Corrosion studies on electro polished stainless steels for the use as metallic bipolar plates in PEMFC applications

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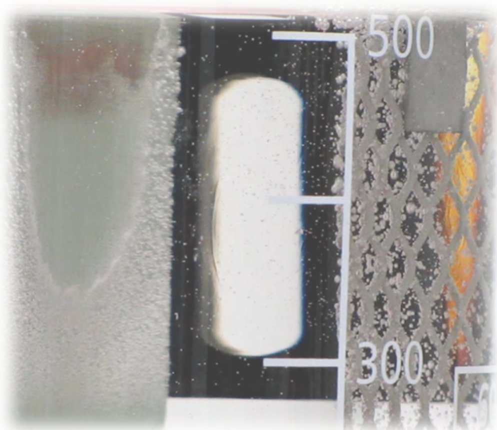

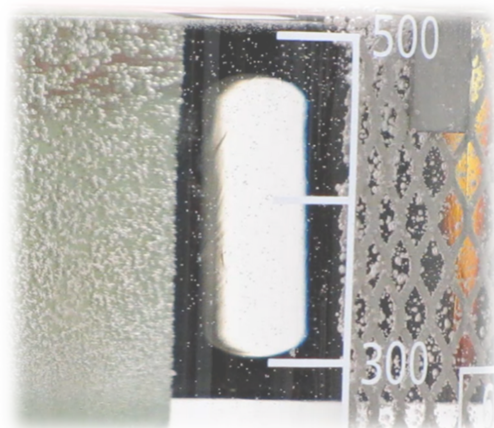

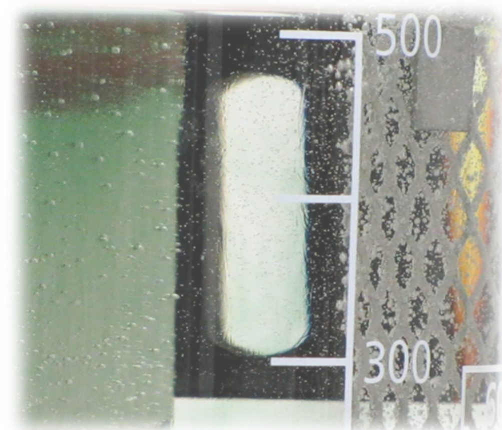

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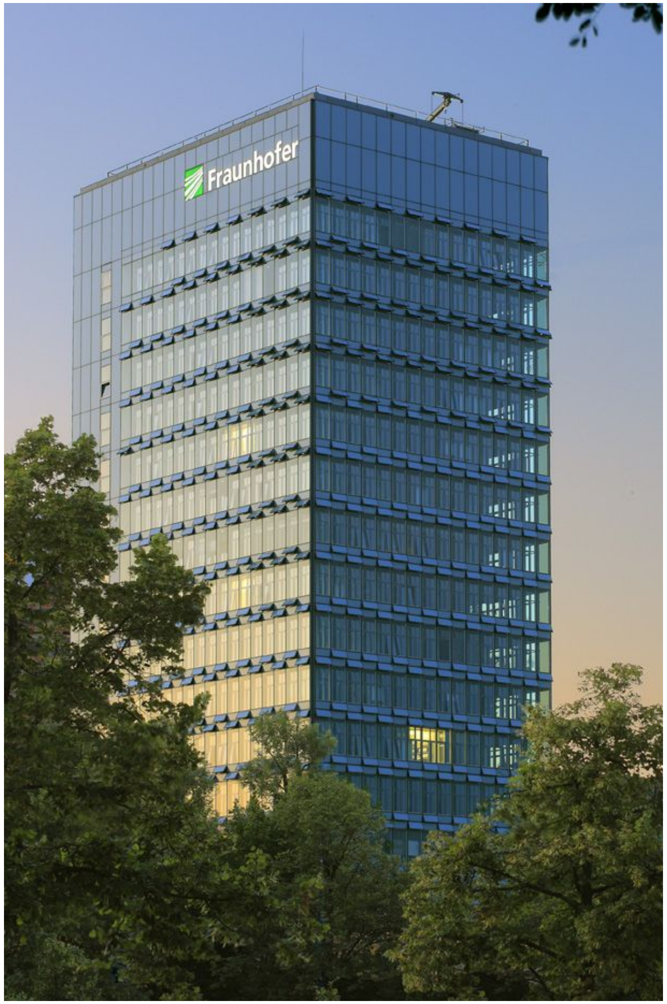

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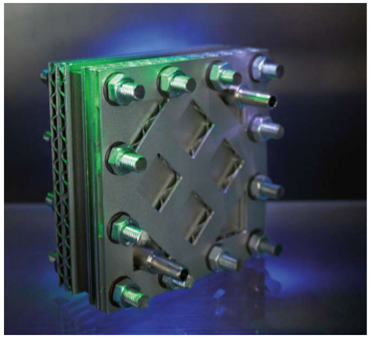

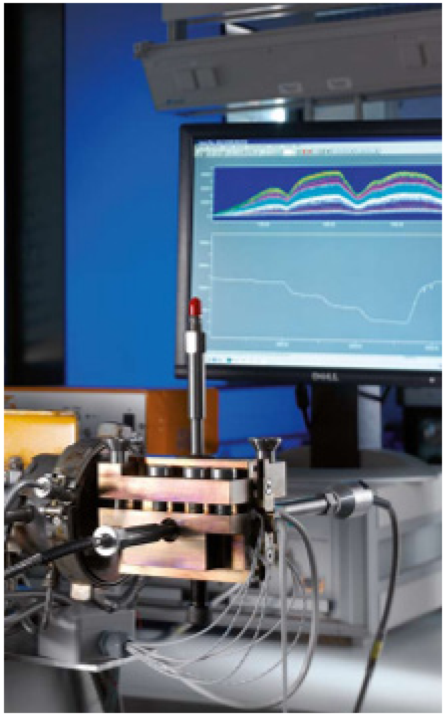

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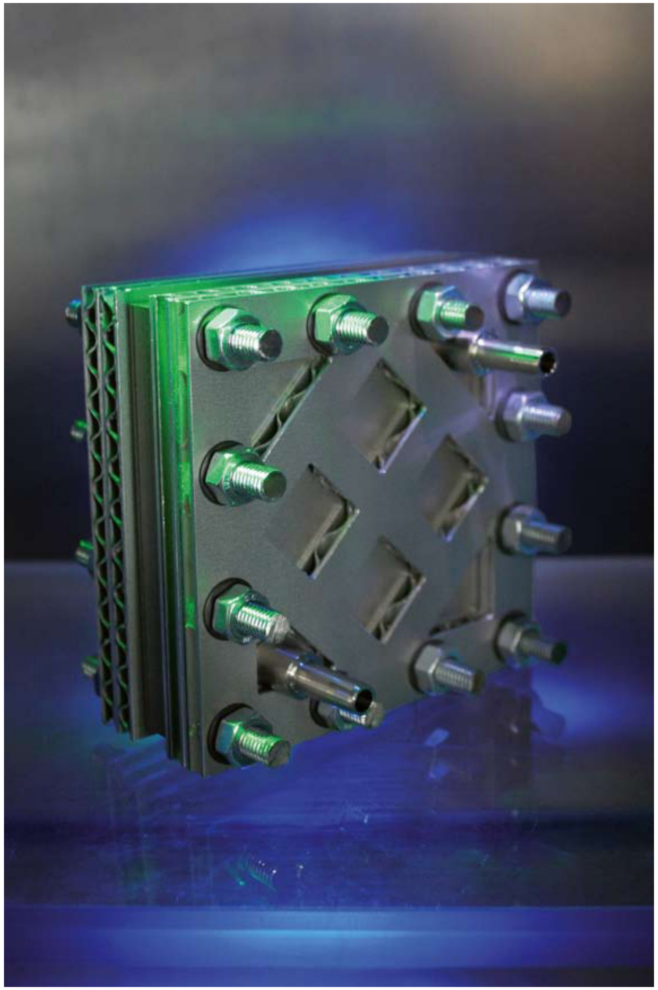


- **Batteries**
  Material and system development, battery testing and service, new battery materials, e.g. for lithium-oxygen and lithium-sulfur
- **Redox-Flow-Batteries**
  Material and System development, electrolytes, electrodes, membranes, bipolar plates
- **Fuel cells**
  Direct ethanol fuel cells (DEFC), alkaline DAFCs, PEMFC, component development, reformers, hybrid systems, catalyst screening
- **Sensor technology and analysis systems**
  Electrochemical sensors, trace detection, pattern recognition, online analysis of volatile substances, corrosion detection

Motivation

Stainless steels posses great potential for the use as metallic bipolar plates in LT-PEMFC application.

The disadvantages of these materials are the contact resistance and the corrosion stability.

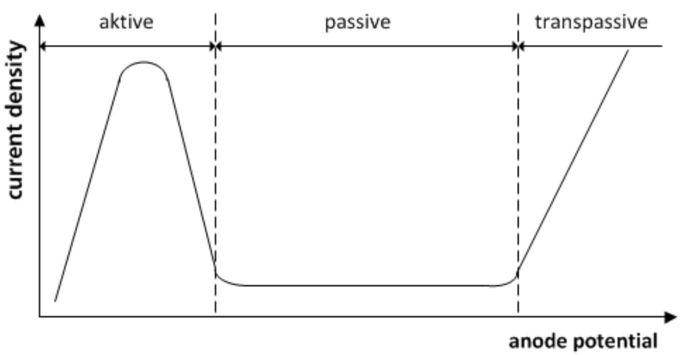
The corrosion resistance can be increased by e.g. applying an electrochemical treatment such as an electro polishing procedure.

The motivation of this research was to find an electro polishing solution which results in an increase in corrosion resistance of the metallic bulk materials.

Introduction to the electro polishing method

- Since the beginning of the 19th century the electrochemical dissolution of metals has been studied by many researchers.
- Electro polishing is used for decorative purposes or to obtain surfaces with
  - High purity (e.g. medical equipment)
  - Increased chemical stability

- During the polishing the process the metal dissolves and goes into the electrolyte.
- Additionally oxygen is generated on the substrate surface.
- All polishing tests were carried out in the transpassive region.



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Electro polishing solution and samples

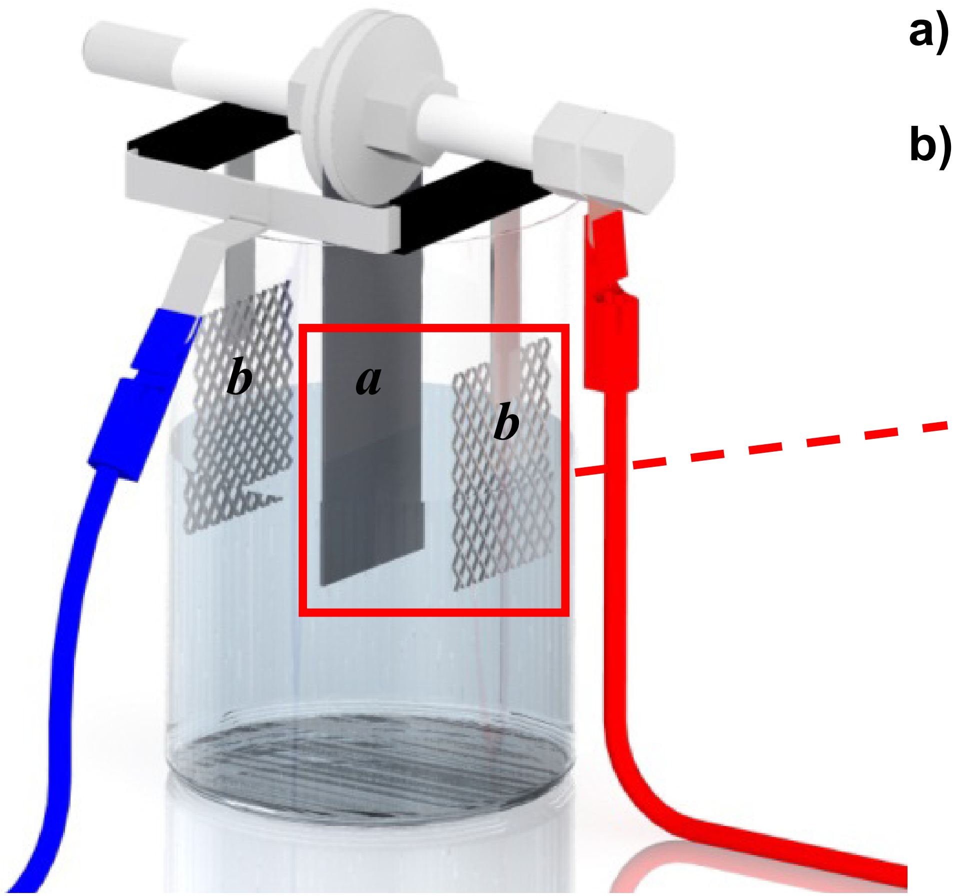
Table 1: Investigated materials

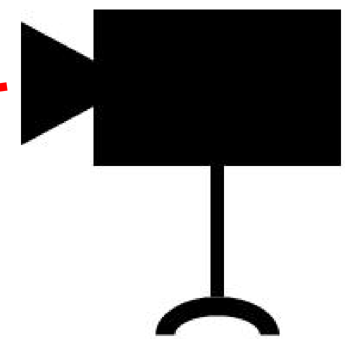
AISI	Material composition	Material number
316L	X2CrNiMo17-12-2	1.4404
316Ti	X6CrNiMoTi17-12-2	1.4571
Al276	NiMo16Cr15W	2.4819
Al265	NiCr22Mo9Nb	2.4856
Al6XN	X1NiCrMoCuN25-20-6	1.4529

Table 2: Used electrolyte compositions

Labeling	Methane-sulfonic acid	1,2 Propanediol
70/30	70 vol%	30 vol%
50/50	50 vol%	50 vol%
30/70	30 vol%	70 vol%

Electro polishing setup and procedure





a) metallic substrate (*anode*)

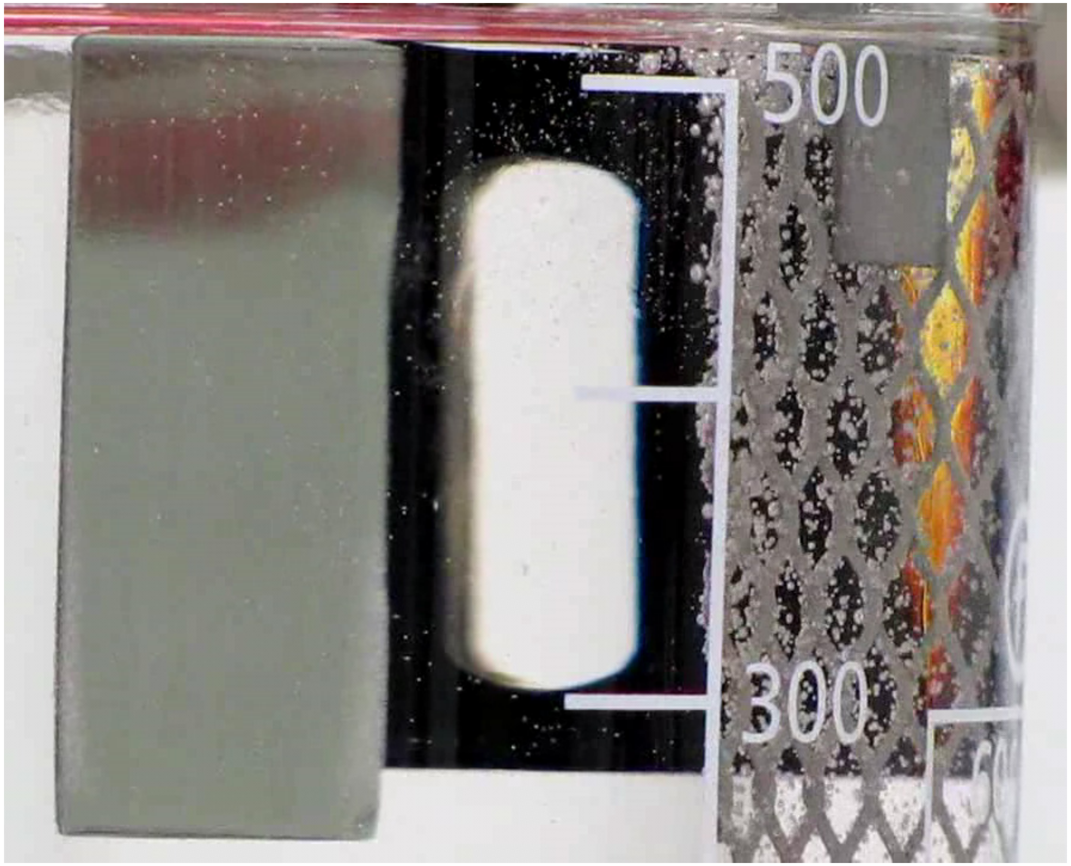
b) platinized titan electrode meshes (*cathode*)

50 mA/cm² for 15 min
100 mA/cm² for 10 min

Electro polishing

316L at 50mA/cm²

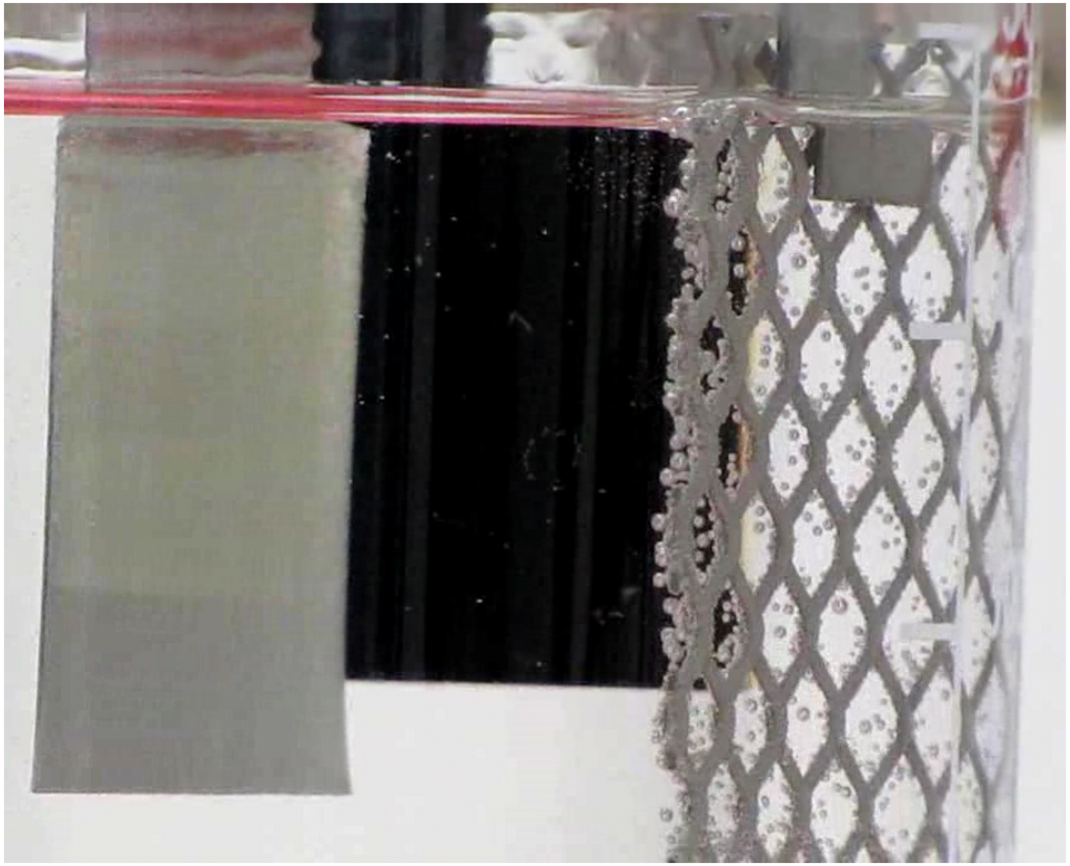
50% Methane sulfonic acid / 50% 1,2-propanediol



Electro polishing

316L at 100mA/cm²

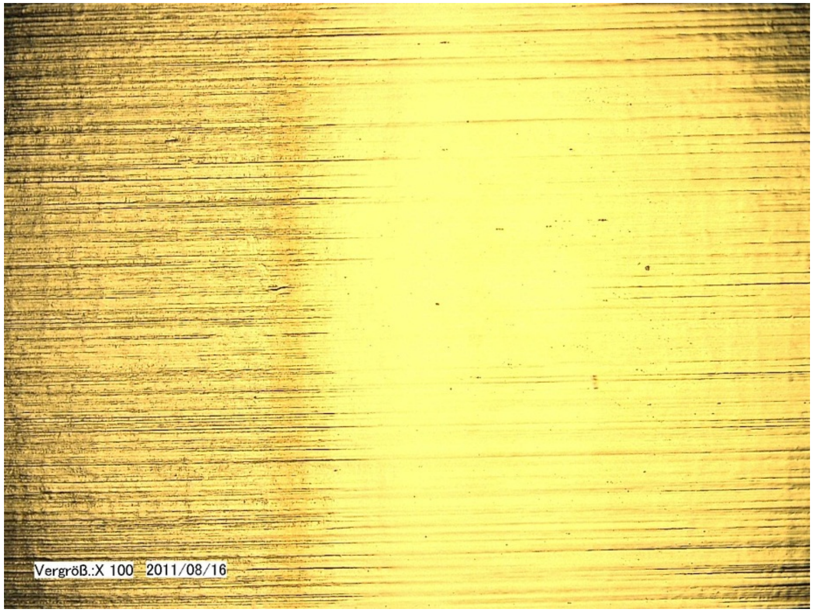
50% Methane sulfonic acid / 50% 1,2-propanediol



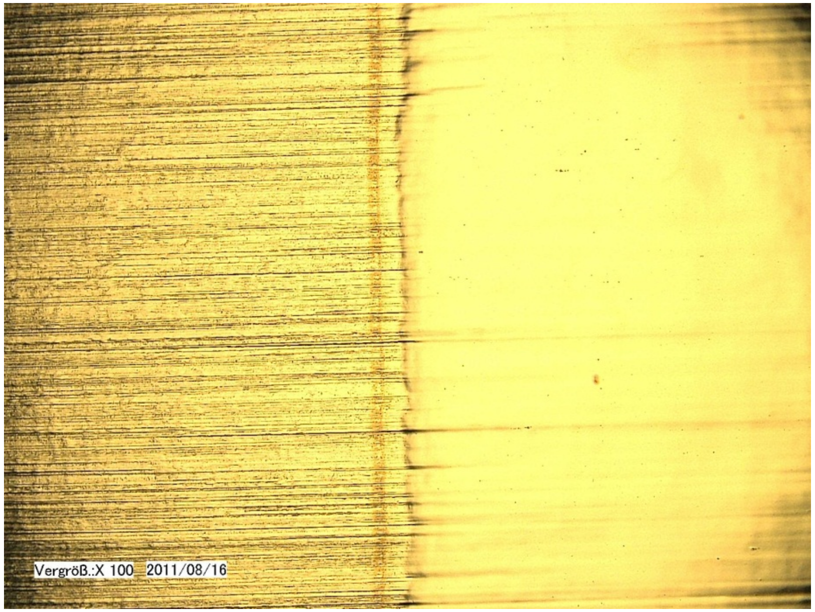
Microscopic Images

50% Methane sulfonic acid / 50% 1,2-propanediol

316L polished at 50mA/cm²



316L polished at 100mA/cm²



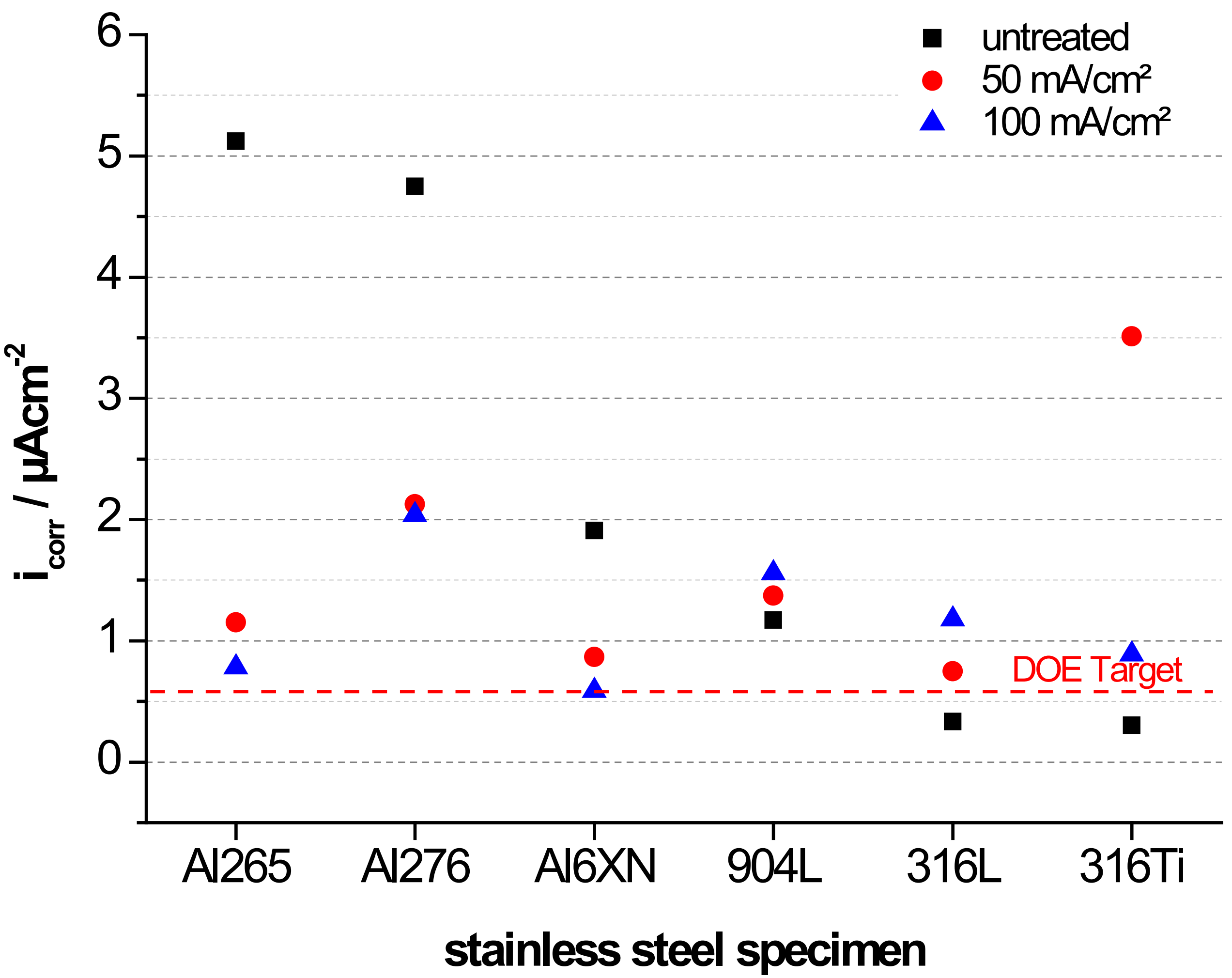
Electrochemical Measurements

- Electrolyte consisting of deionized water containing 1.8 ppm of fluoride- (F^-) and 1.3 ppm of sulfate- (SO_4^{2-}) ions. [S. Jin et al., Journal of Power Sources 162 (2006) 294-301]
- The corrosion tests were done at room temperature.
- The corrosion currents were calculated through the measuring program using the *Buttler*-*Volmer*-Equation.

Corrosion test results

- The untreated samples exhibited an increasing corrosion resistance by the order of Al265 < Al276 < Al6XN < 904L < 316L < 316Ti.
- A selection of tested samples are shown on the following slides to demonstrate some tendencies.

Corrosion results (30-70 electrolyte composition)



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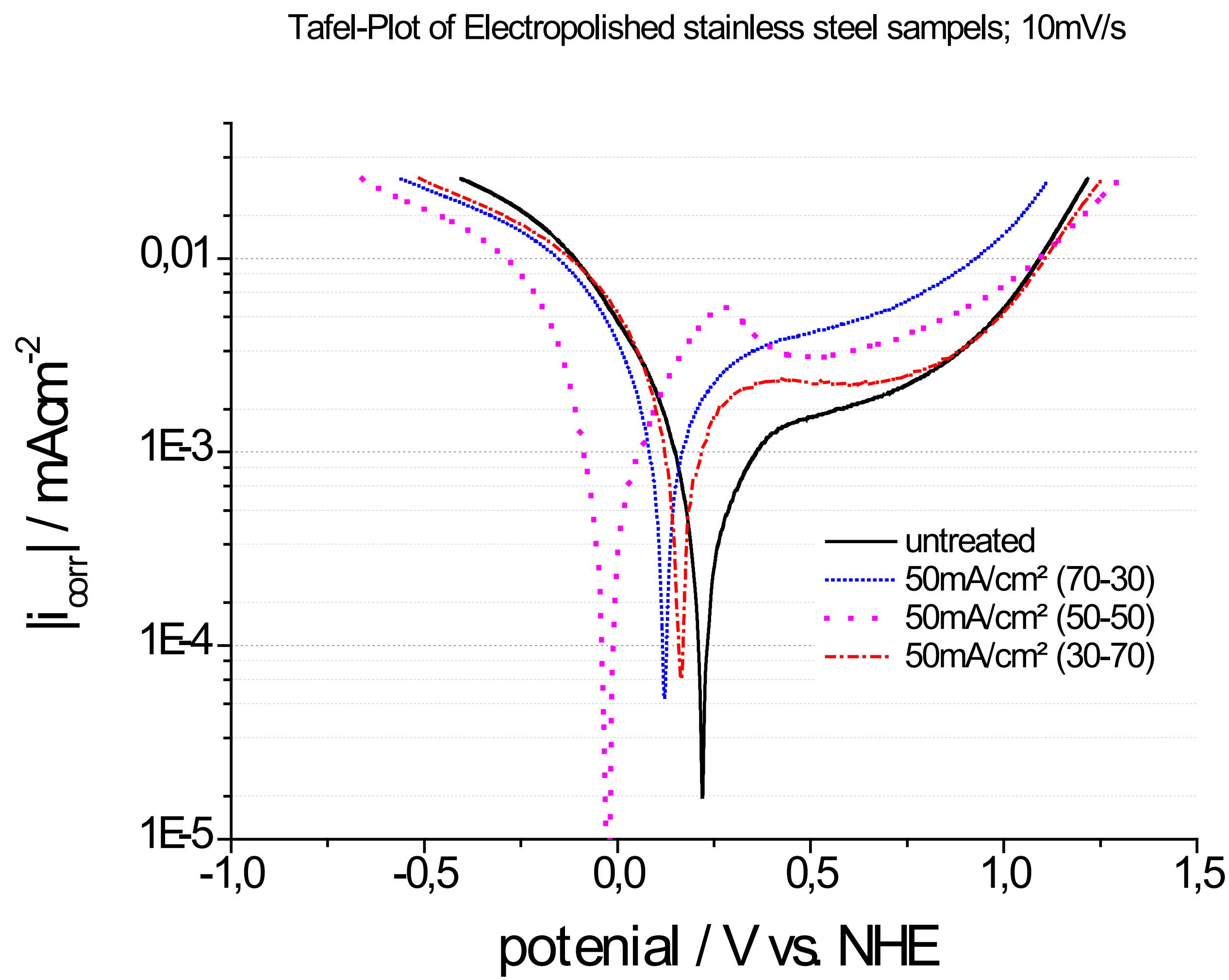
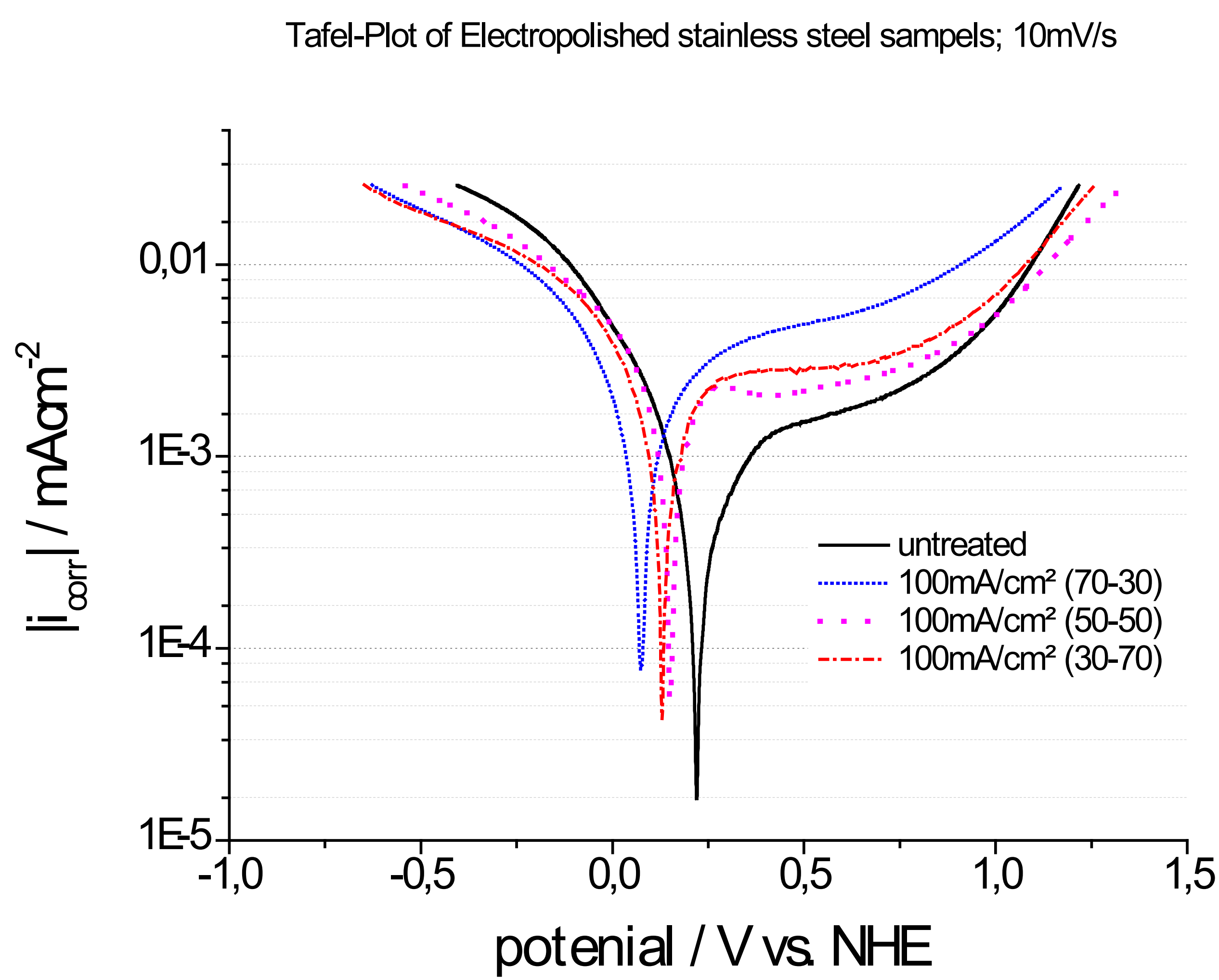
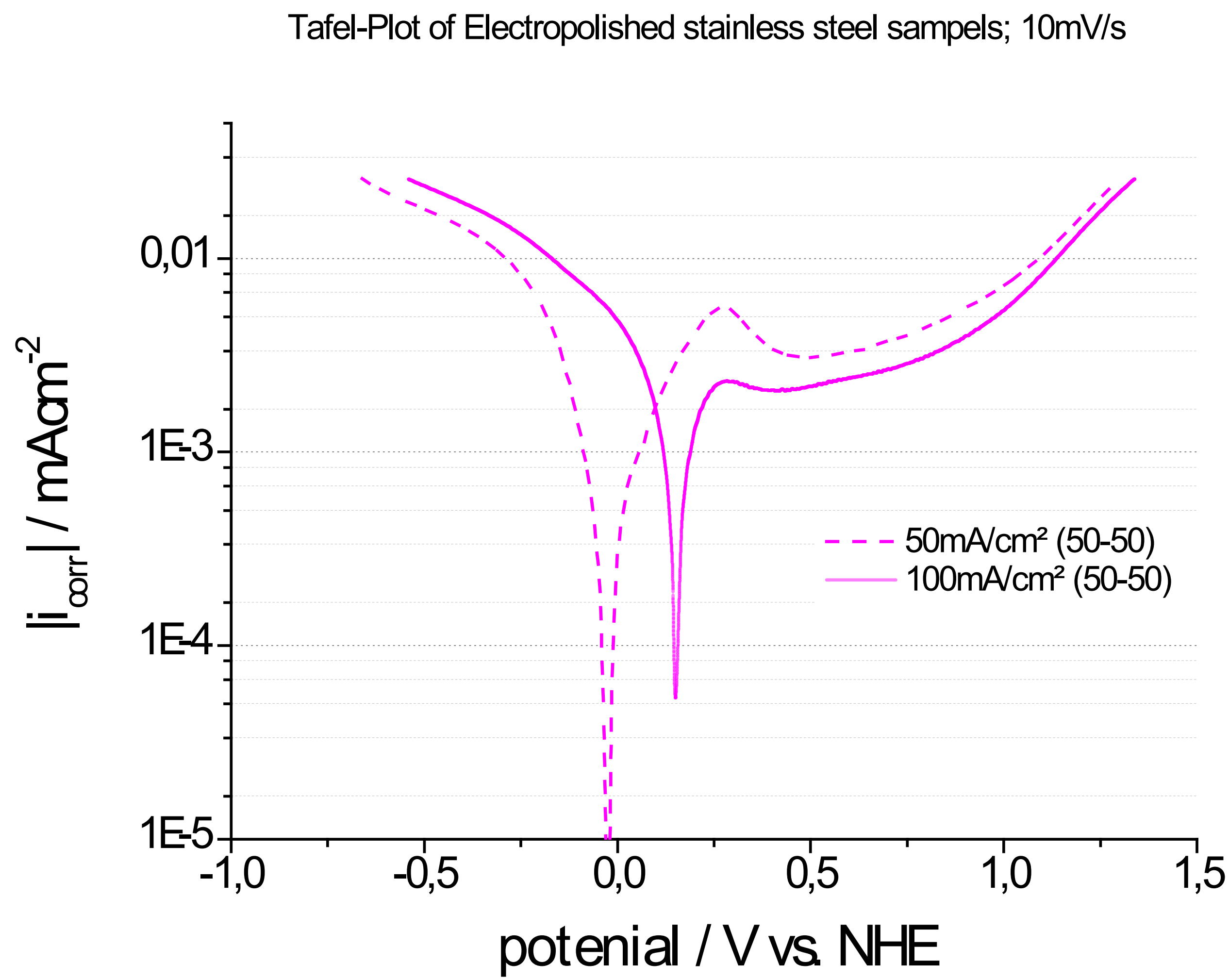
Corrosion test results (316L)



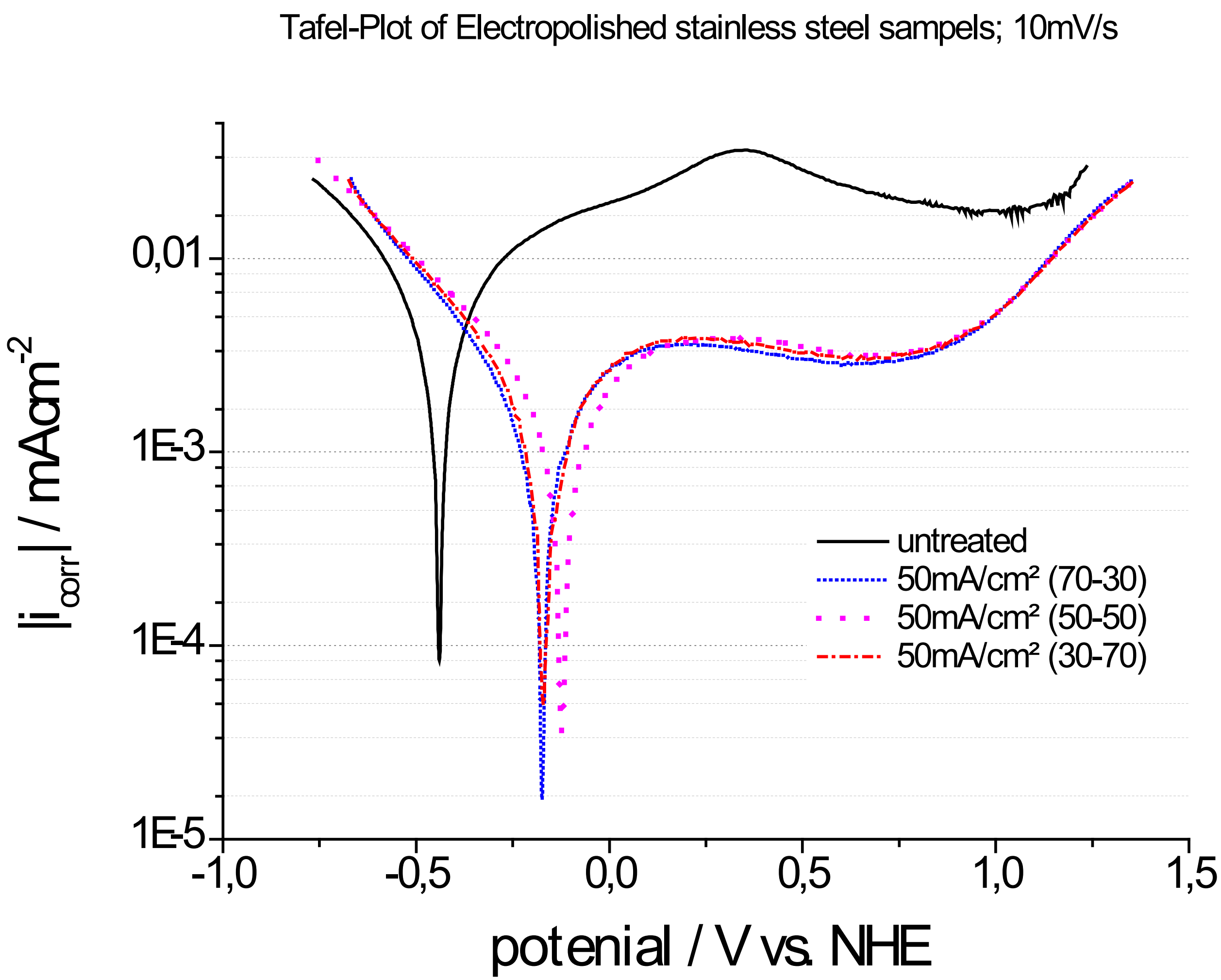
Corrosion test results (316L)



Corrosion test results (316L)



Corrosion test results (Al265)



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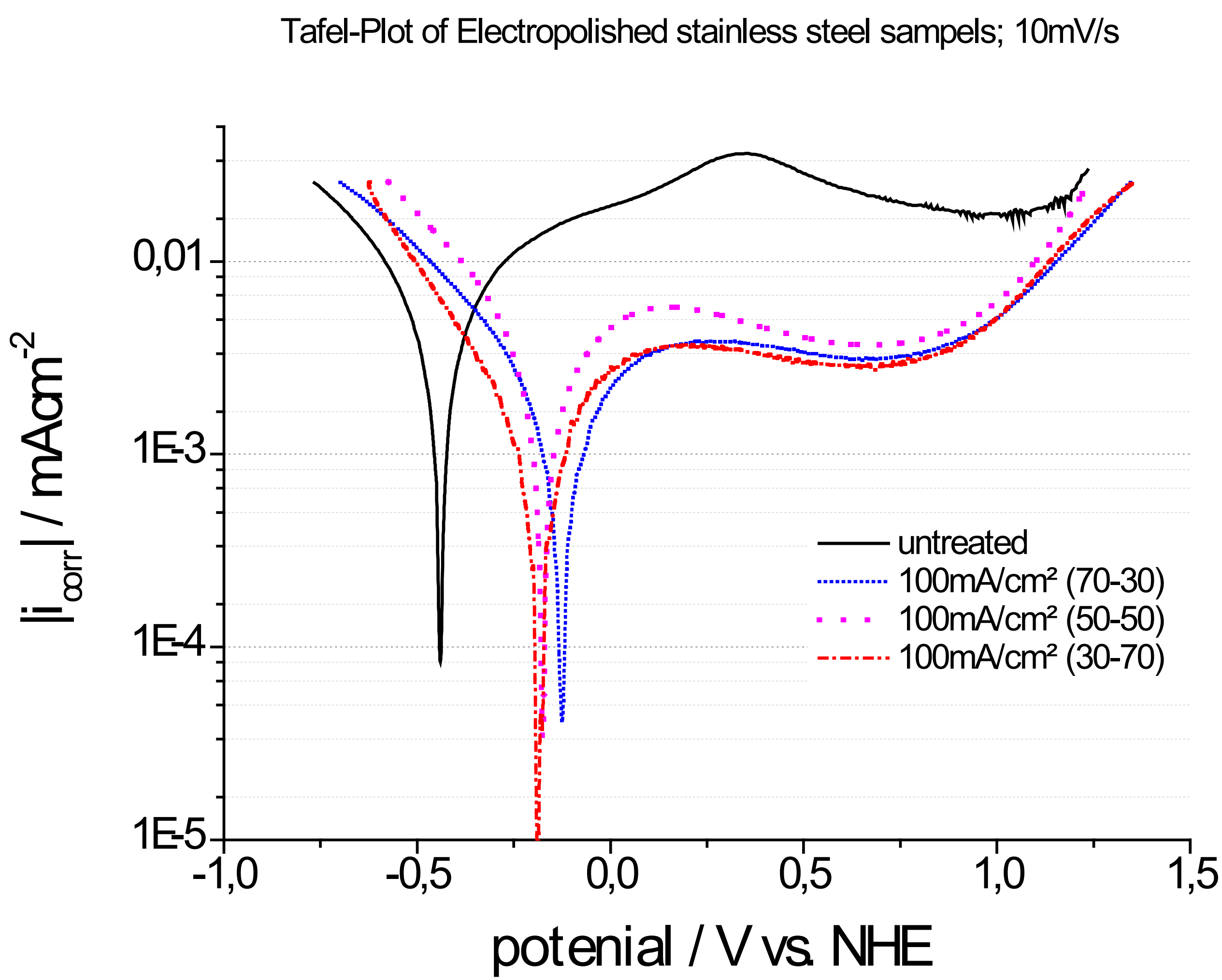
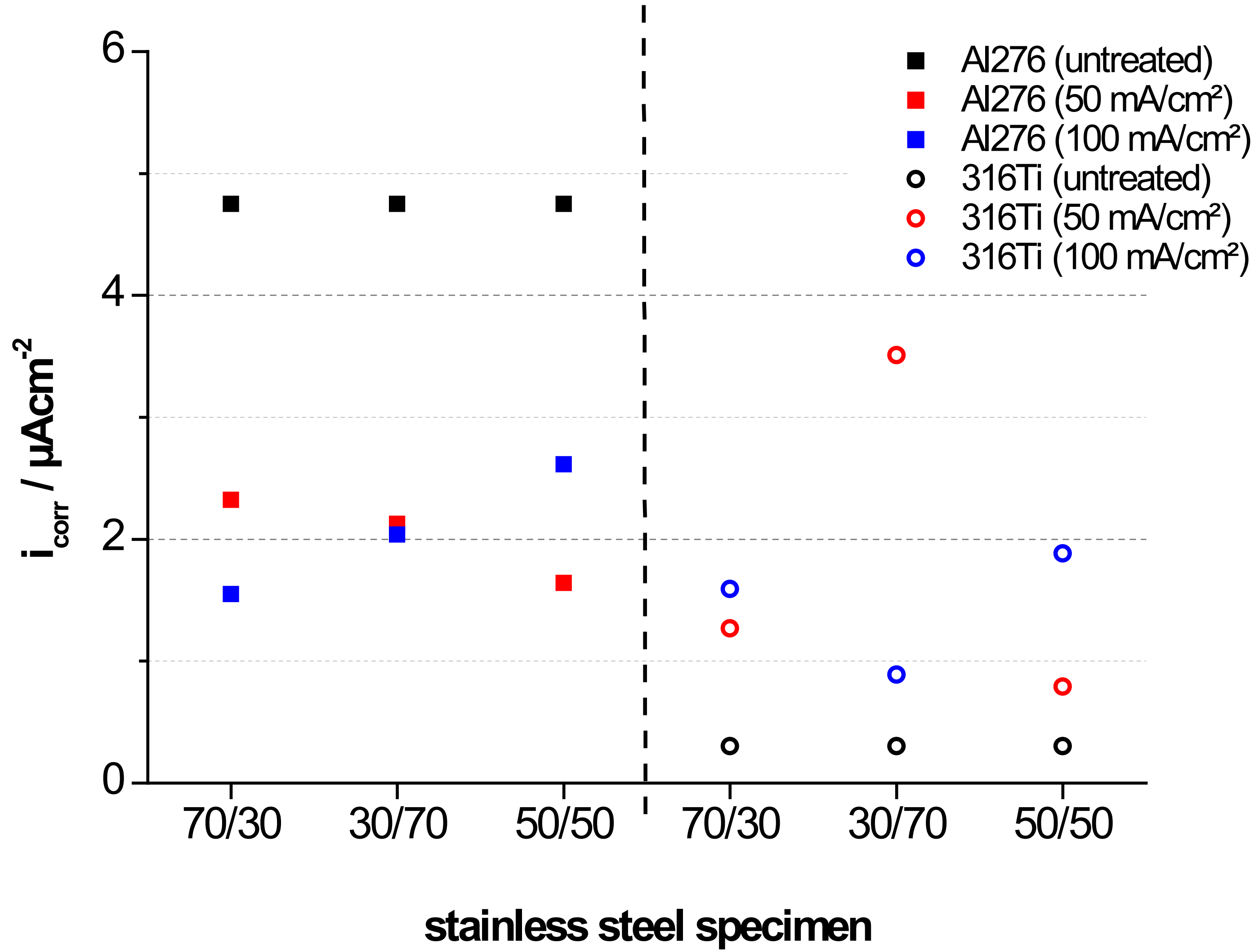
Corrosion test results (Al265)



Corrosion test results (Al276 & 316Ti)



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Summary and conclusion

- Electrochemical corrosion properties of AI276, AI265 and AI6XN regarding LT-PEMFC applications can be improved by an electro polishing process.
- 316L, 316Ti and 904L showed an increase of corrosion currents.
- All polished samples exhibited an increase in resistivity.
  - Lowest AI265 with ~10-50% increase

- More tests are necessary to find the optimized electro polishing solution for each stainless steel material.
- The electro polishing procedure has to be individually selected for stainless steel materials to provide better corrosion resistance.

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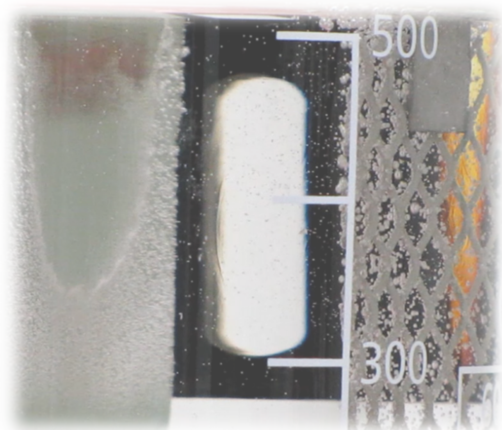

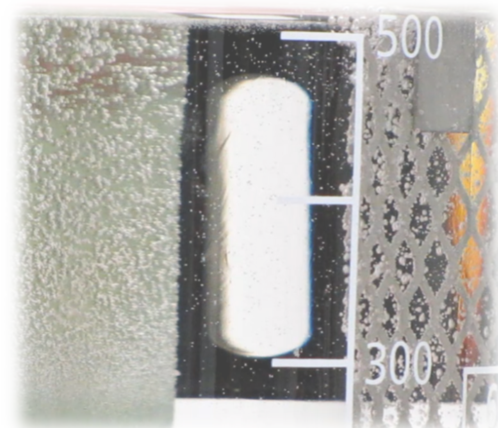

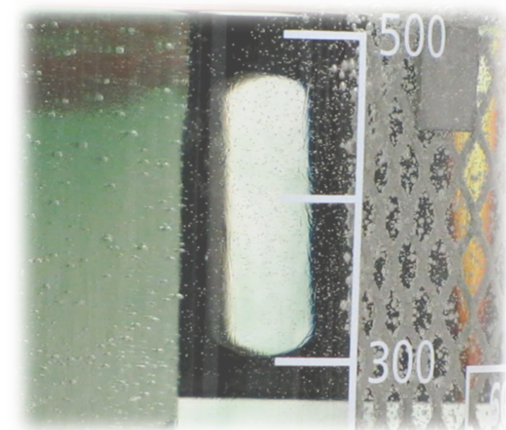

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