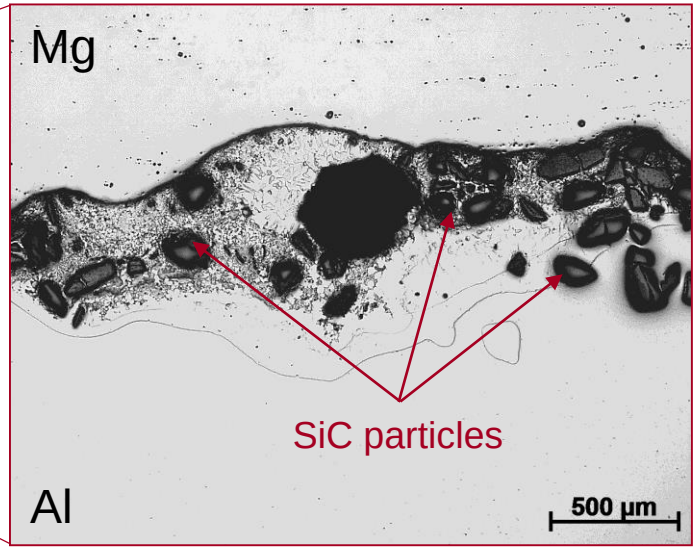


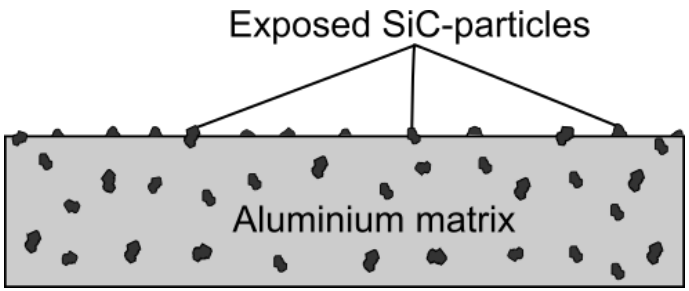
- highest dislocation density for diamond smoothed surfaces
- results correlate with contact angle measurement → sandblasted and diamond smoothed surface treatments show highest potential

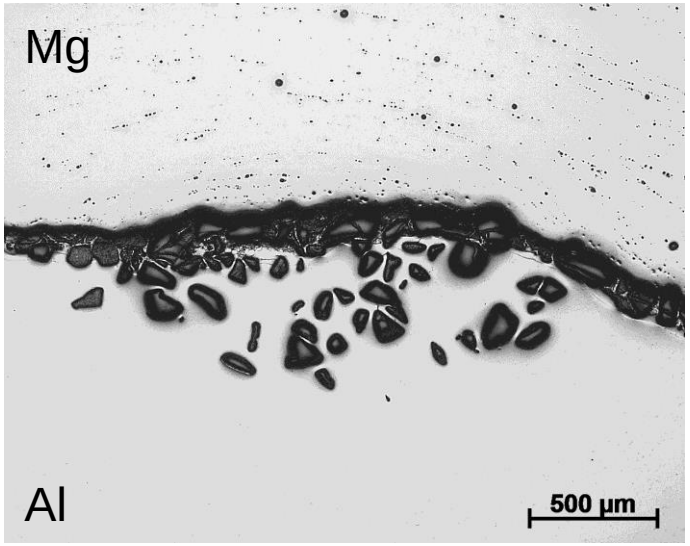
What is the advantage of in-line surface treatment and diffusion bonding?

diffusion bonding of AMC (AA7075+SiC_p) and AZ31



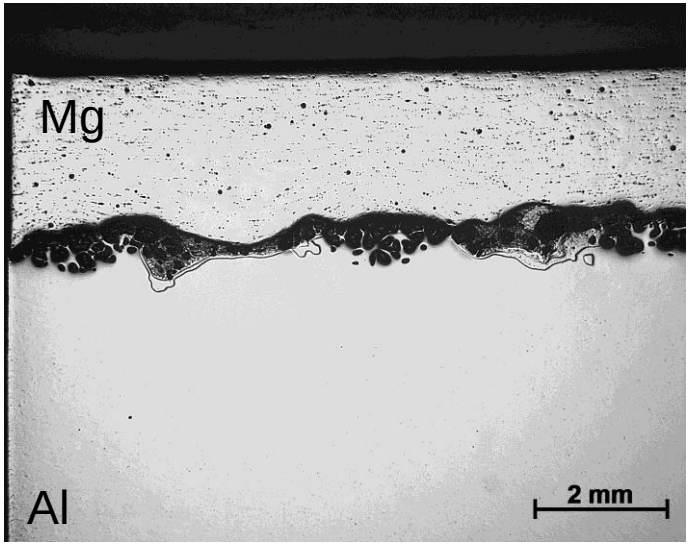


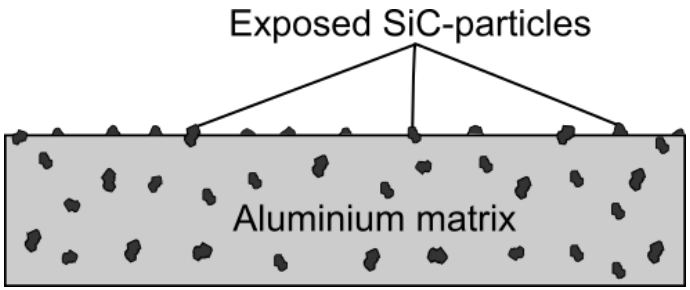


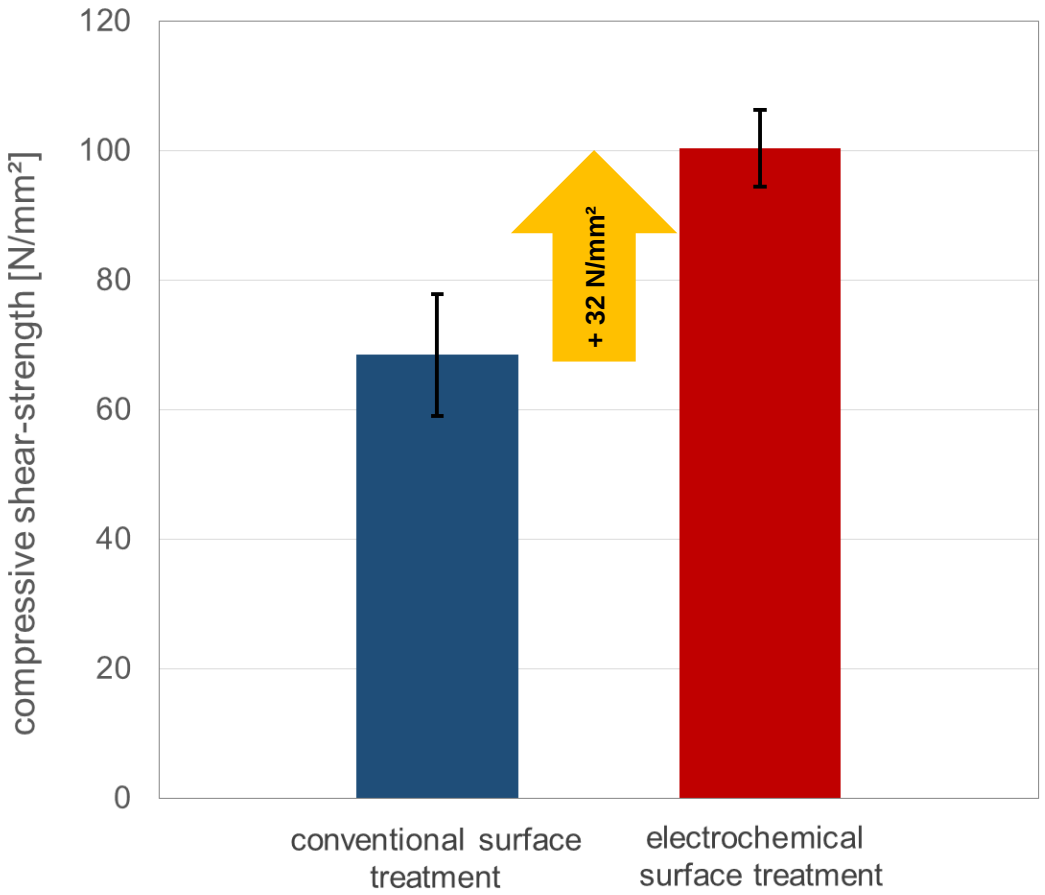


electrochemically treated suface for SiC_p exposure

diffusion bonding of AMC (AA7075+SiC_p) and AZ31

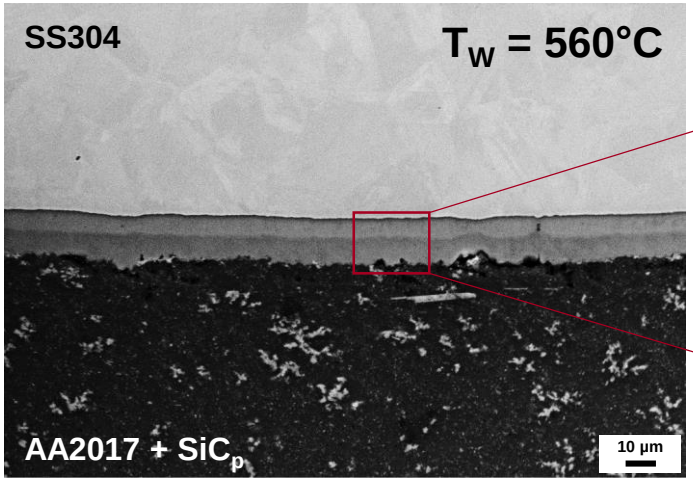


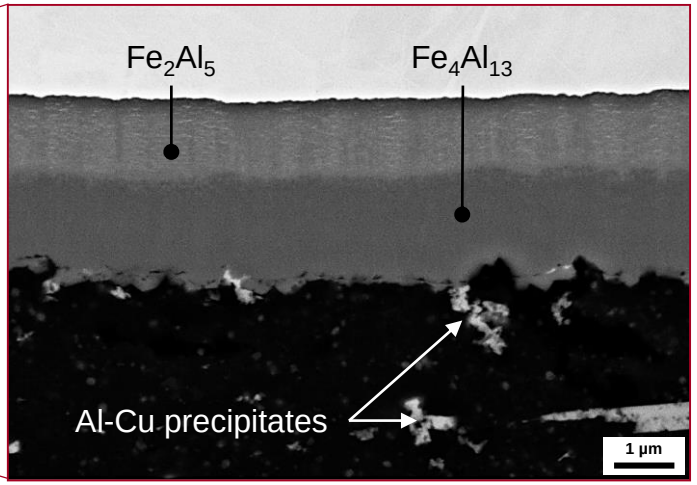




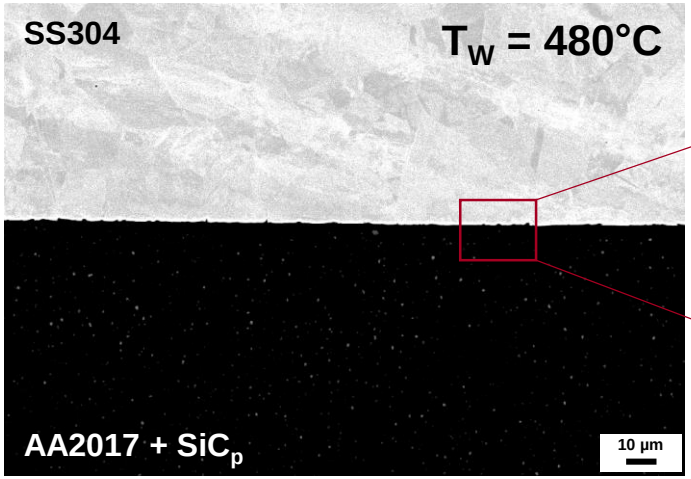
electrochemically treated suface for SiC_p exposure

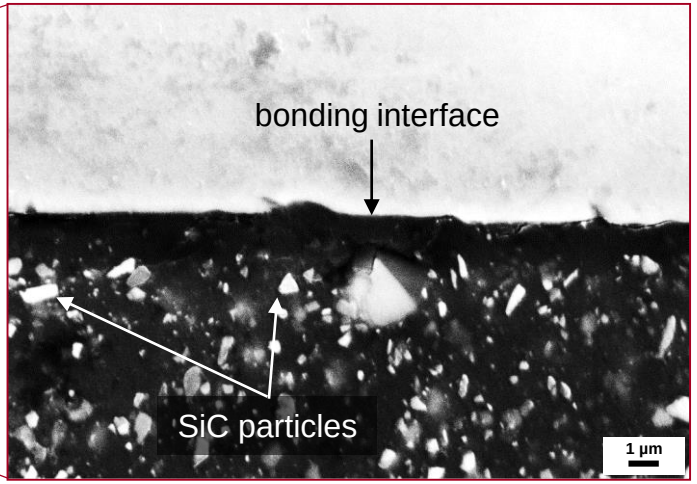
diffusion bonding of AMC and stainless steel



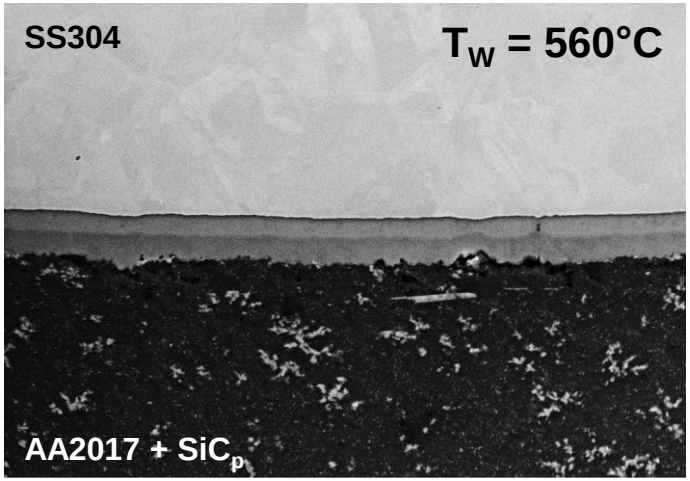


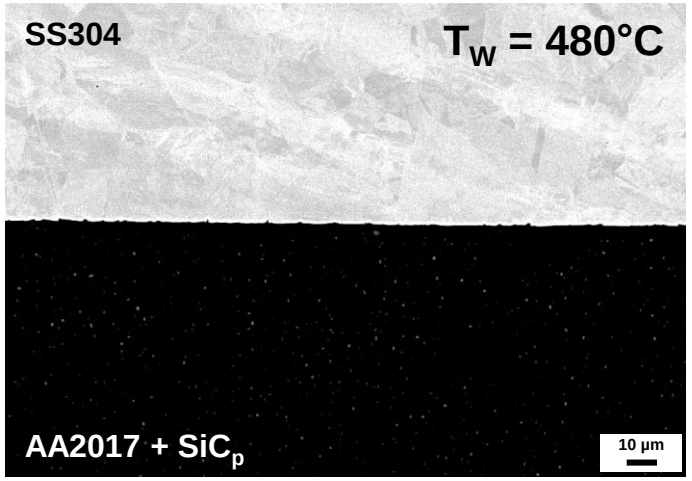
temperature reduction by 80°C

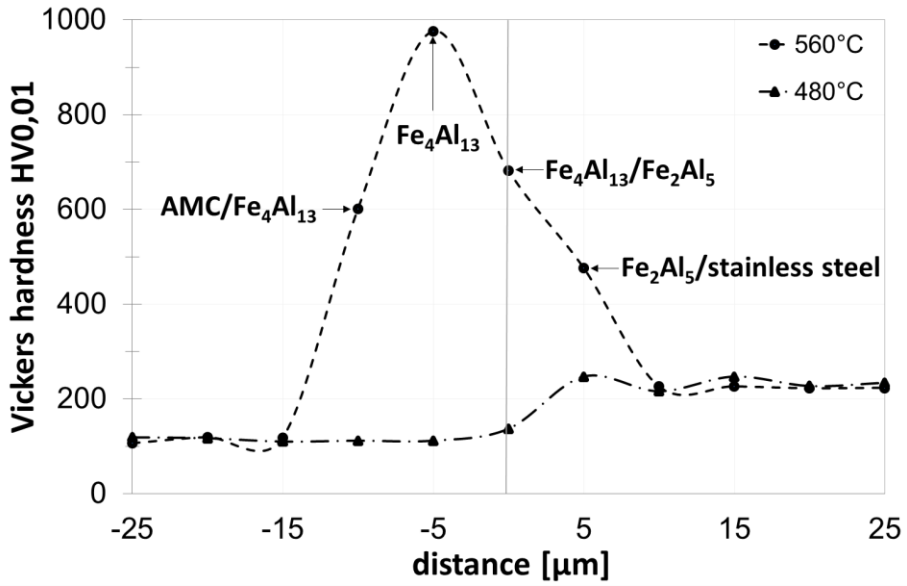




diffusion bonding of AMC and stainless steel

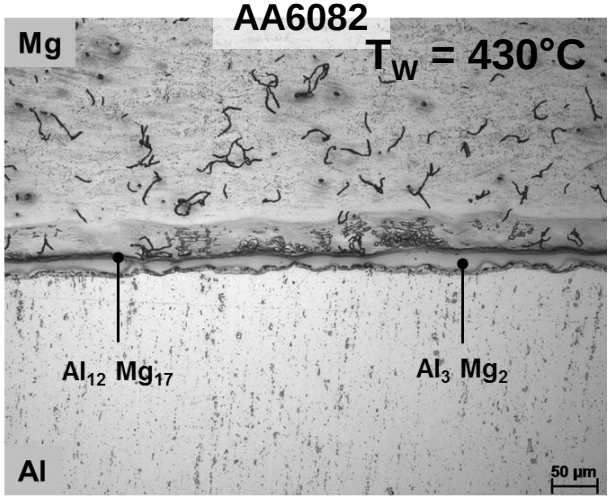




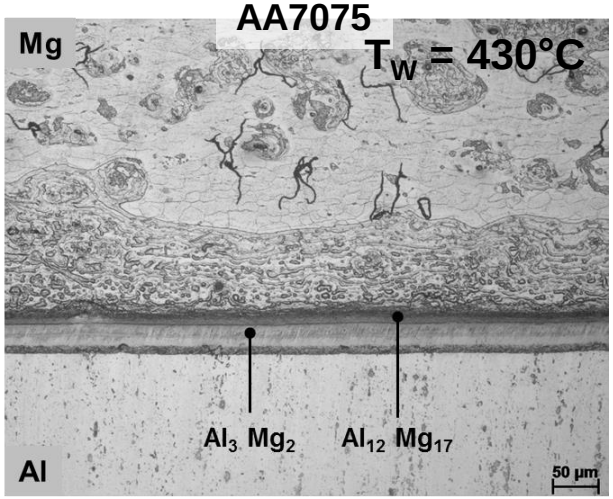


diffusion bonding of aluminium and magnesium

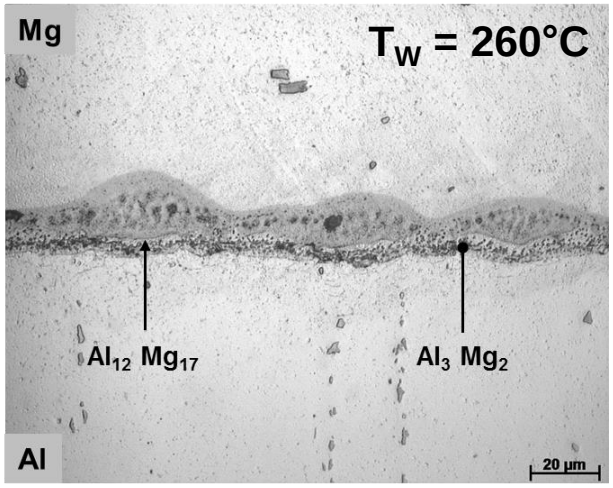
AA6082

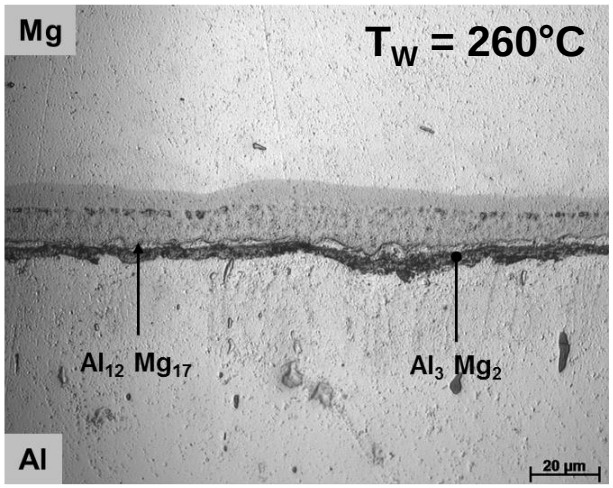


AA7075

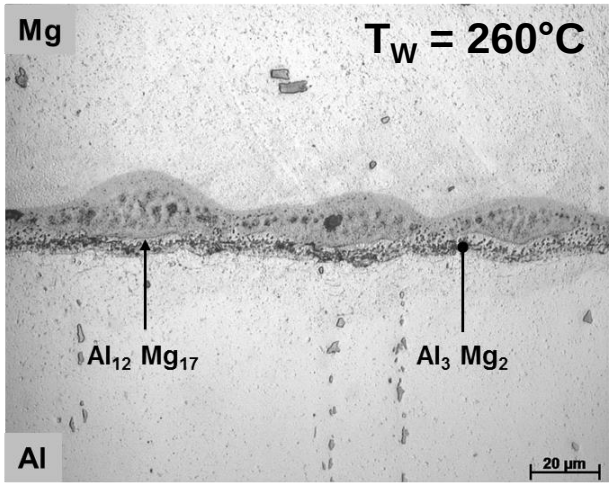


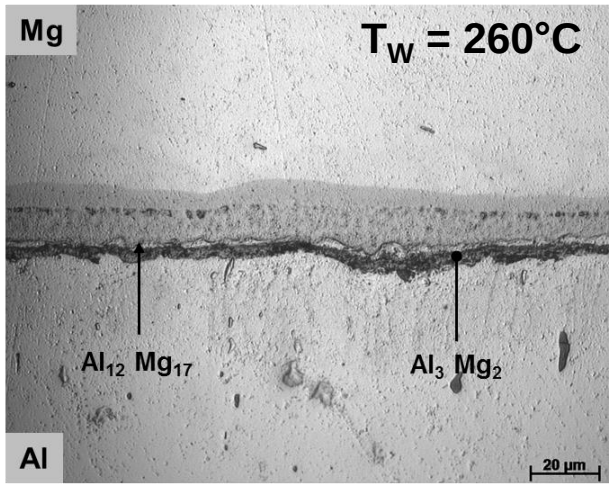
temperature reduction by 160°C
IMC thickness reduction by ca. 80%

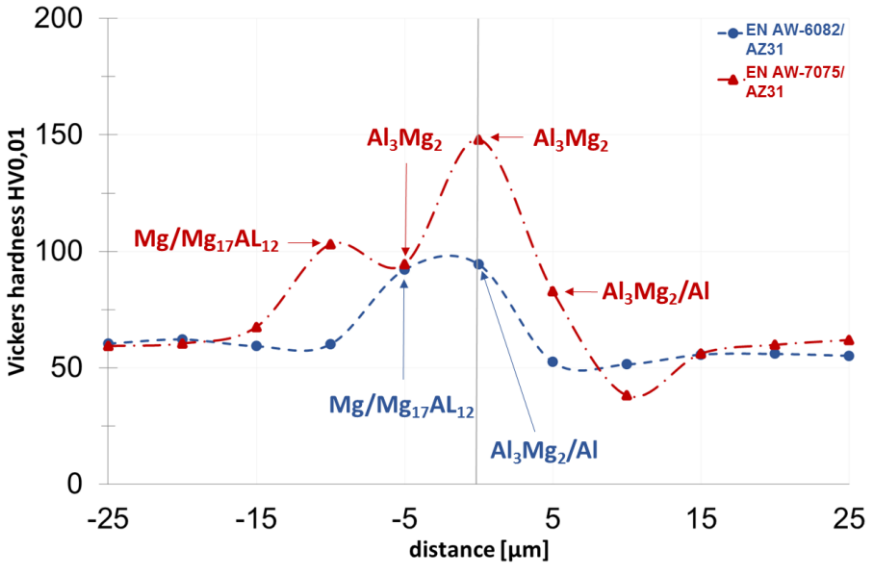




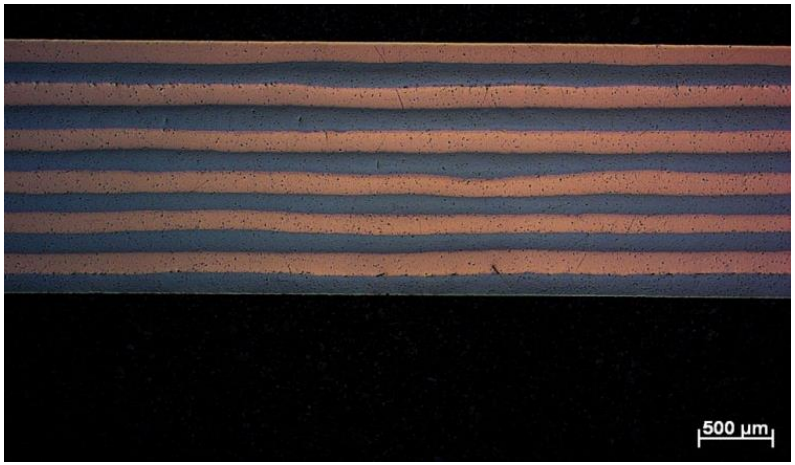
diffusion bonding of aluminium and magnesium



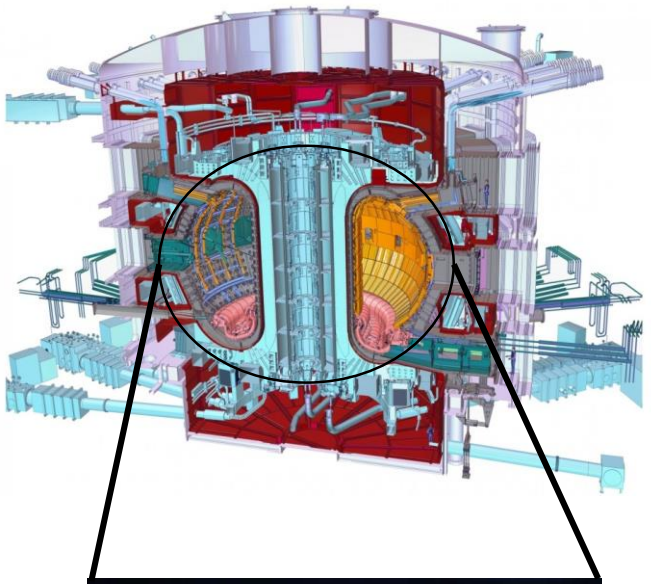




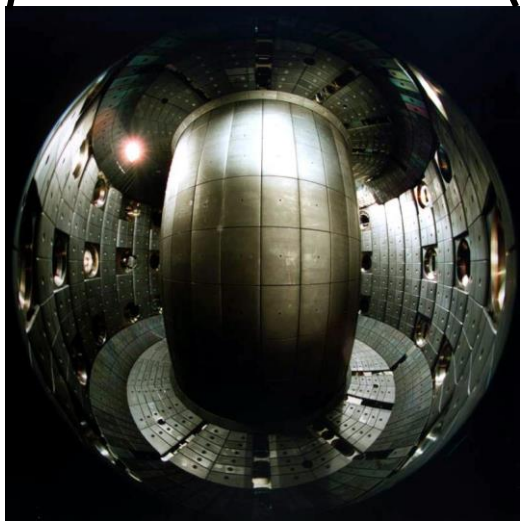
diffusion bonding of CuNb multi-layered compound material



multi-layer structure of CuNb compound material

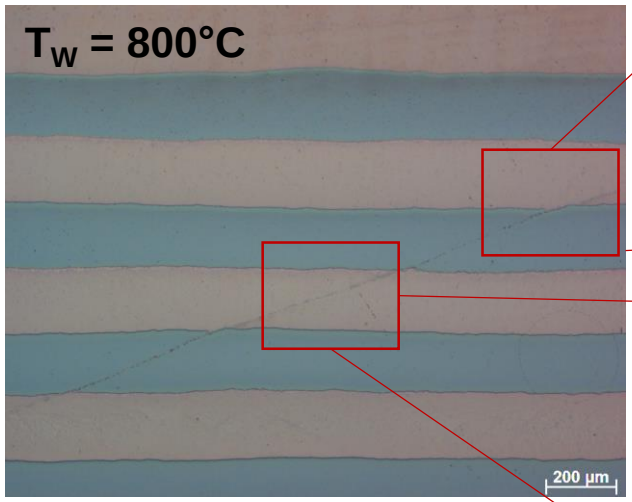


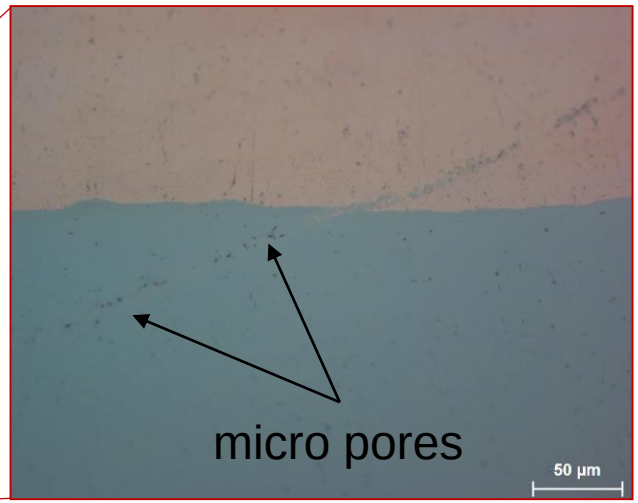
scheme of the fusion reactor ITER
source: BMPA

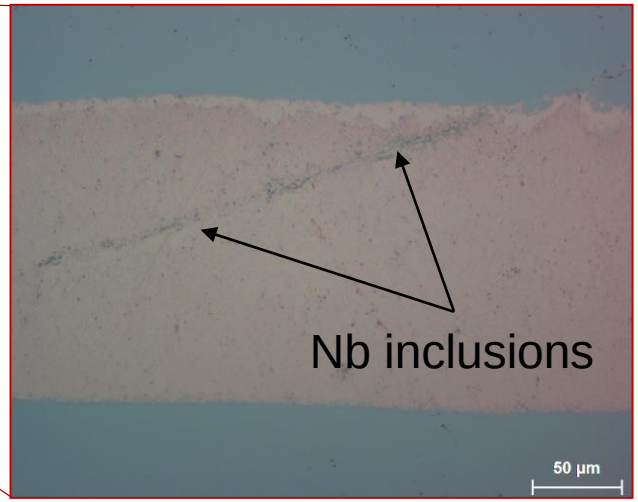


interior view of a tokamak fusion reactor
→ application range for CuNb-plates
source: EPFL

diffusion bonding of CuNb multi-layered compound material



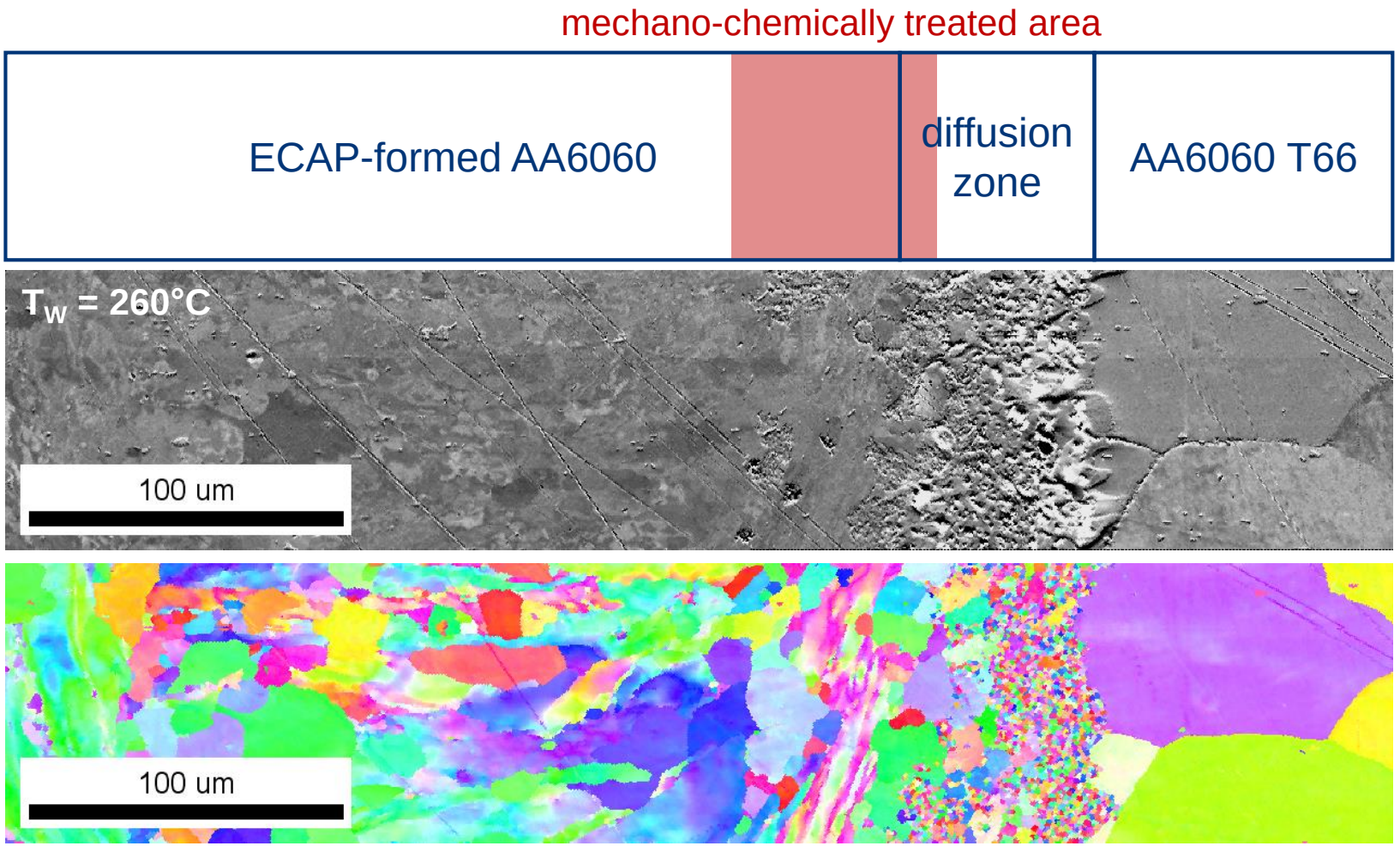




improved diffusivity by chemical surface treatment

What is the highest potential of the in-line surface treatment and diffusion bonding technology?

diffusion bonding of UFG materials, e.g. ECAP-formed AA6060



almost no recrystallization of the ECAP-formed microstructure

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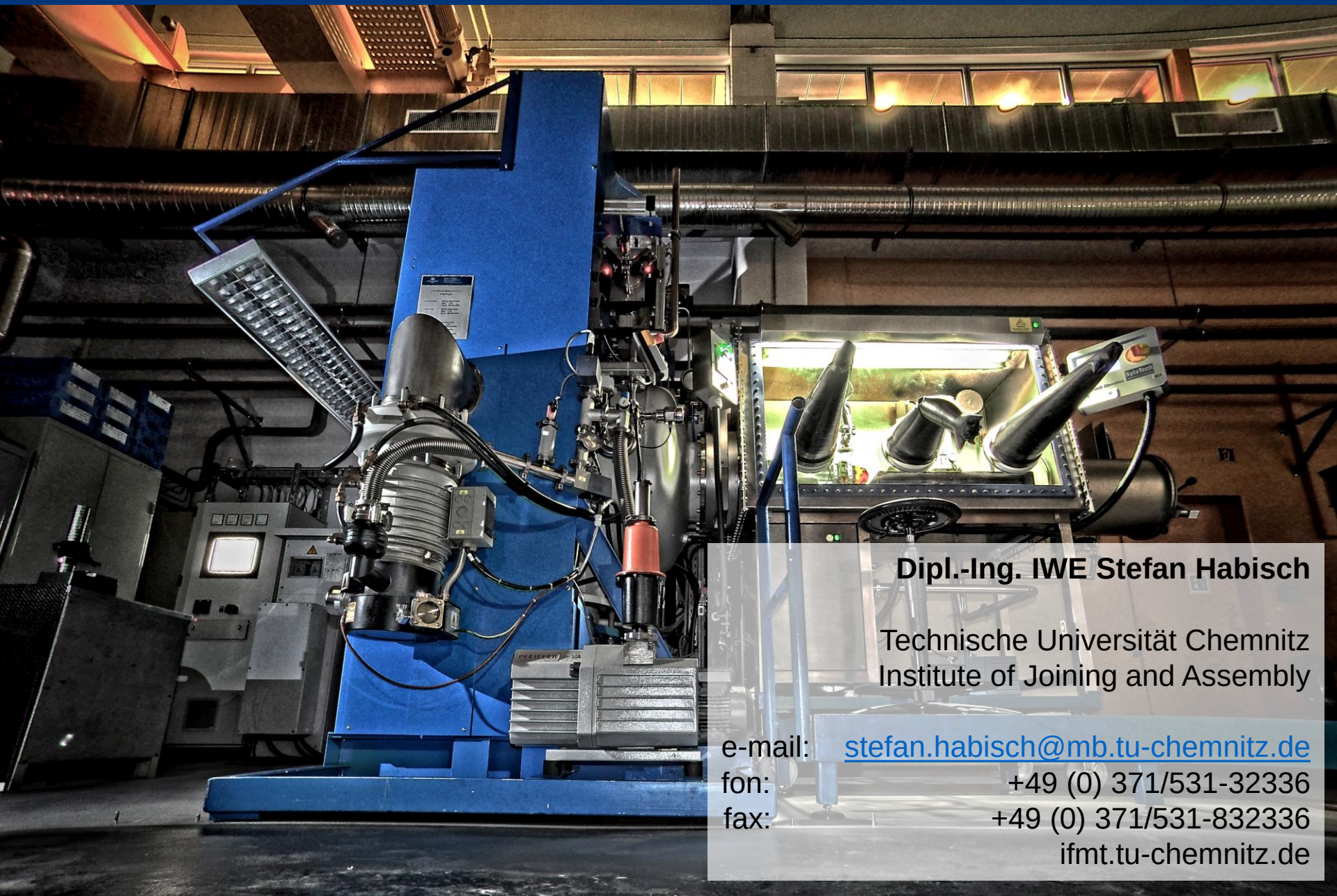
Thank you very much for your attention!



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