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ElyKon

Electrolysis System Components for Dynamic/Intermitting Operation

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[2] CiS - Forschungsinstitut für Mikrosensorik GmbH, D-99099 Erfurt (Thüringen)
[3] TUBAF – Technische Universität Bergakademie Freiberg , 09599 Freiberg (Sachsen)
[4] ISLE Steuerungstechnik und Leistungselektronik GmbH, 98693 Ilmenau (Thüringen)
[5] Areva H2 Gen, 91940 Les Ulis, FRANCE

DLR Deutsches Zentrum für Luft- und Raumfahrt

CiS Forschungsinstitut für Mikrosensorik GmbH

TU Bergakademie Freiberg – Technische Universität Bergakademie Freiberg, Die Ressourcenuniversität. Seit 1765.

isle Steuerungstechnik und Leistungselektronik GmbH

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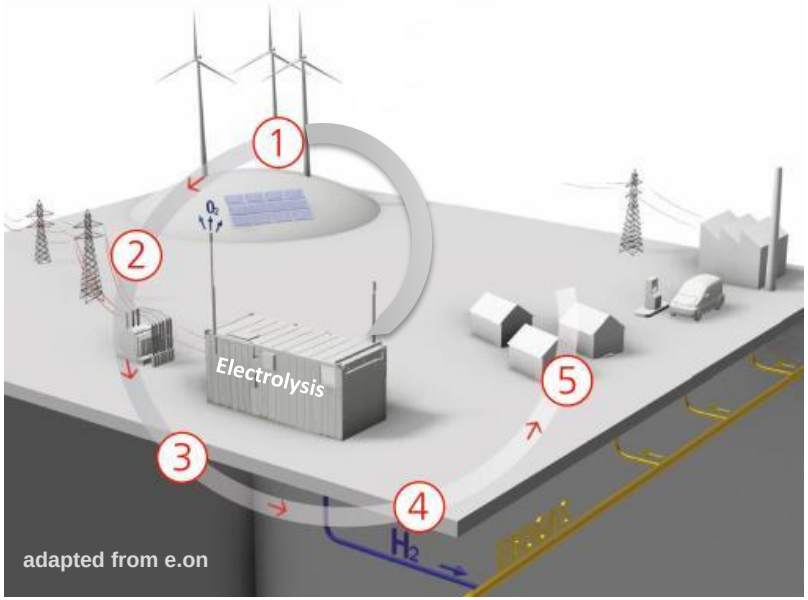
Motivation

- Hydrogen in frame of Energy Transition



1. **Intermitting Renewables** - Wind and Solar
2. **Local electricity grid -** Grid service
3. **H2 generation via Electrolysis**
4. **H2 distribution**
5. **H2 utilization** - Industry, Transport, Energy

- Challenges faced by Elykon:
  - **Dynamic Operation**
  - **Accelerated Degradation**
  - **Innovative Control Strategy**

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Objectives

Optimization of efficiency, lifetime and reliability of PEMWE under intermitting load from renewable energies.

- Identification and quantification of undesired **operation conditions** (global and local) based on sensor finger prints
- **Improvement of efficiency** via on-line optimization of operation parameters
- Extension of **operation range to 200%** of nominal power
- **Development ASTs protocols and their use for improving lifetime**
- **Scalable controller and operation strategy**

ElyKon Consortium

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Partner	Role	Location
DLR Deutsches Zentrum für Luft- und Raumfahrt (Research center)	Coordination; Stack tests, degradation study; AST development; Development of segmented cell	Stuttgart, Germany
CiS Forschungsinstitut für Mikrosensorik GmbH (Research institute)	Development of T, RH sensors	Erfurt, Germany
TU Bergakademie Freiberg – Technische Universität Bergakademie Freiberg. Die Ressourcenuniversität. Seit 1765. (University)	Development of ion detectors for water loop	Freiberg, Germany
isle Steuerungstechnik und Leistungselektronik GmbH (SME)	Development of controller/algorithm	Ilmenau, Germany
AREVA H_2Gen (Industry)	*Associated partner;* *Providing PEMWE Stacks*	*Les Ulis, France*

Project duration and budget

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Project start: 04/2019

Project end: 12/2021

- Total budget: 2.6 M€
- Requested funding: 2.2 M€
- In-kind contribution: Stack and support from AREVA H2 GEN

WP-Nr.	WP-Name	WP leader	Project-months 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
1	Project management	DLR	M1.1 M1.2 M1.3 M1.4 M1.5 M1.6
2	Sensor development	CIS	M4 M9
3	PEMWE operation	DLR	M2 M3 M5 M10
4	Controller development	DLR	M6 M8
5	Sensor and controller integration	ISLE	M7 M11
6	Demonstration of the system	DLR	M12 M13

Approach to achieve PEMWE lifetime improvement at intermitting operation

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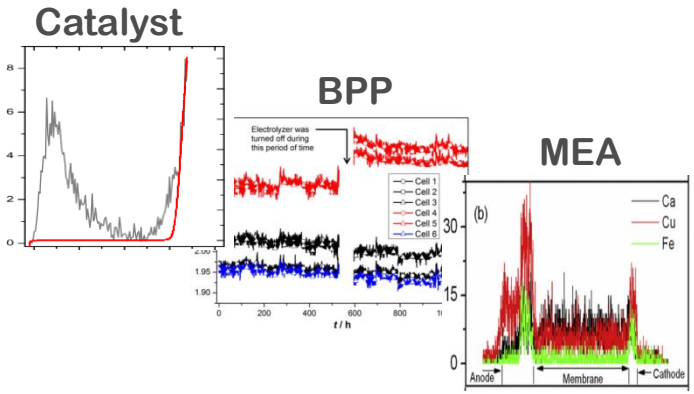
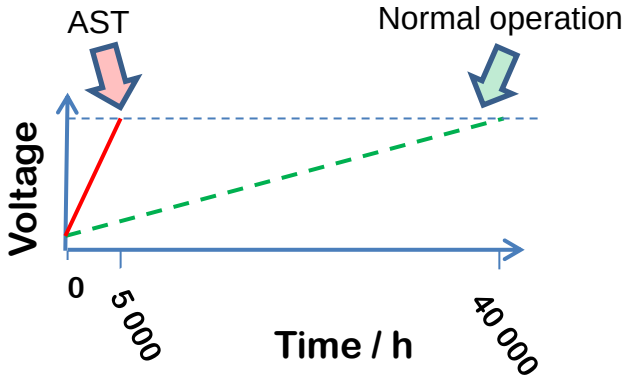
PEMWE degradation





New Sensors ⇄ PEMWE Stack

- Knowledge about degradation
- Development of ASTs

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Approach to achieve PEMWE lifetime improvement at intermitting operation

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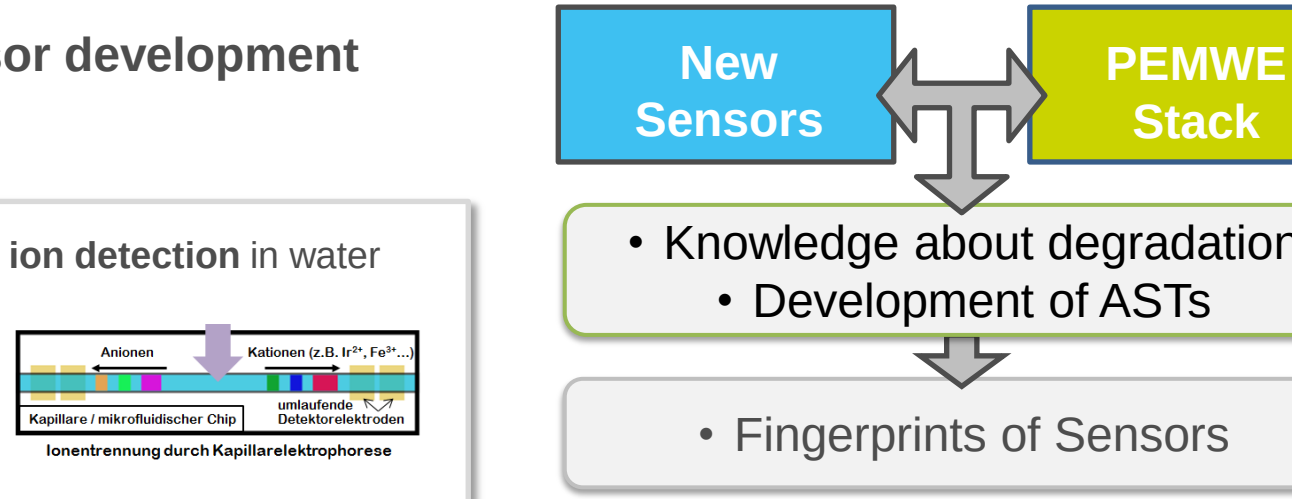
Sensor development



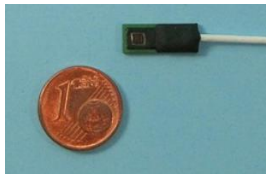
Selective **ion detection** in water

TU BERGAKADEMIE FREIBERG

Ionentrennung durch Kapillarelektrophorese

Miniaturized **Temperature-Humidity** sensors for high RH-conditions

CiS Forschungsinstitut für Mikrosensorik GmbH



- **Current density distribution** monitoring
- H2 Sensors for saturated gases

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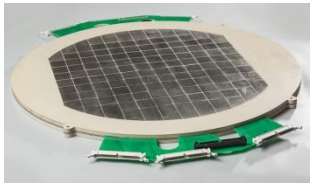

Approach to achieve PEMWE lifetime improvement at intermitting operation

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Control algorithm

isle Steuerungstechnik und Leistungselektronik GmbH

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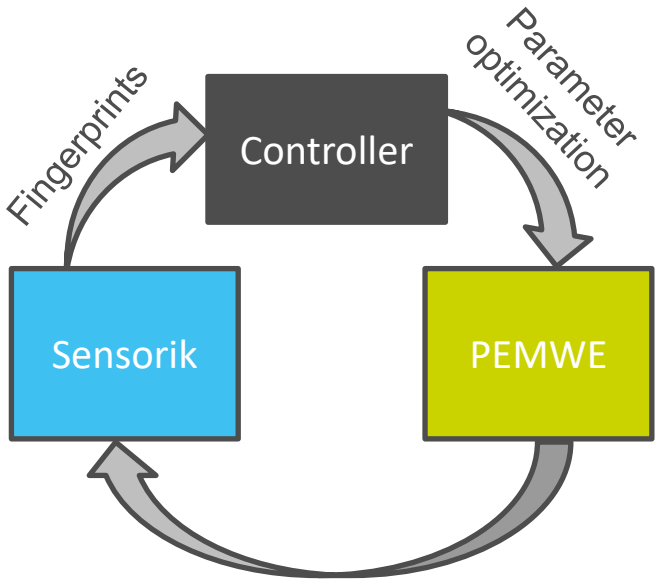
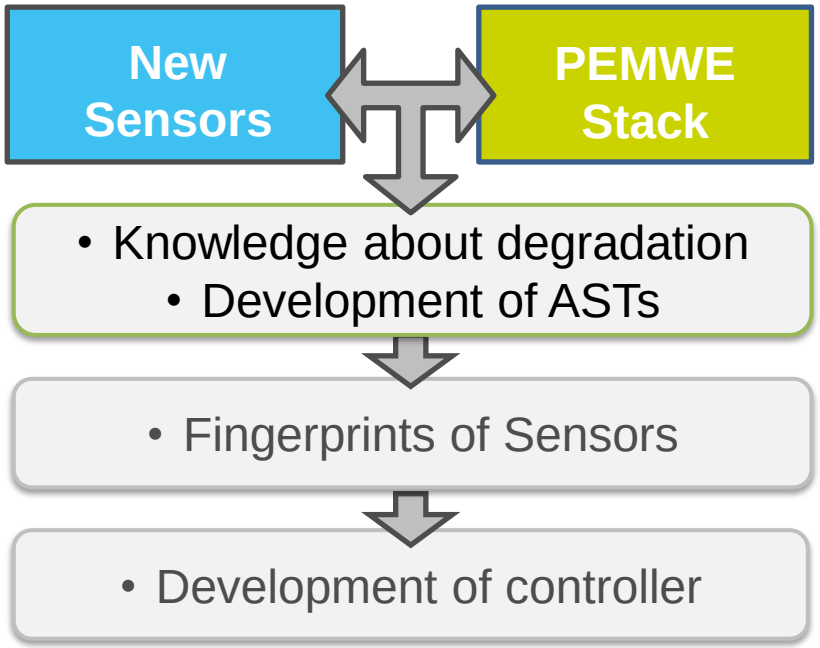


SoH, operation conditions



Approach to achieve PEMWE lifetime improvement at intermitting operation

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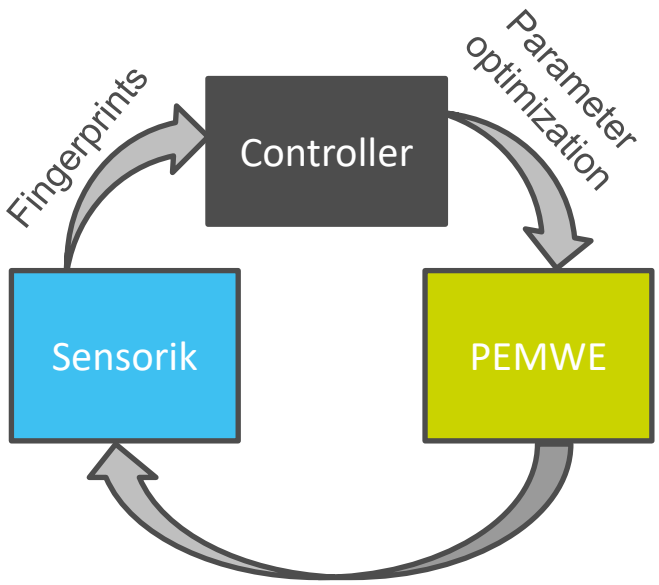
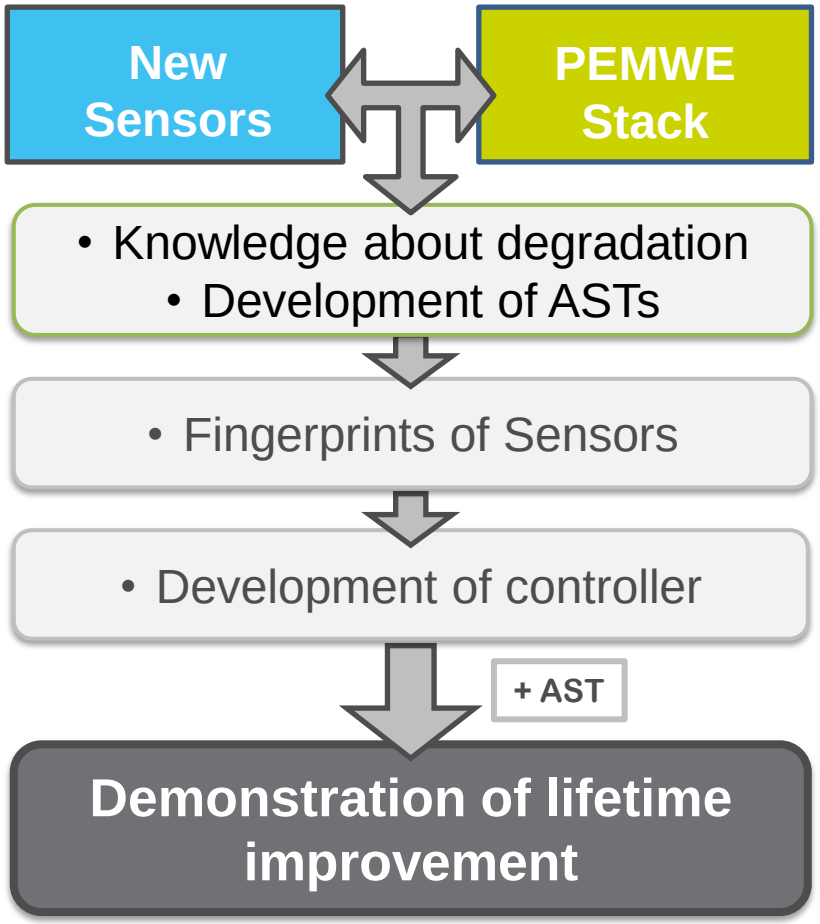
Lifetime improvement

- Optimized operation parameters
- On-line monitoring of SoH
- Mitigation of critical conditions





Work Package Structure

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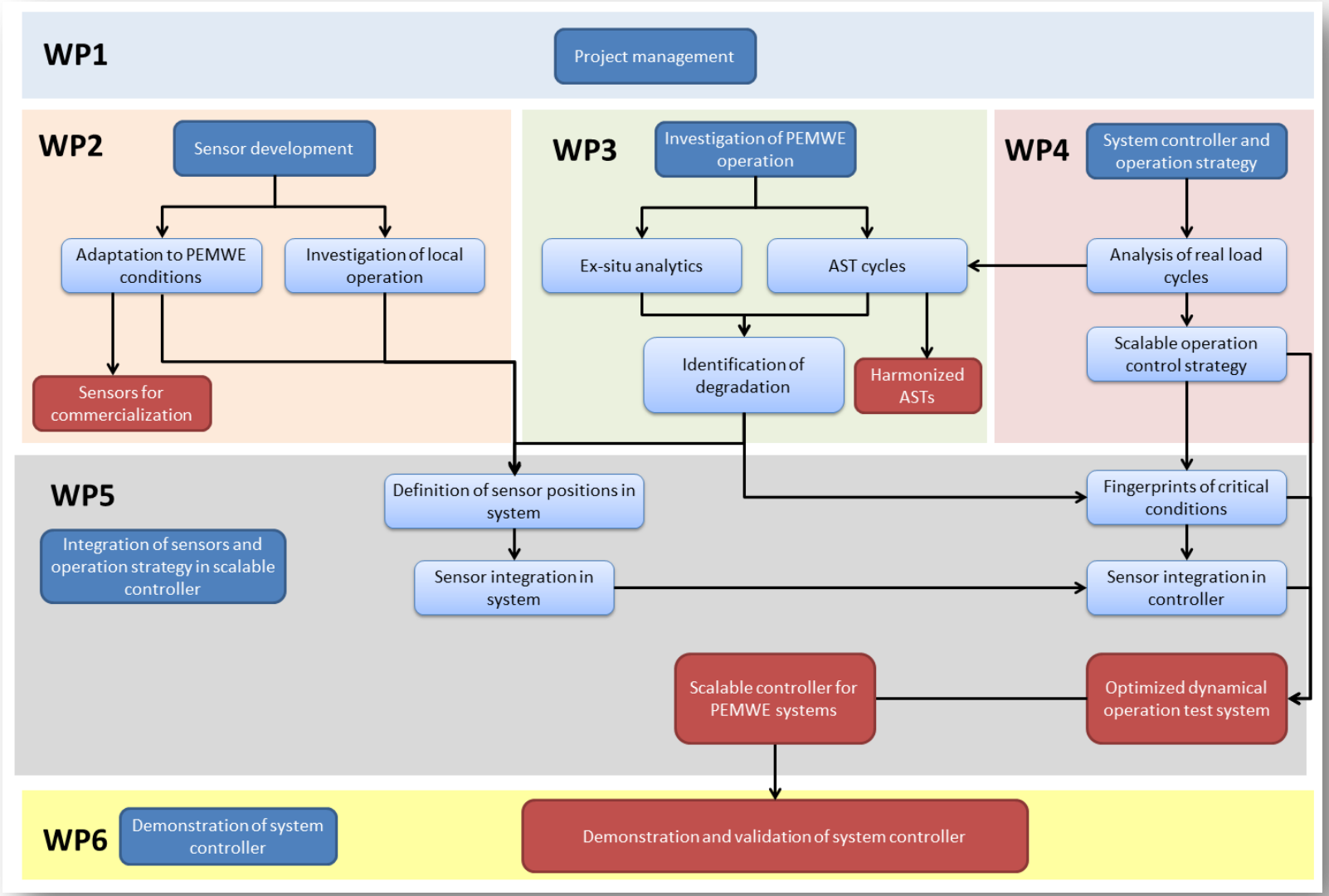

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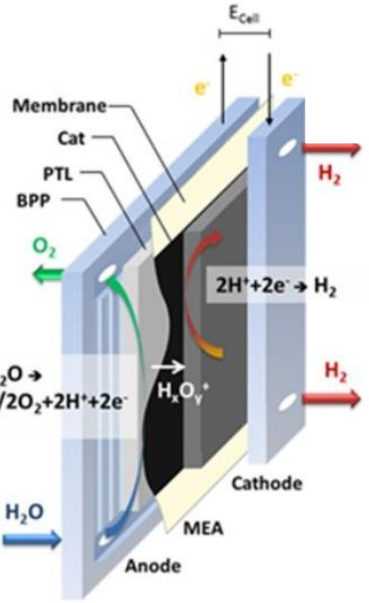
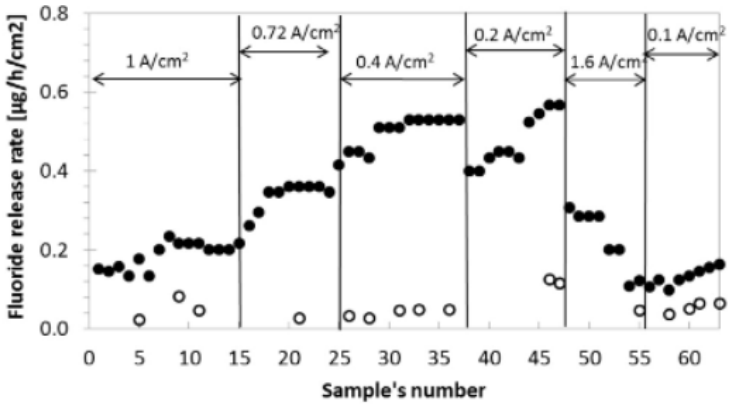
State-of-the-art: Degradation



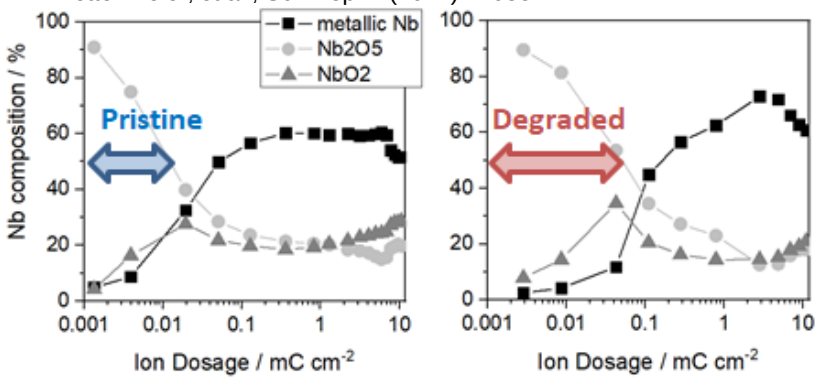
P. Lettenmeier, PhD Thesis, U Stuttgart, 2018.

M. Chandesris, et al., Int. J. Hydrogen Energy 40 (2015) 1353.



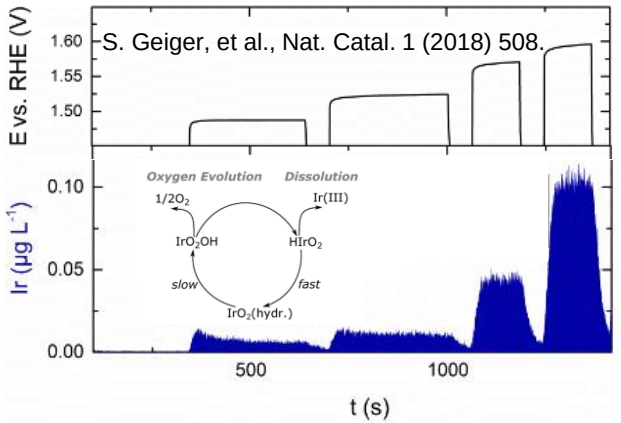
Fluoride release rate at different current densities

P. Lettenmeier, et al., Sci. Rep. 7 (2017) 44035.



Oxide layer formation on aged Nb/Ti/ss BPP

S. Geiger, et al., Nat. Catal. 1 (2018) 508.



Ir dissolution rate at different potentials

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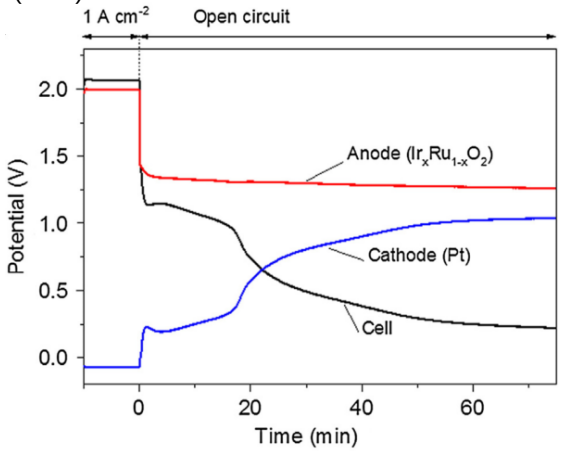
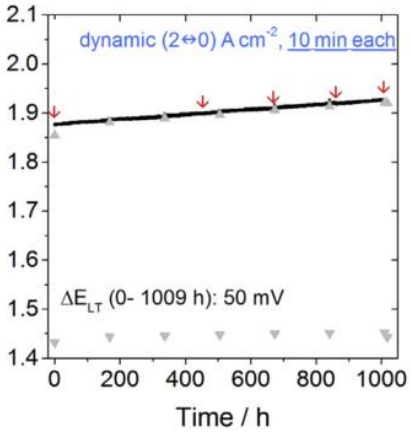
State-of-the-art: Stressors

E. Brightman, et al., Electrochem. Commun. 52 (2015) 1.



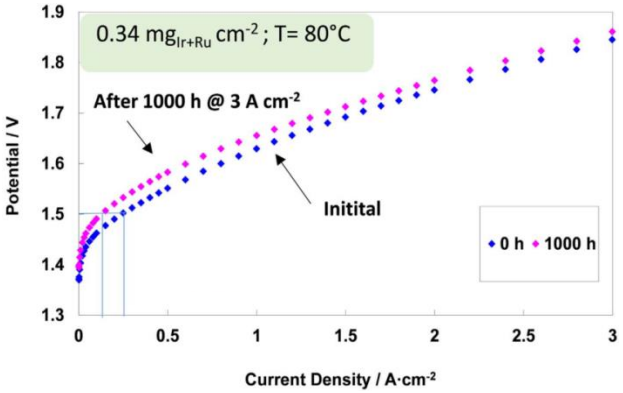
Shut-down: Evolution of electrode potentials

C. Rakousky, et al., J. Power Sources 342 (2017) 38.



Dynamic operation

S. Siracusano, et al., Nano Energy 40 (2017) 618.



High current density

Challenges

- Investigation and understanding of degradation under stress conditions
- Designing AST for dynamic operation
- Requirement of specialized sensors to monitor degradation

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Operation strategy – Accelerated Stress Tests (AST)

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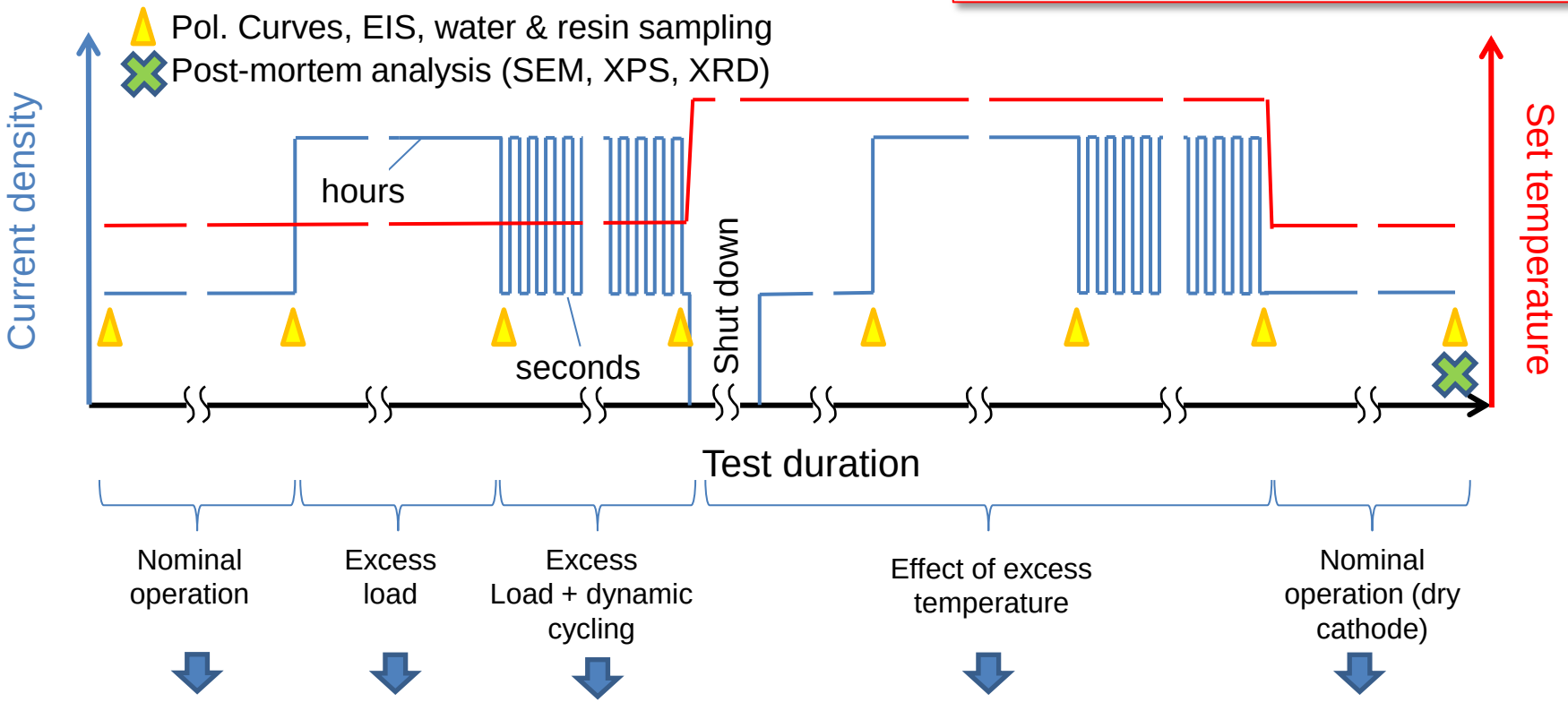
Stack Testing (3 stacks to be tested)

A review on AST protocols will be published early next year in:
Current Opinion in Electrochemistry



Specific **single cell tests** along with **post mortem analysis** for deep understanding of degradation under certain stressors

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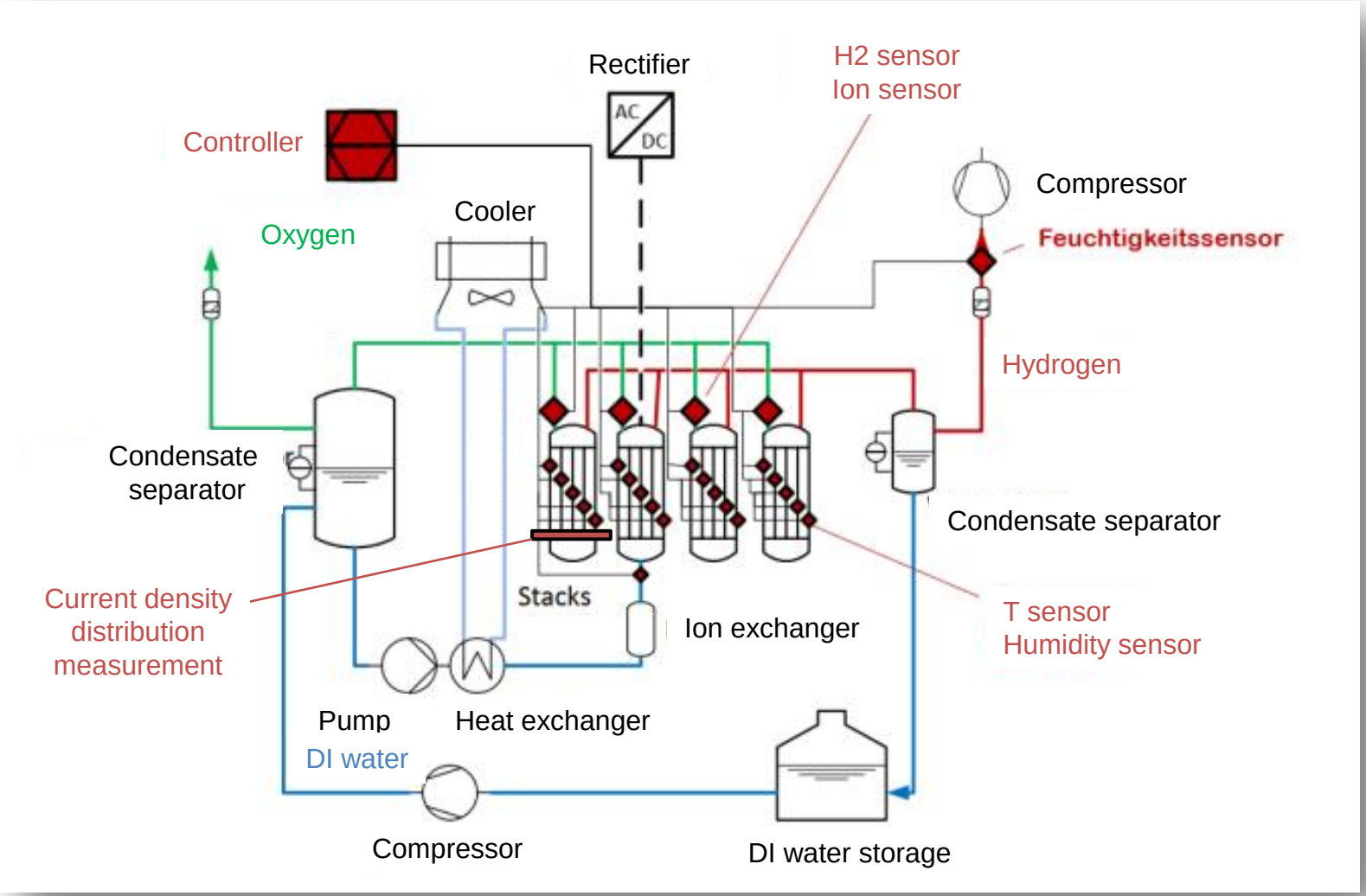
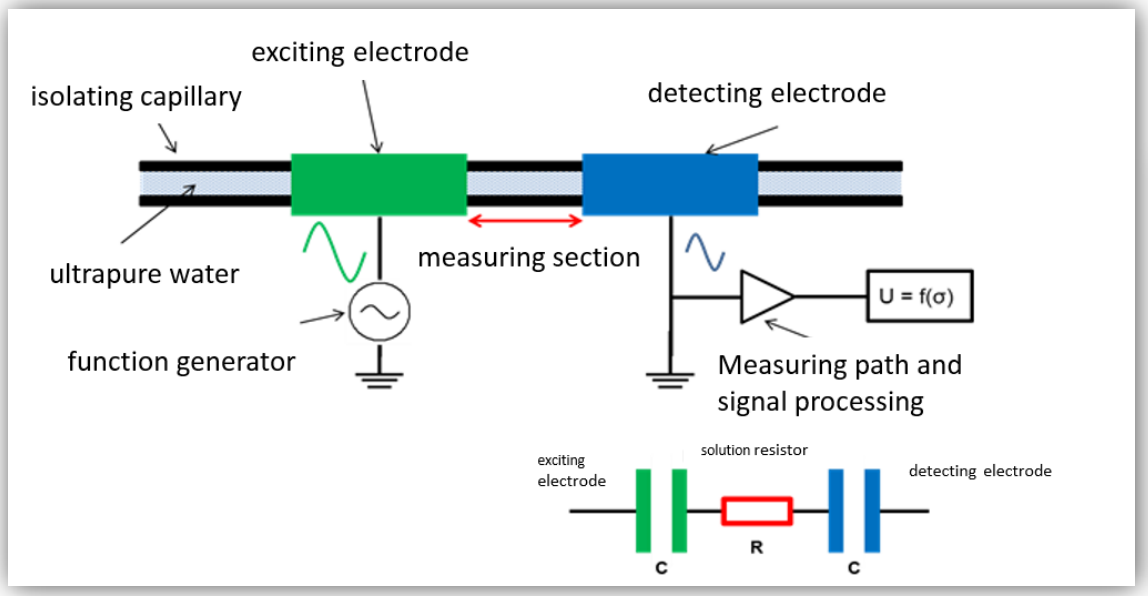
Definition of sensor positions



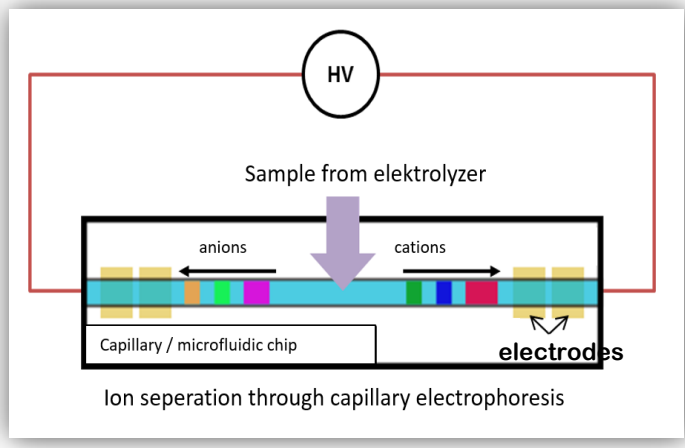
Ion and conductivity sensors

- Contactless Conductivity detection
  → no contamination through sensor

- Combination with electrophoresis for ion separation
  → detection of different Ion Species possible



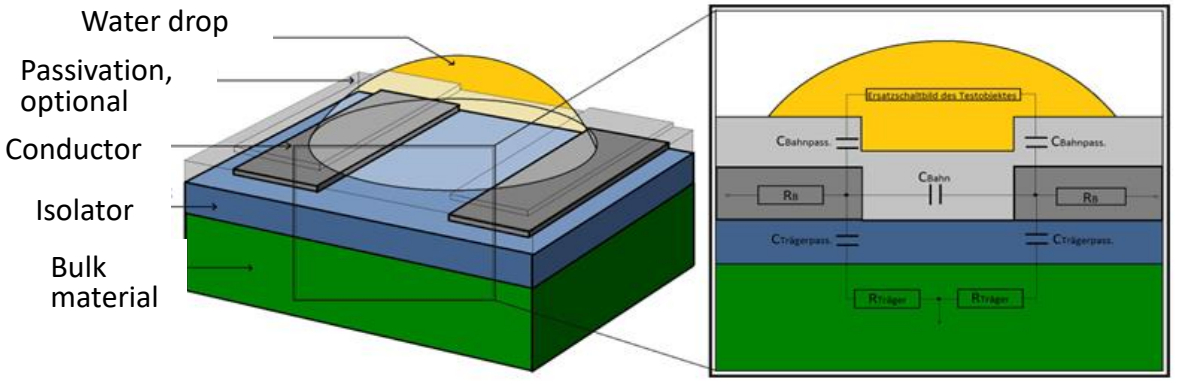
Challenges:
- Purity of the water → low conductivity
- High temperatures



Ion seperation through capillary electrophoresis

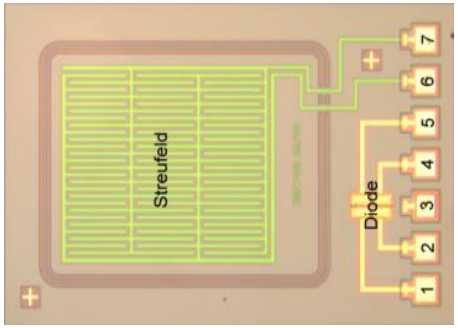
Humidity sensors

Detection of water drops



Protection of hydrogen compressor

Pressure dew point measurement



Different structural dimensions, capacitive and galvanic coupling

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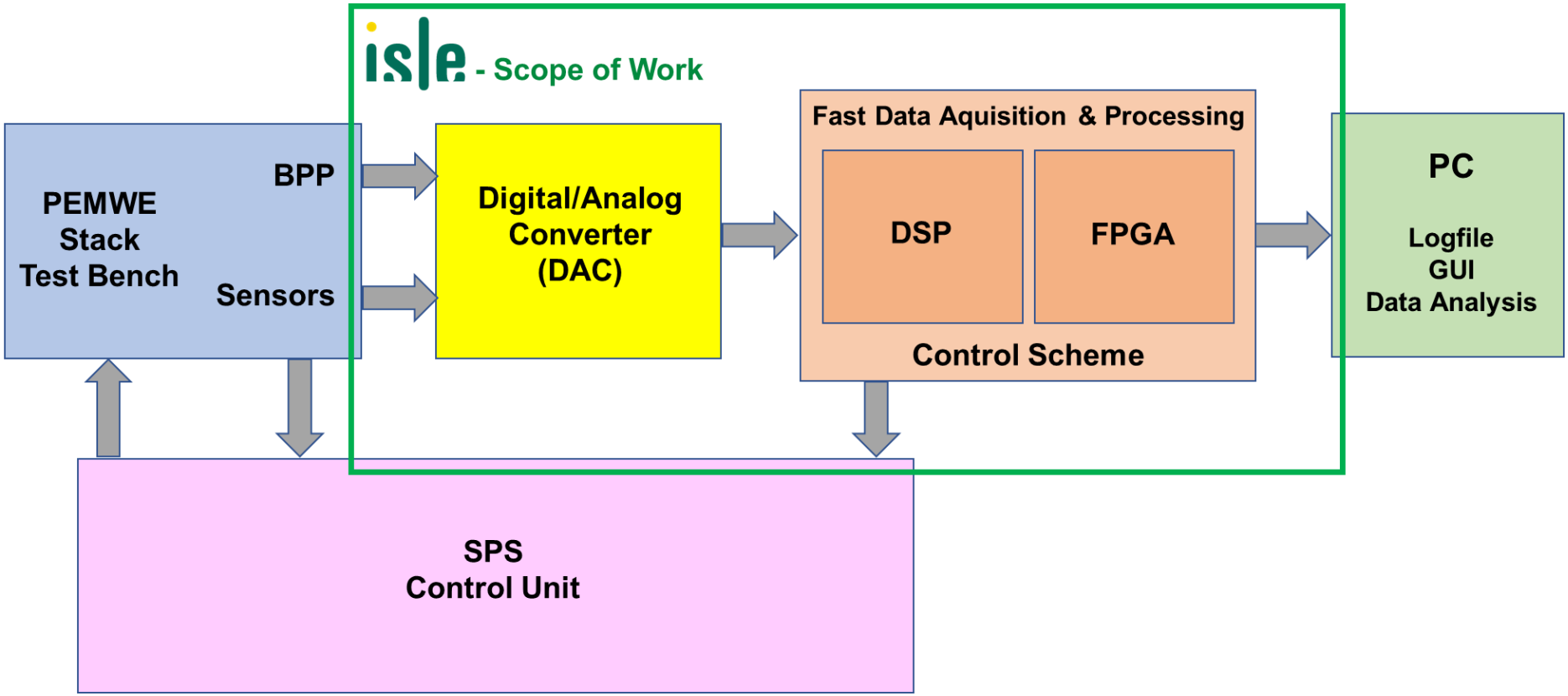
Controller



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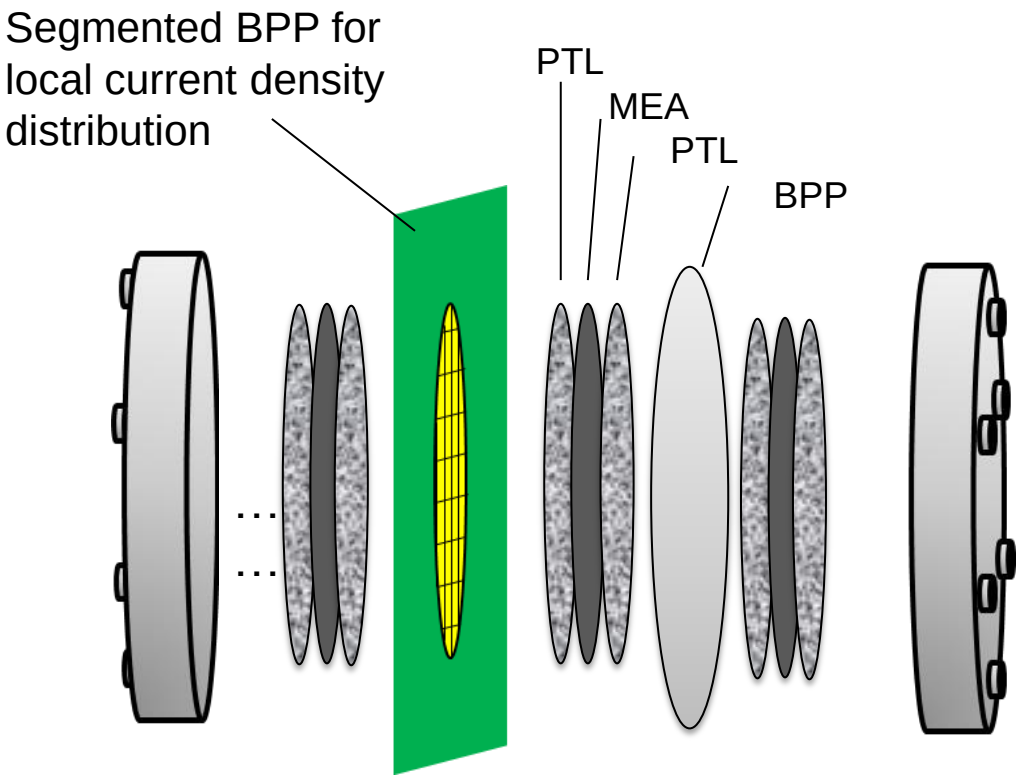
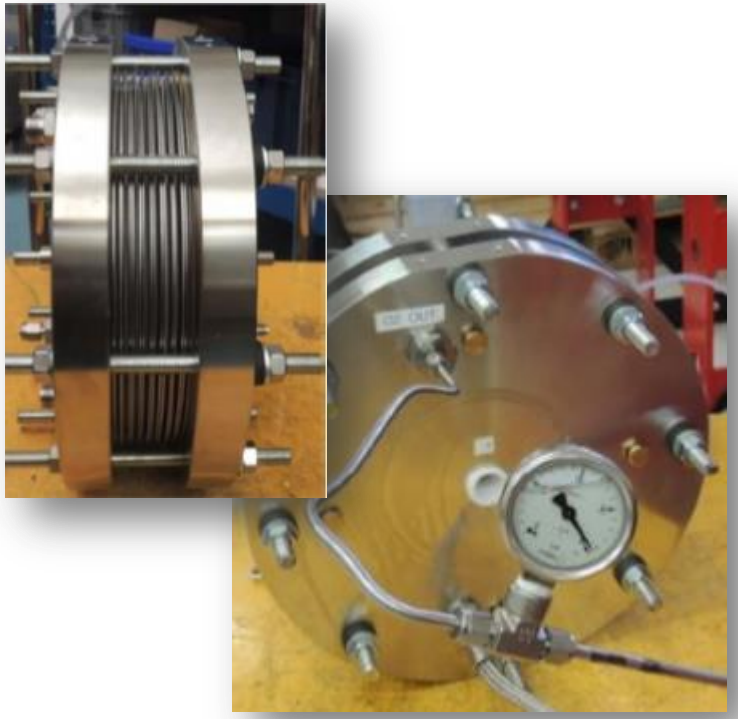
Segmented cell for PEMWE Stack from Areva H2 Gen





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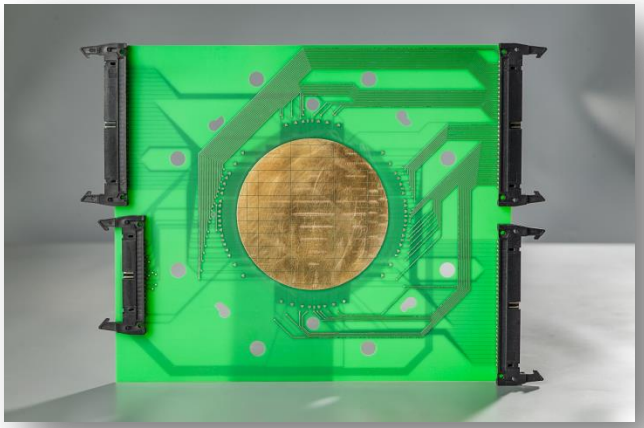
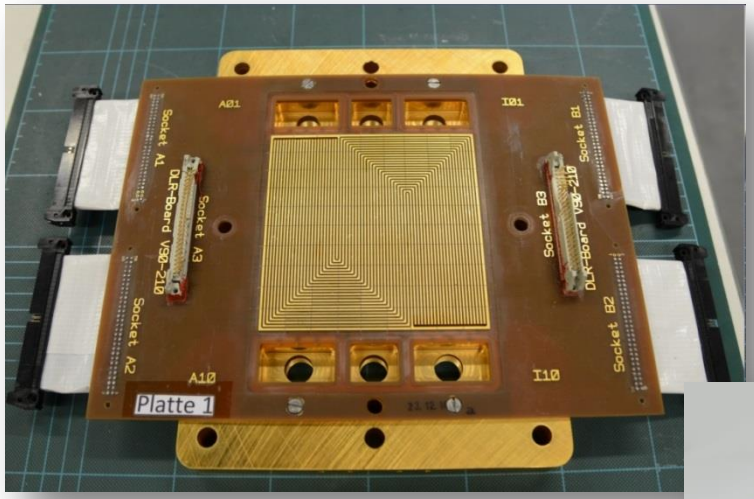
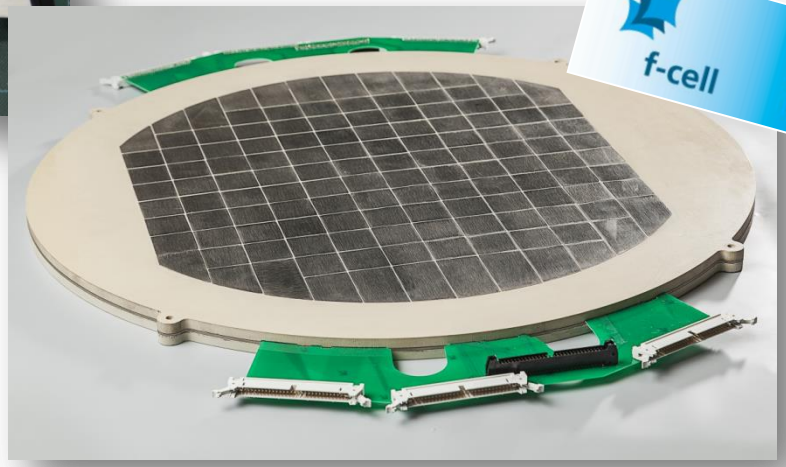
Locally resolved measurement of Current density distribution



Segmented bipolar plate for AEM electrolyser



Segmented bipolar plate
for PEM fuel cell



f-cell award
AWARD FOR INNOVATIVE FUEL CELL TECHNOLOGY

Modular segmented bipolar plate for alkaline electrolyser

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Status of Elykon – Next Steps

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Today

WP-Nr.	WP-Name	WP leader	Project-months 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
1	Project management	DLR	M1.1 M1.2 M1.3 M1.4 M1.5 M1.6
2	Sensor development	CIS	M4 M9
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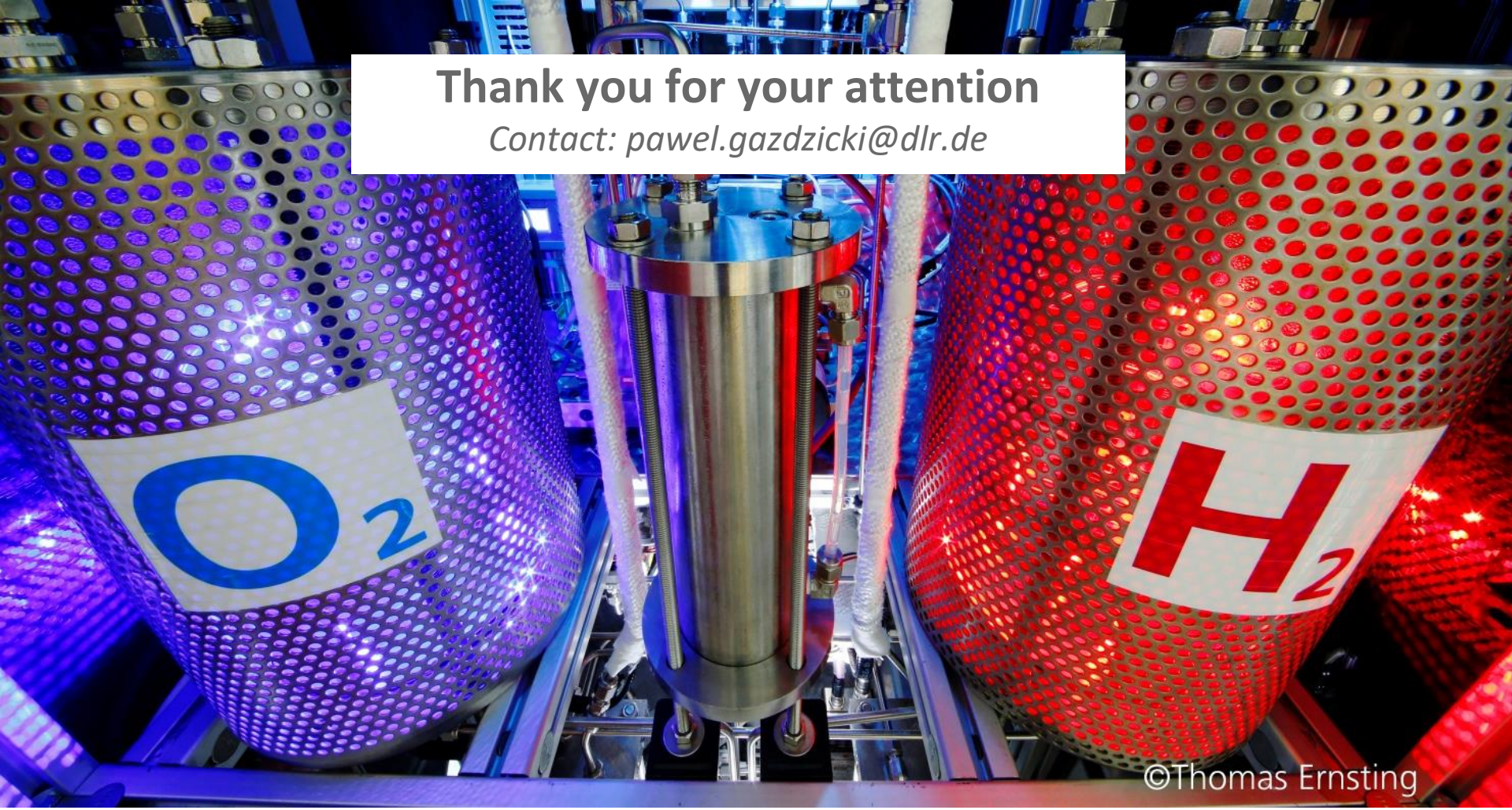
4	Controller development	DLR	M6 M8
5	Sensor and controller integration	ISLE	M7 M11
6	Demonstration of the system	DLR	M12 M13

- Launch of stack degradation study
- Sensor prototypes available
- Mitigation strategy for critical conditions
- Identification of sensor fingerprints
- Control strategy available



Thank you for your attention

Contact: pawel.gazdzicki@dlr.de

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