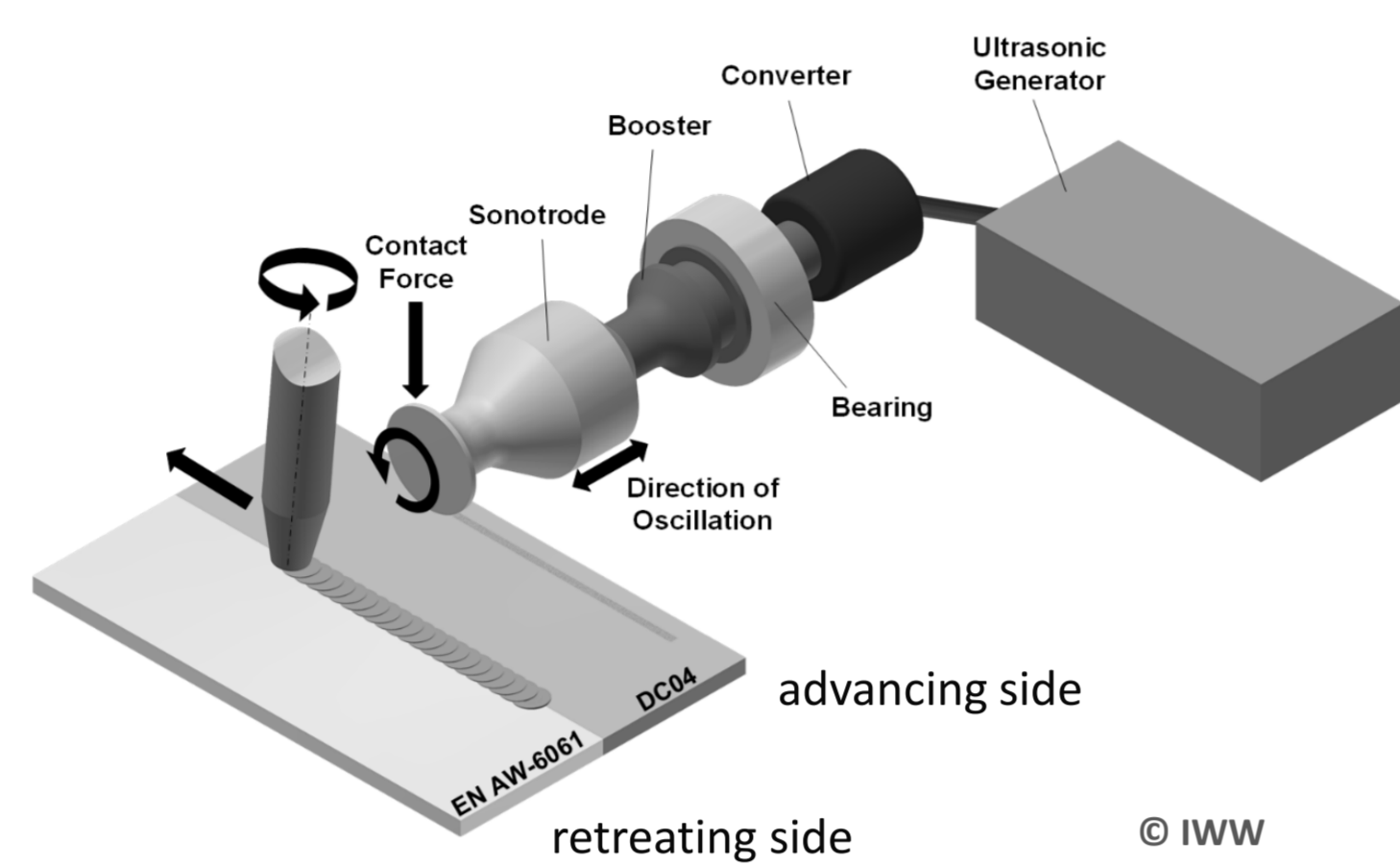


Realization of Al/steel-hybrid-joints by ultrasound supported friction stir welding - Corrosion properties of the joints

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Introduction

- FSW enables joining by plastic deformation
- additional ultrasound to reduce brittle phases and improve the stirring in the joining area – USE-FSW



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Experimental

- Microstructure of the joints
- Local corrosion properties (Scanning Kelvin Probe)
- Electrochemical Set-up:
 - three electrode set-up with mini cell (Ø 3 mm)
 - reference electrode: SCE (+245 mV vs. NHE)
 - electrolyte: 0.5 M NaCl solution



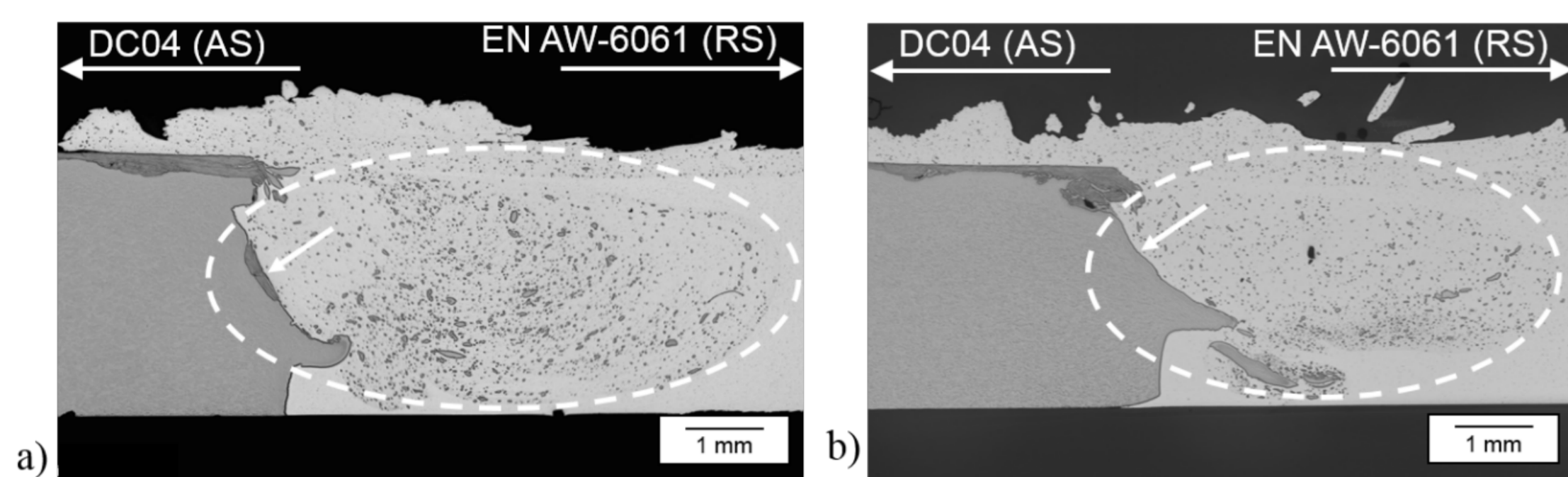
Electrochemical mini cell set-up

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Results

Microstructure of the joints

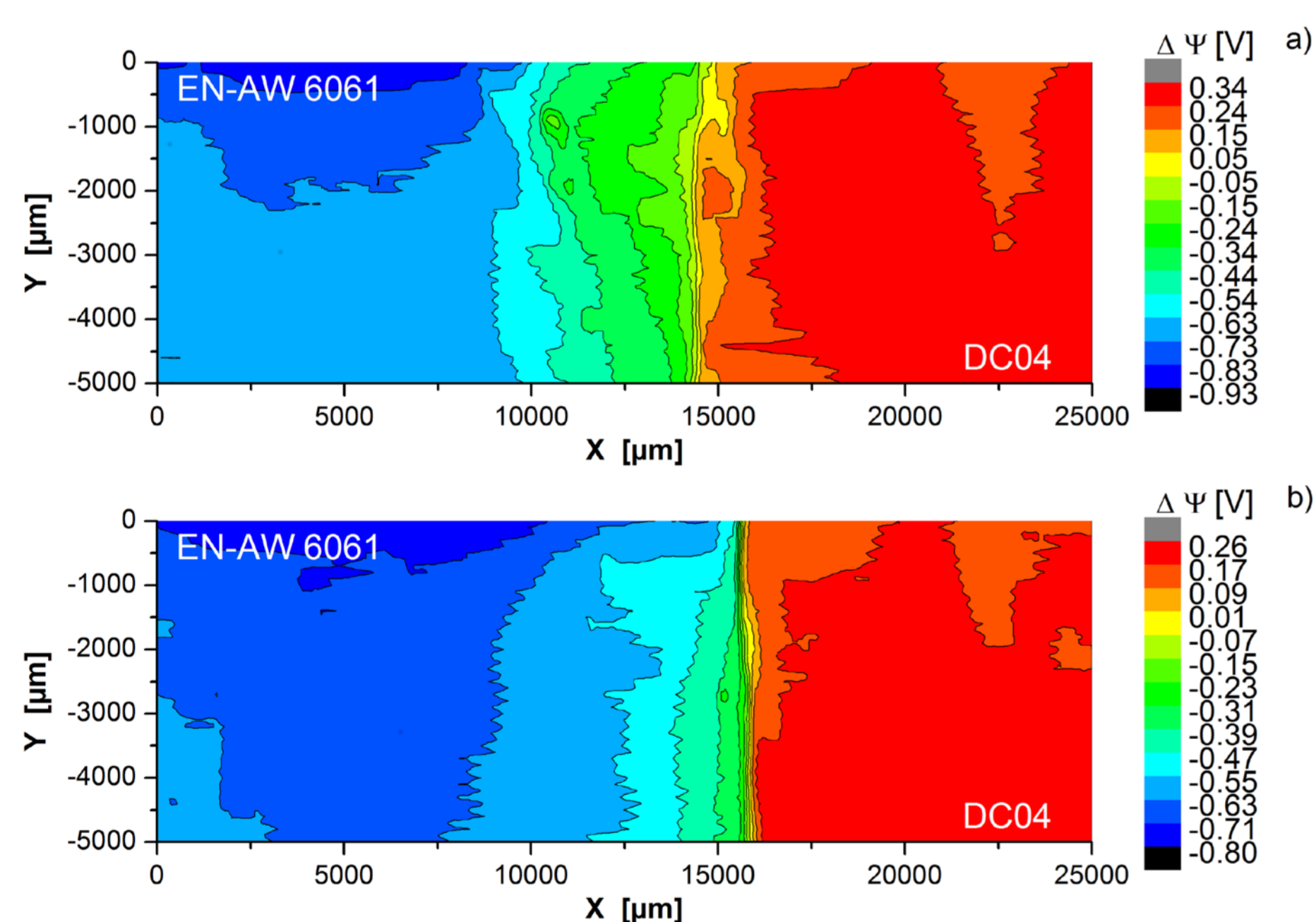
- less and smaller particles in the welding zone of the USE-FSW-joint
- more uniform interface in case of the USE-FSW-joint



Cross section images of a) aluminum/steel-FSW joints and b) aluminum/steel-USE-FSW joints (© IWW).

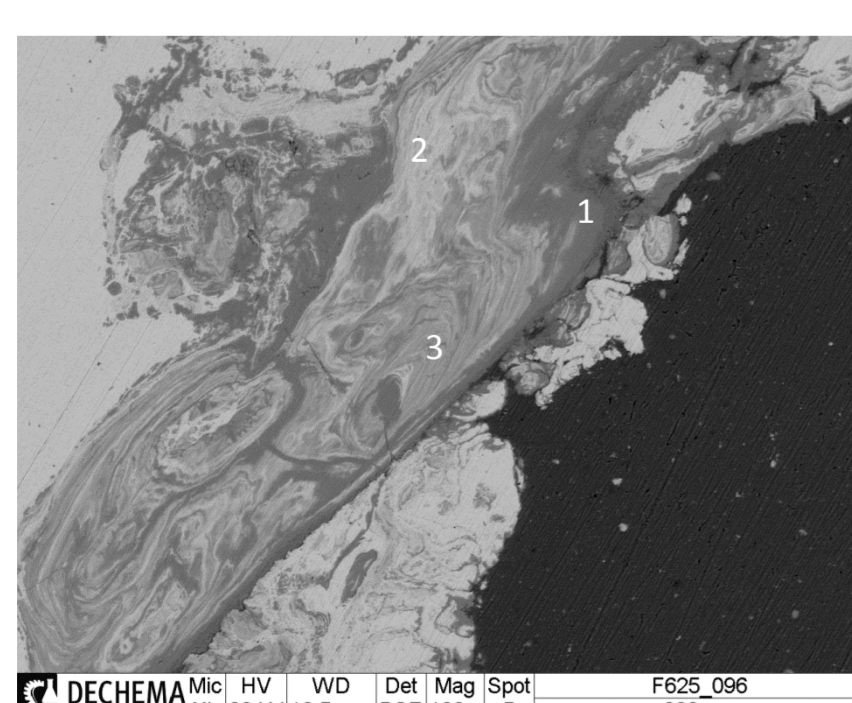
Volta Potential Maps (Scanning Kelvin Probe)

- Volta potential difference between steel and Al-alloy about 1 V
- FSW-joint shows 1-2 mm broad seam at the Al/steel interface



Volta potential maps of a FSW-joint (a) and a USE-FSW-joint (b)

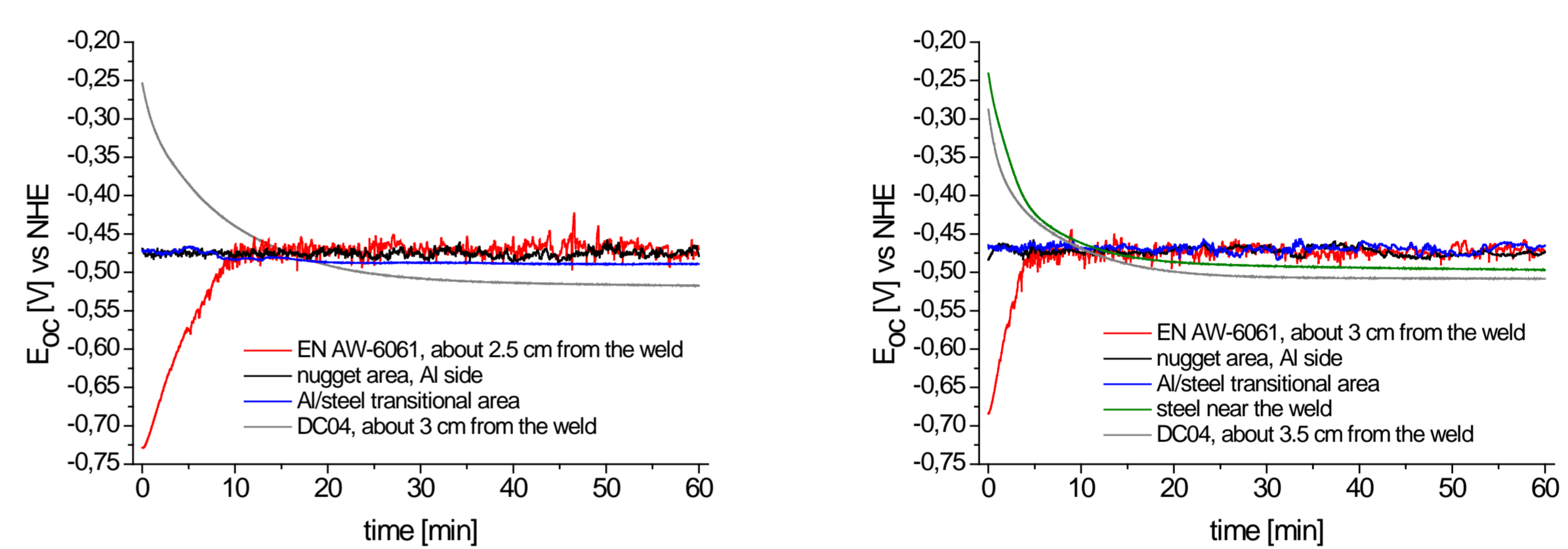
SEM/EDX investigations of the intermetallic phases (IM)



	Al	Fe	phase
1	77.0	21.4	Al ₃ Fe (Al ₁₃ Fe ₄)
2	25.5	74.5	AlFe ₃
3	60.1	39.9	Al ₃ Fe ₂

Open Circuit Potential

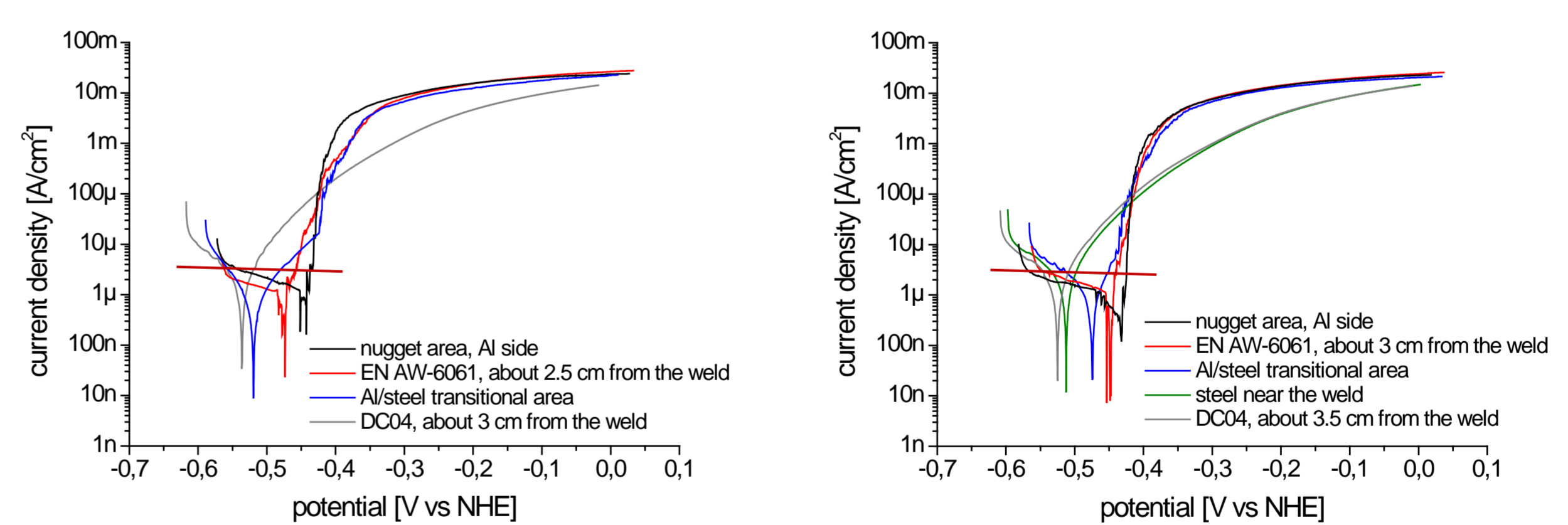
- only small differences in the OCP after 60 min measurement
- after 15 min values of the steel are lower than that of the Al-alloy



Open circuit potential of the Al/steel-joints without (left) and with (right) ultrasound enhancement

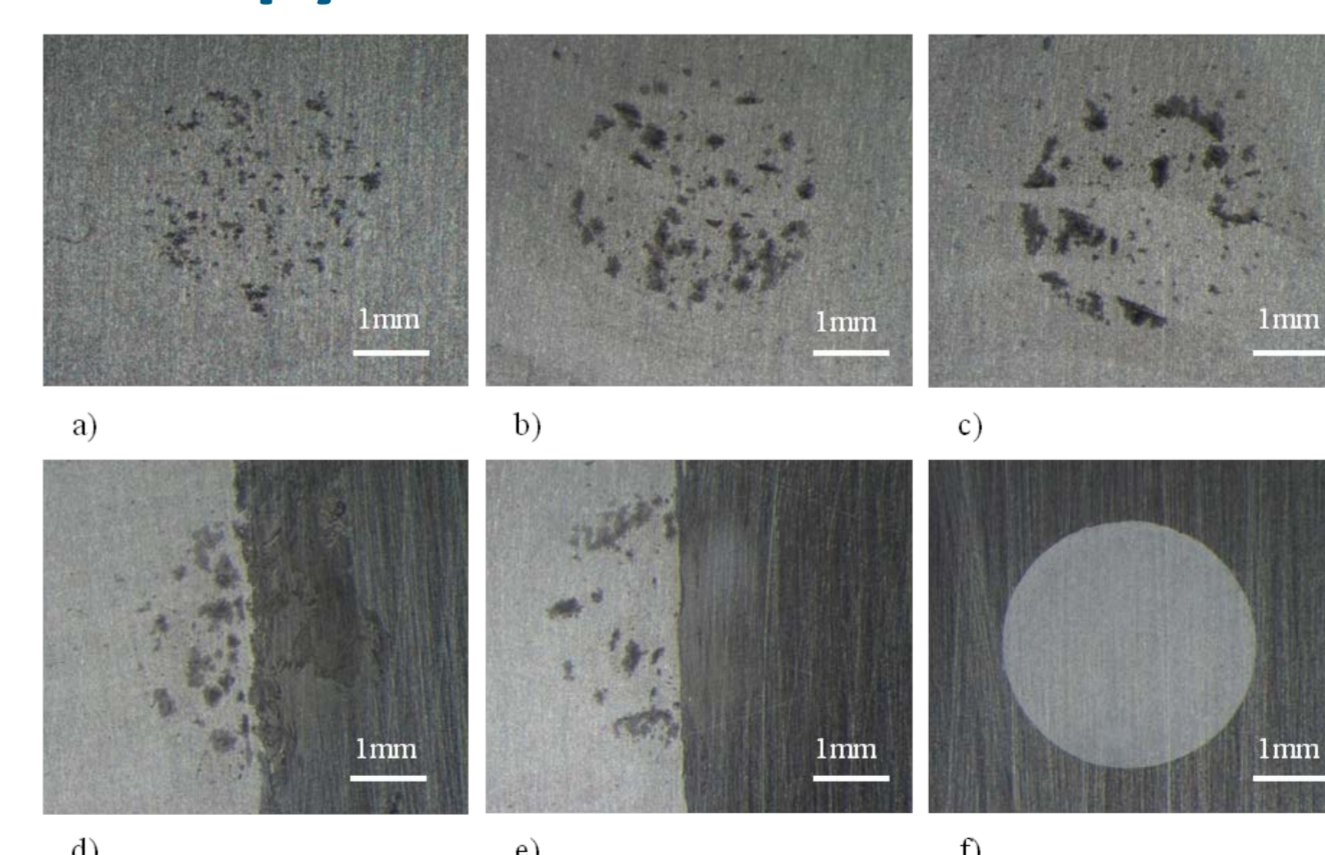
Potentiodynamic Polarization

- steel shows continuous increase of current density in the anodic region
- current densities at E_{OC} are all in the range of 1 – 3 µA/cm²



Potentiodynamic polarization curves of the Al/steel-joints without (left) and with (right) ultrasound enhancement

Light Microscopy



- a) Al alloy
- b) nugget (FSW)
- c) nugget (USE-FSW)
- d) Al/steel transitional area (FSW)
- e) Al/steel transitional area (USE-FSW)
- f) DC04 steel

Outlook

- realization of hybrid-joints of different alloy combinations (Al-steel (high strength steel))
- detailed characterization of the intermetallic phases
- investigation of the influence of corrosion on mechanical properties

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Literature

- DOI: 10.1007/978-3-319-52383-5_19
- DOI: 10.1088/1757-899X/181/1/012004

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