

Platinum Pulse plating on aligned MWCNTs for PEMFC

M. Weiser^{1*}, S. Dörfler², M. Schneider³, H. Althues², A. Michaelis^{1,3}, S. Kaskel^{2,4}

1 TU Dresden, IfWW, Helmholtzstr. 7, 01069 Dresden, Germany

2 Fraunhofer IWS, Winterbergstr. 28, 01277 Dresden, Germany

3 Fraunhofer IKTS, Winterbergstr. 28, 01277 Dresden, Germany

4 TU Dresden, Institut für Anorganische Chemie, 01069 Dresden, Germany

*mathias.weiser@ikts.fraunhofer.de



1. Introduction

2. Results

- plating electrolyte
- MWCNT functionalisation

3. Summary

Introduction

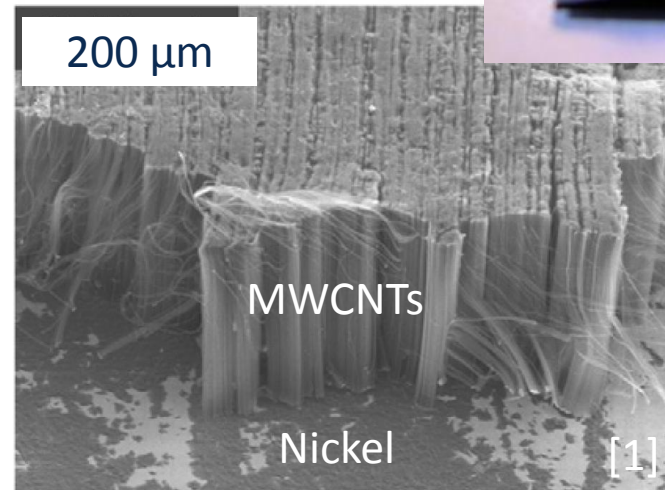
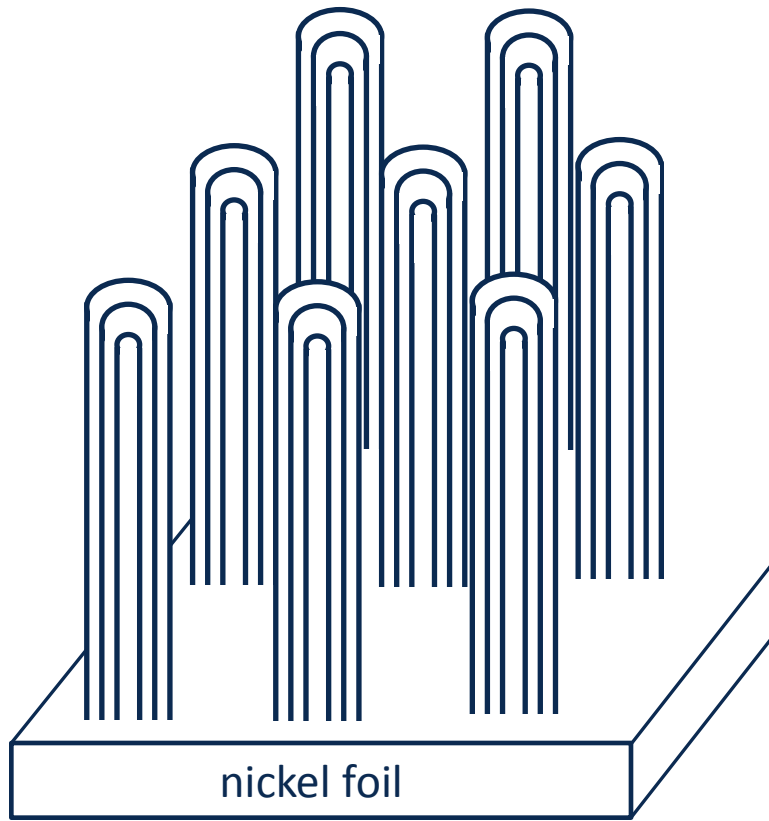
- aligned multi-walled carbon nanotubes (MWCNTs) = substrate for electrodeposition

A_{specific} 250 m²/g

\varnothing 10...20 nm

length ca. 100 μm

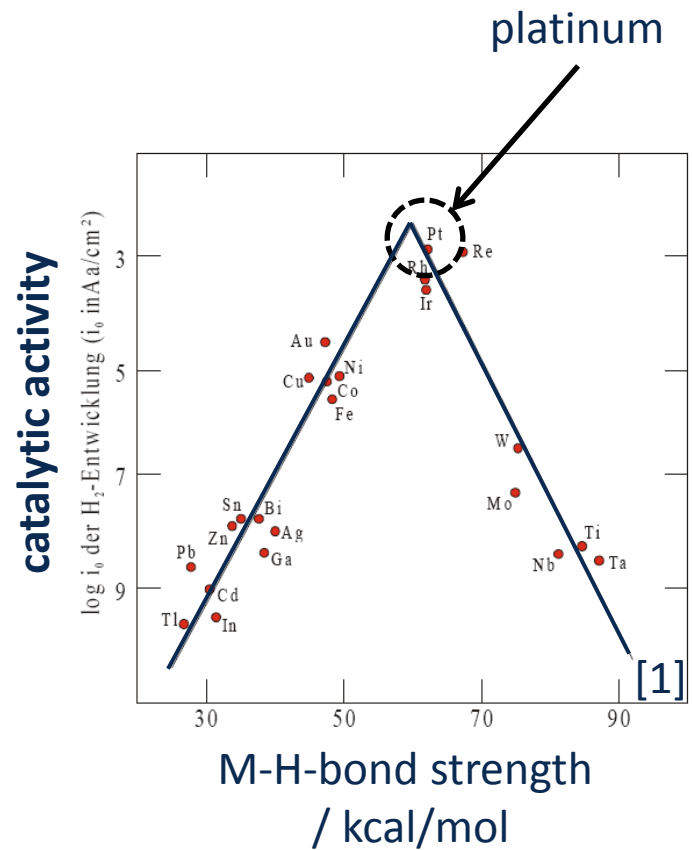
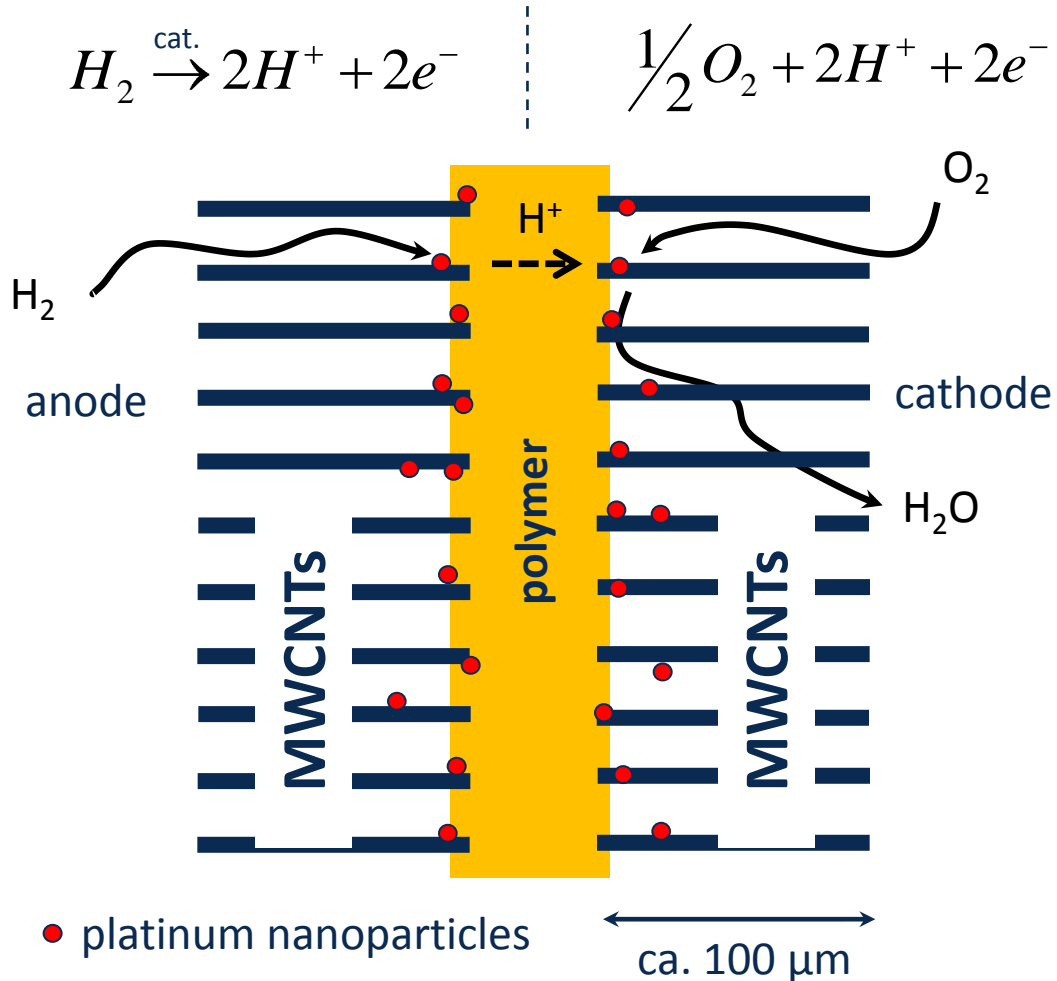
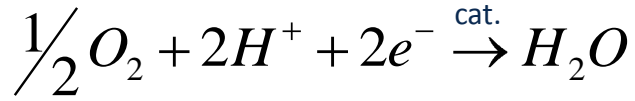
density 1,35 g/cm³



Introduction

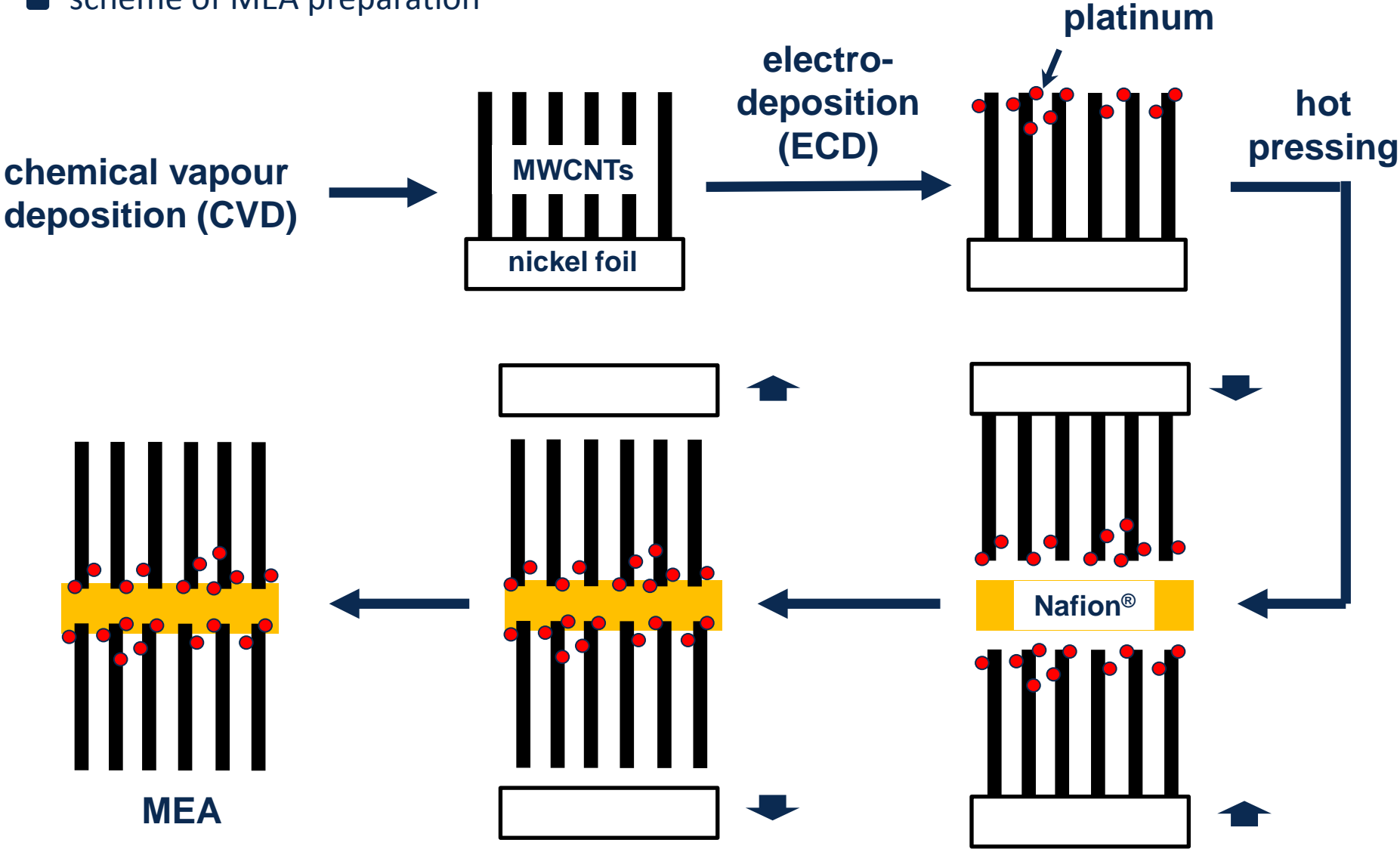
- motivation = integration of aligned MWCNTs in the polymer electrolyte membrane

fuel cell (PEMFC)



Introduction

■ scheme of MEA preparation



Results → plating electrolyte

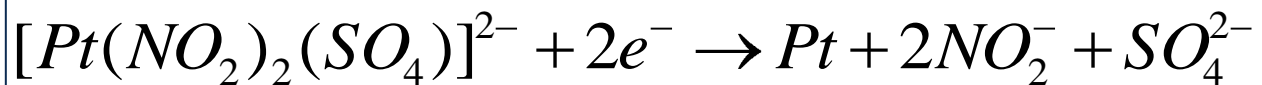
- ECD → criteria of the plating electrolyte?

→ chloride free

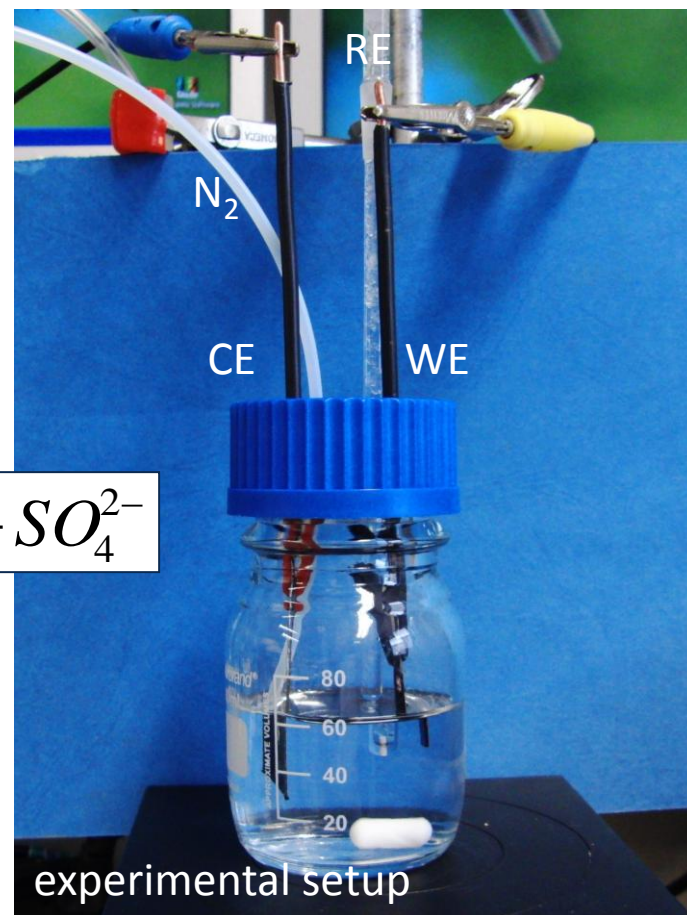
→ no surface-active agents



plating electrolyte: 0.1 M H₂SO₄
+ 7.7 mM K₂[Pt(NO₂)₄]

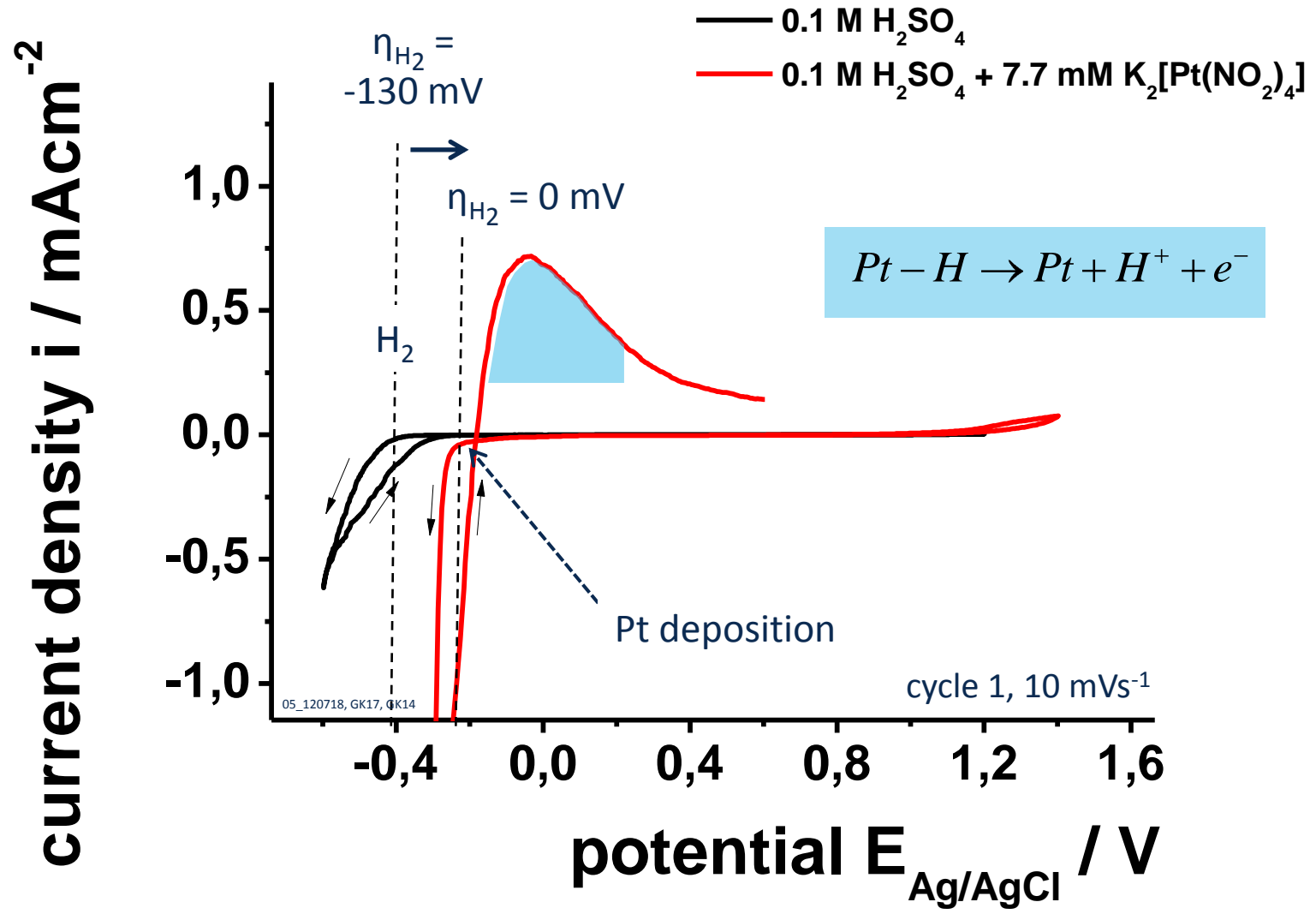


characterisation on glassy carbon



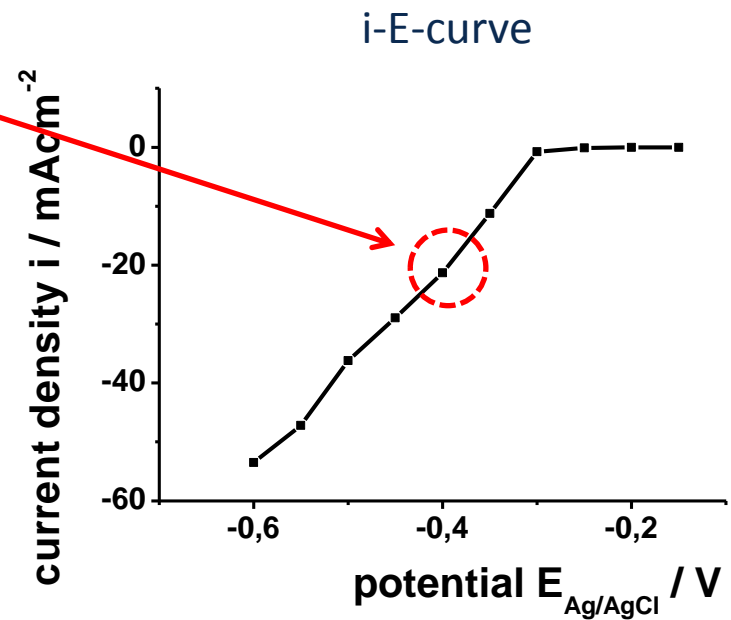
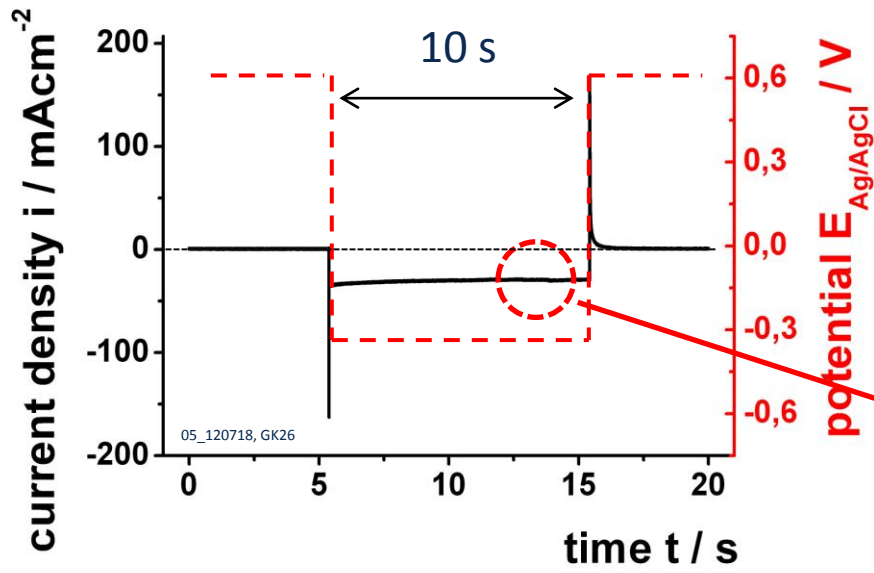
Results → plating electrolyte

■ glassy carbon → cyclic voltammetry



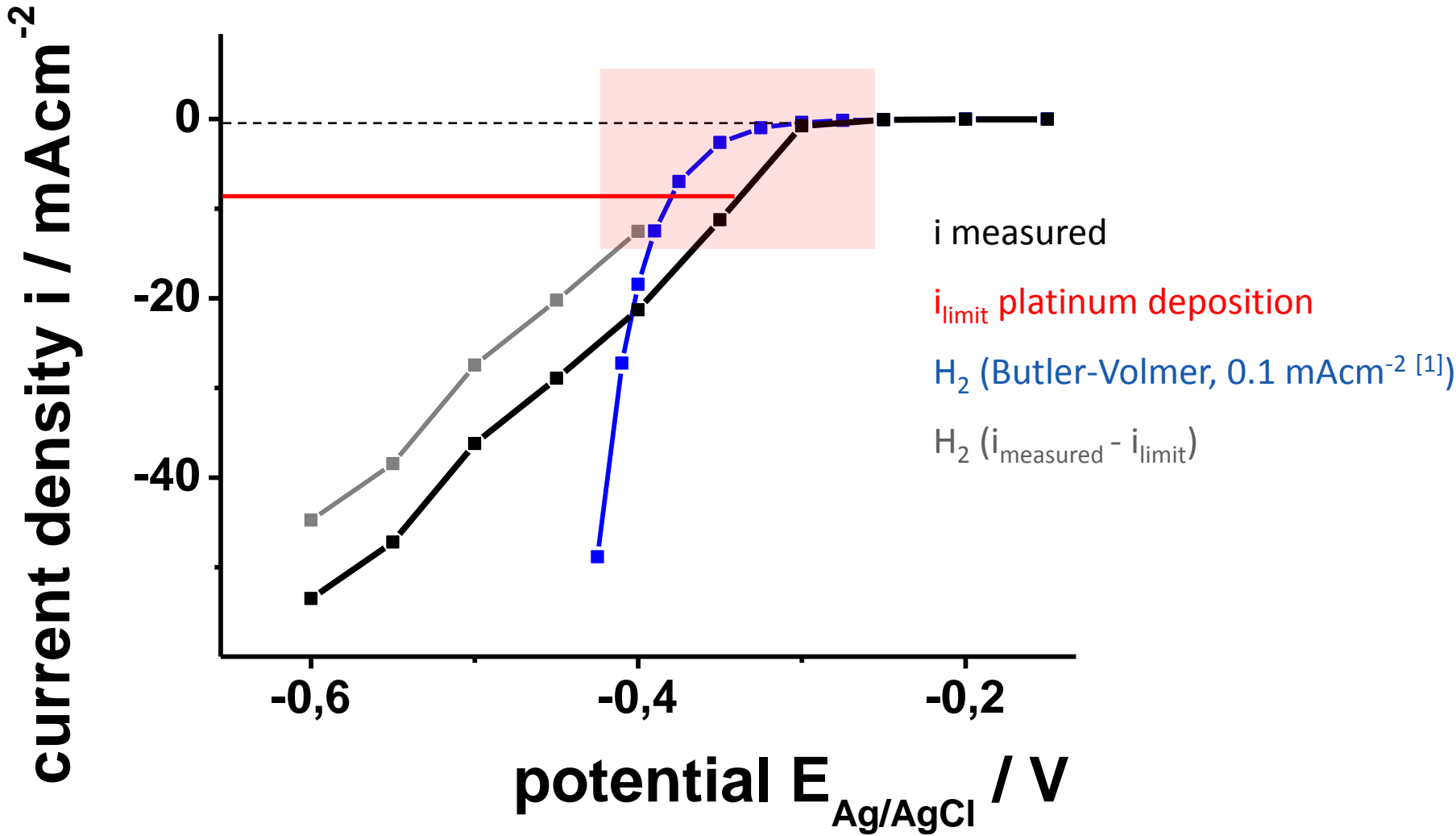
Results → plating electrolyte

■ current transients



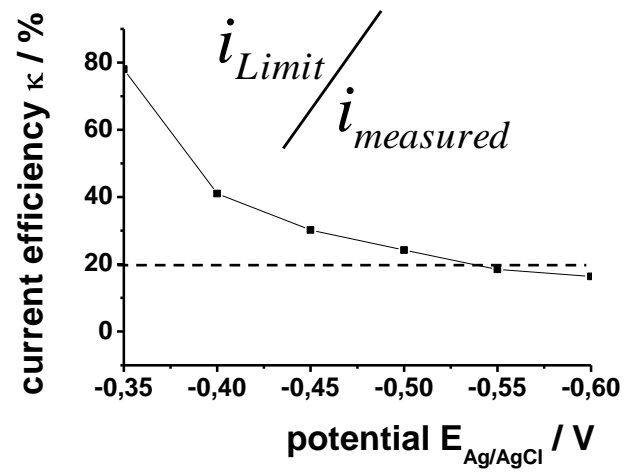
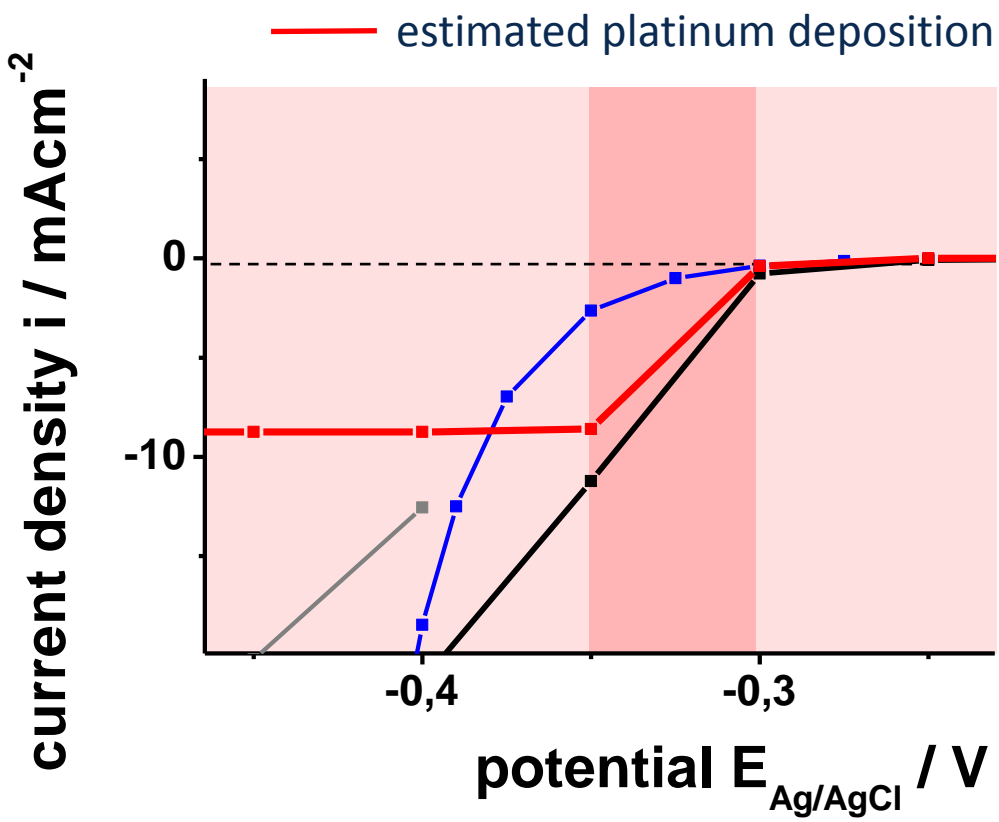
Results → plating electrolyte

■ i-E-curve



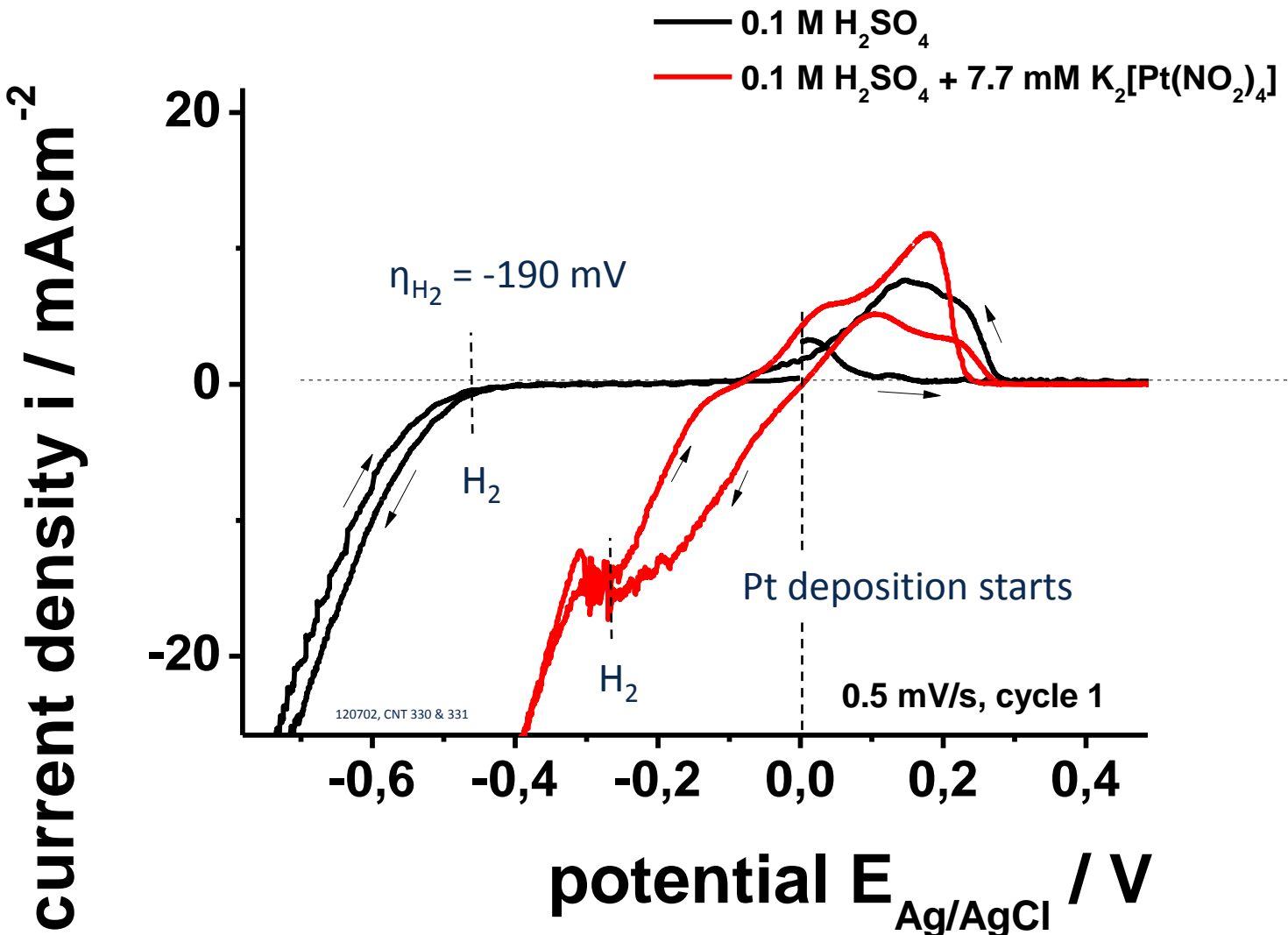
Results → plating electrolyte

■ i-E-curve



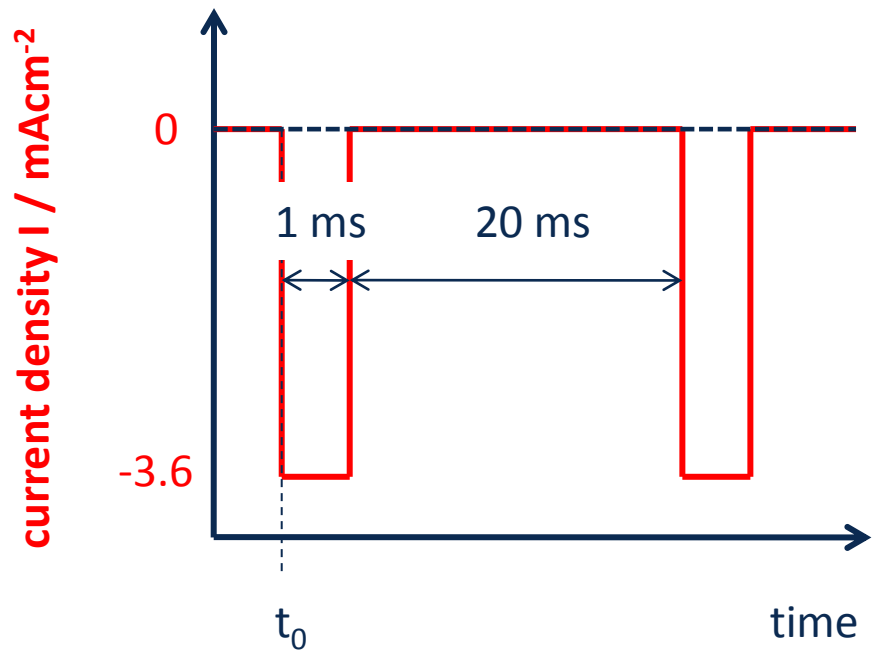
Results → platinum functionalisation of MWCNTs

■ aligned MWCNTs → cyclic voltammetry



Results → platinum functionalisation of MWCNTs

- pulse plating → smart adaption of → particle size
- particle distribution
- platinum content



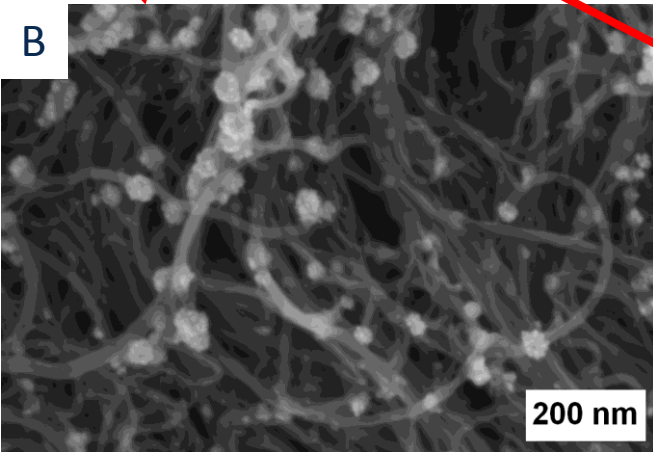
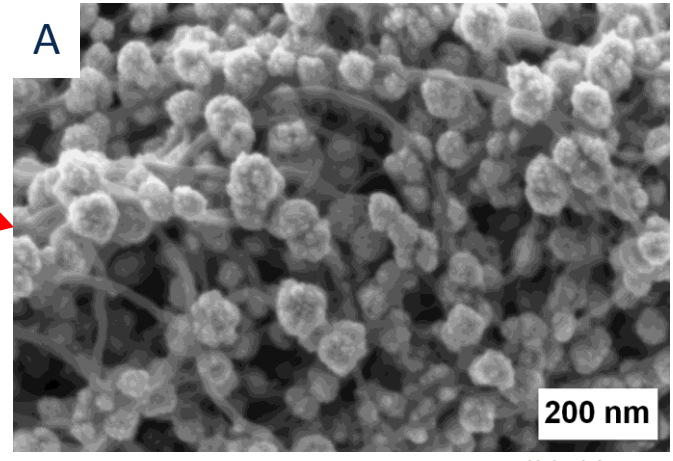
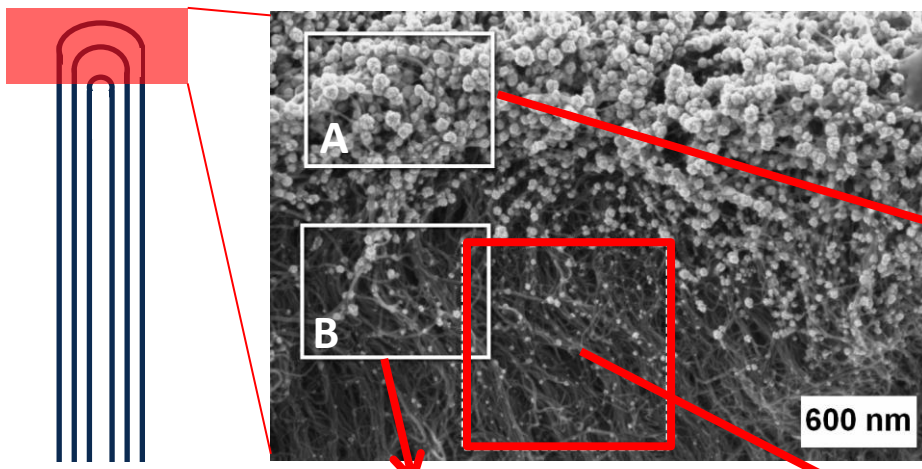
		$J / C Me z+$					i/i_{Limit}	[1]
		Very low	Low	Medium	High	Very high		
Inhibition intensity	Very low	No deposit or FI or screw dislocation No nucleation	BR	BR	BR	FI dendrites	FI powder	
	Low	BR	BR	BR	BR or FI	FI powder or UD if bad crystallization	hydrogen evolution or	
	Medium	BR	BR	Z or FT	FT	UD	discharge of another ion	
	High	Z	UD	UD	UD	UD in powder		
	Very high	FT	UD	UD in powder	UD	hydrogen evolution or discharge of another ion		

Additional annotations in the table: 'nanoparticles' is written above the 'UD' cells. 'increasing $N_{c,2}$ ' and 'increasing $N_{c,3}$ ' are written between columns. The 'UD in powder' cells are highlighted with red boxes.

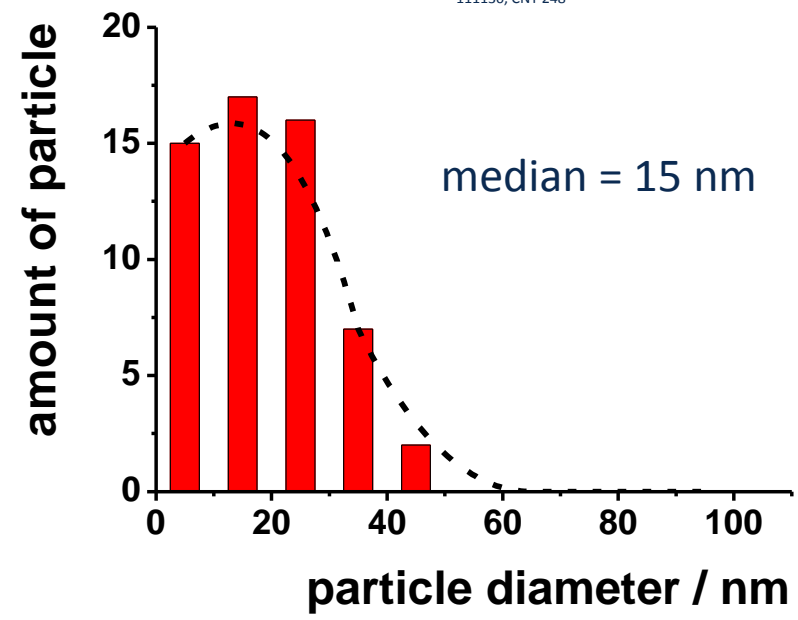
- current pulse → application-oriented

Results → platinum functionalisation of MWCNTs

■ cross section of the platinum functionalized aligned MWCNTs

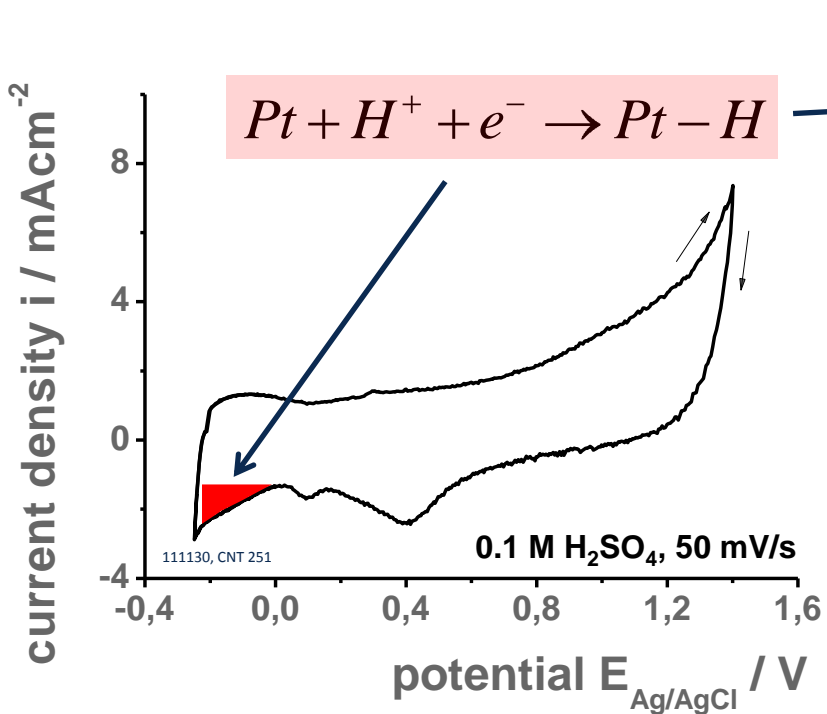


smallest particle size → 5 nm



Results → platinum functionalisation of MWCNTs

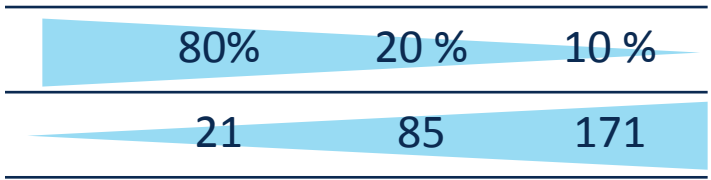
■ electrochemical active surface area (ECSA)^[1]



$$A_{Pt} = \frac{Q_{Pt-H}}{210 \mu C / cm^2}$$

↓
 real platinum mass?
 ↓
 current efficiency κ of plating process?
 ↓
 literature^[2] $\kappa = 15...10\%$

$Q_{ECD} / mCcm^{-2}$
160

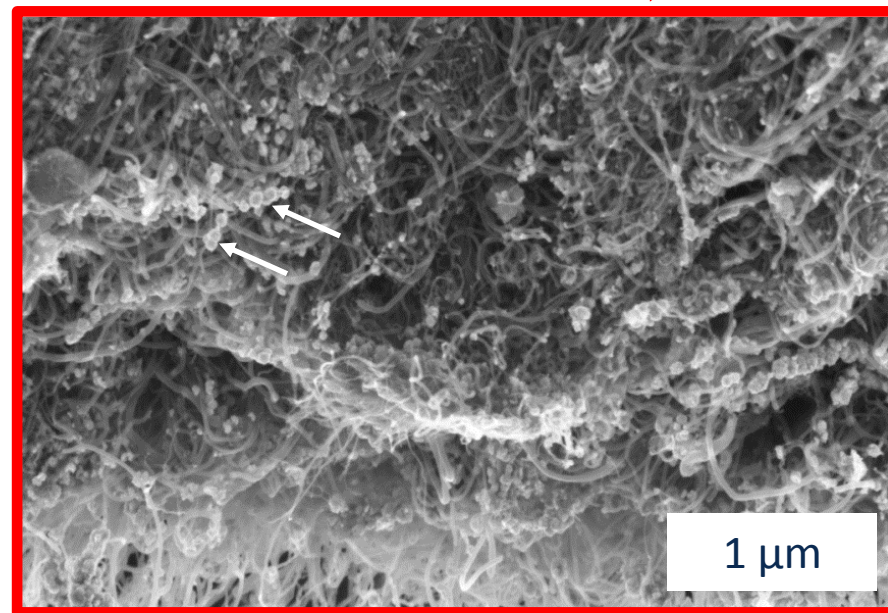
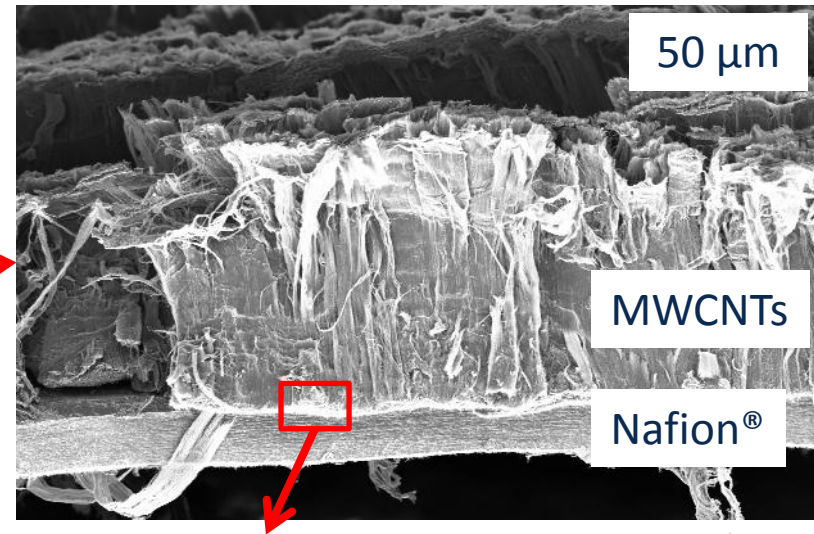
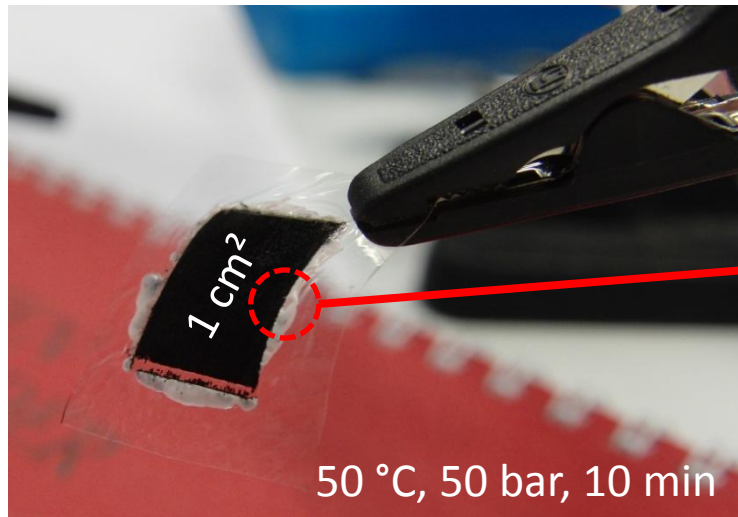


current efficiency [%]
 platinum surface [m^2_{Pt}/g_{Pt}]

[1] Trasatti, S. et al.: J. of Electroanalytical Chemistry, 327, 1992
 [2] Baumgärtner, M. E. et al.: Platinum Metals Review, 32, 1988

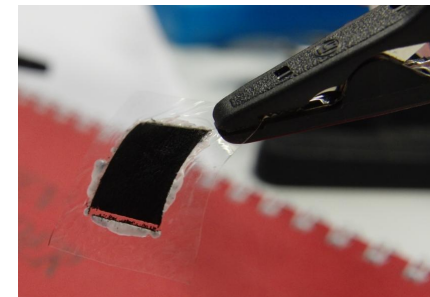
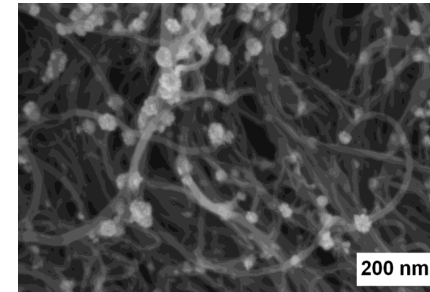
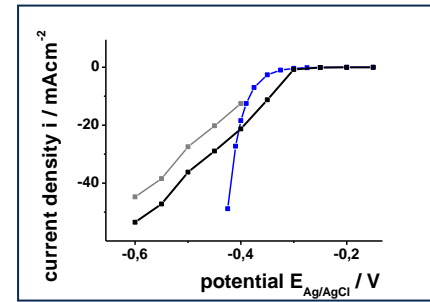
Results → platinum functionalisation of MWCNTs

- prepared MEA



summary

- $[\text{Pt}(\text{NO}_2)_2(\text{SO}_4)]^{2-}$ → suitable for platinum functionalisation of MWCNT tips
- smallest nanoparticles → 5 nm
- nanoparticles size ↓ current density ↑
- high active platinum surface
- successful MEA preparation
 - platinum nanoparticles on the interface of MWCNT /polymer
 - maintenance of the vertical aligned nanostructure





**Thank you
for your attention**

200 nm
|-----|

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