

Catalyst nanomaterials and catalyst layers for hydrogen technologies

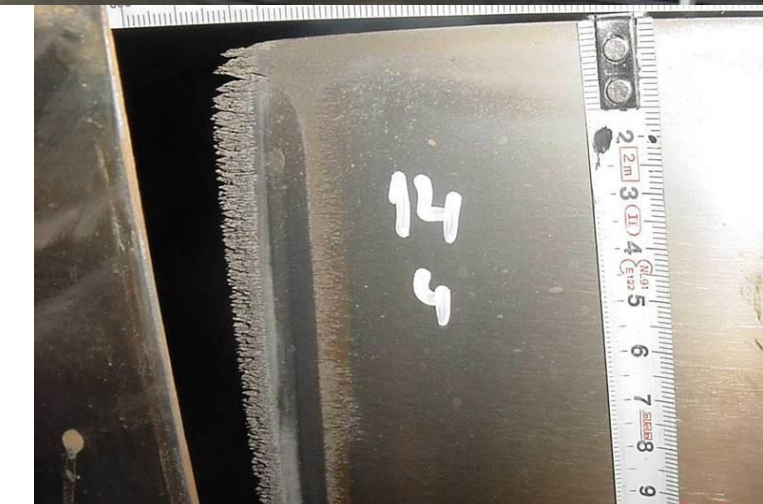
26. 09. 2023

Ing. Bc. Miroslav Kludský, Ph.D.

Ing. Tomáš Němec, Ph.D.

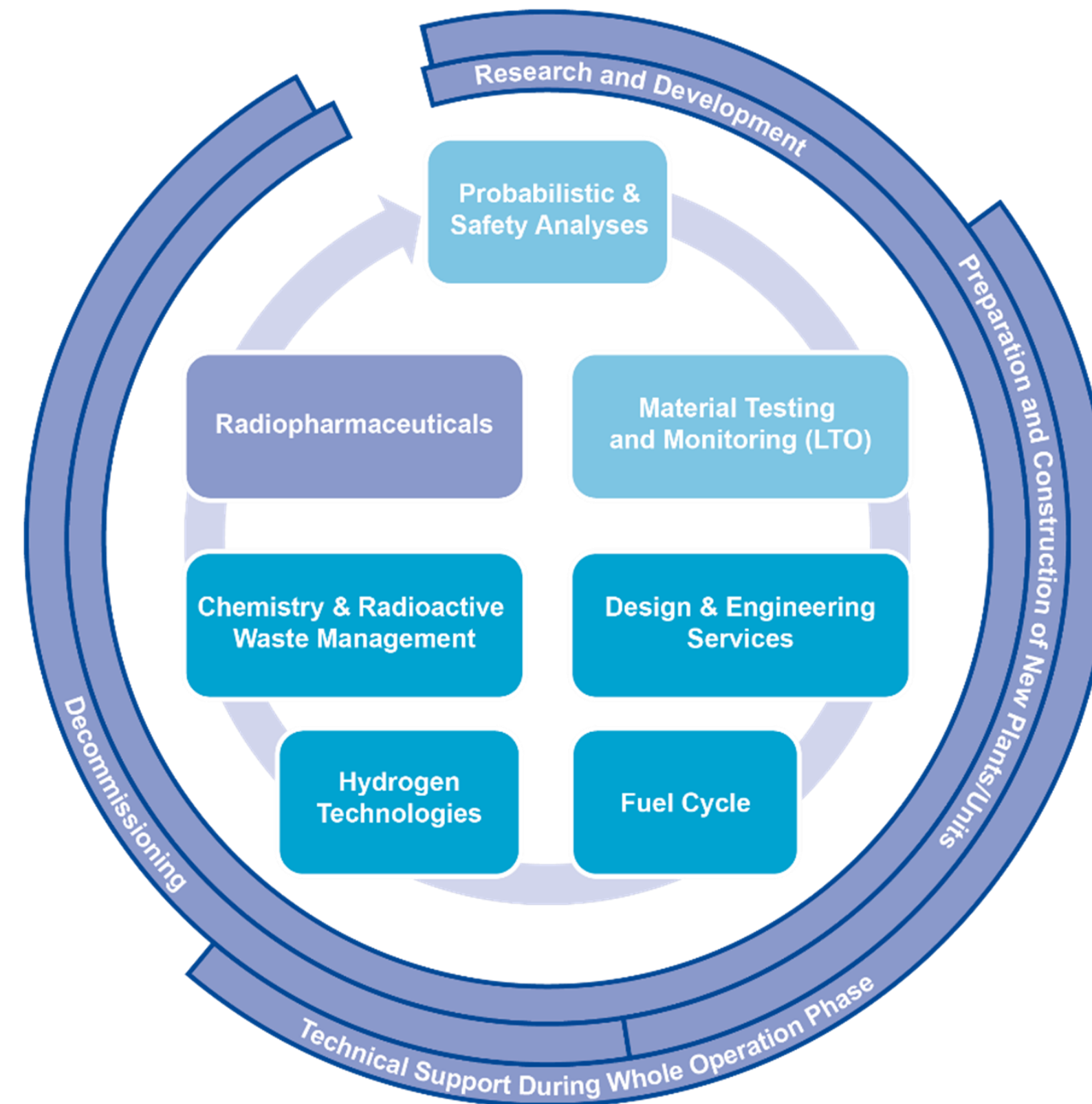
INSTITUTE OF THERMOMECHANICS

- Long-term research in thermodynamics of phase transitions
 - Power cycles development
 - Water condensation, wet steam flow
 - Turbine blade optimization
- Development of theoretical framework for phase transitions
 - Nucleation theory
- Condensation of metallic vapors (since 2015)
 - Formation of metallic nanoparticles
 - Utilization as catalyst nanomaterials for electrochemical processes
- Cooperation with ÚJV Řež (since 2019)
 - Technology development and scale-up



ÚJV ŘEŽ

- Nuclear safety and reliability analysis
- Fuel cycle support services
- Design and engineering
- Radioactive waste and decommissioning
- Technical support for operation of nuclear and conventional power plants
- Applied R&D
- Hydrogen Technologies



OUR FOCUS: HYDROGEN TECHNOLOGIES

H₂



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FUEL CELL STACK

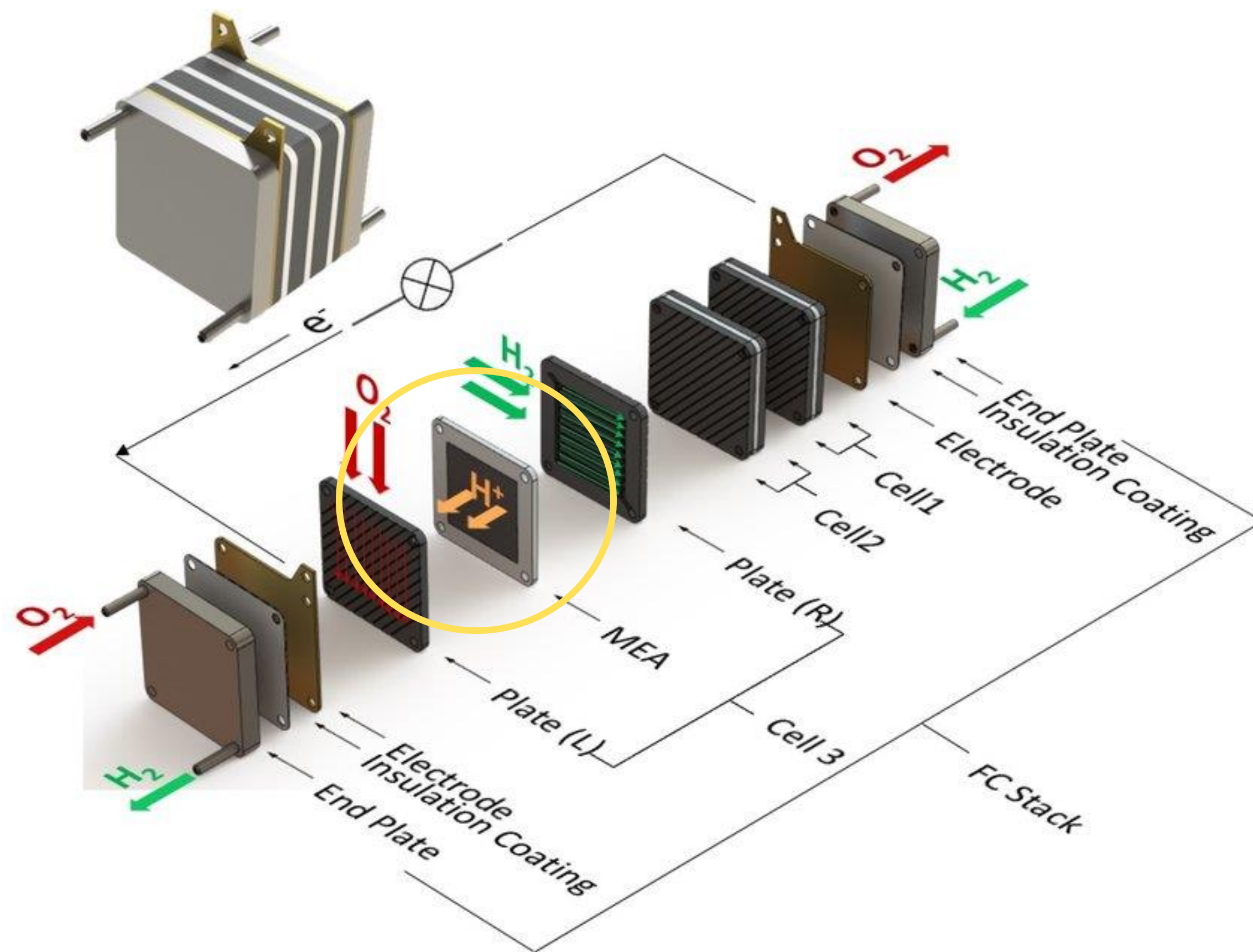
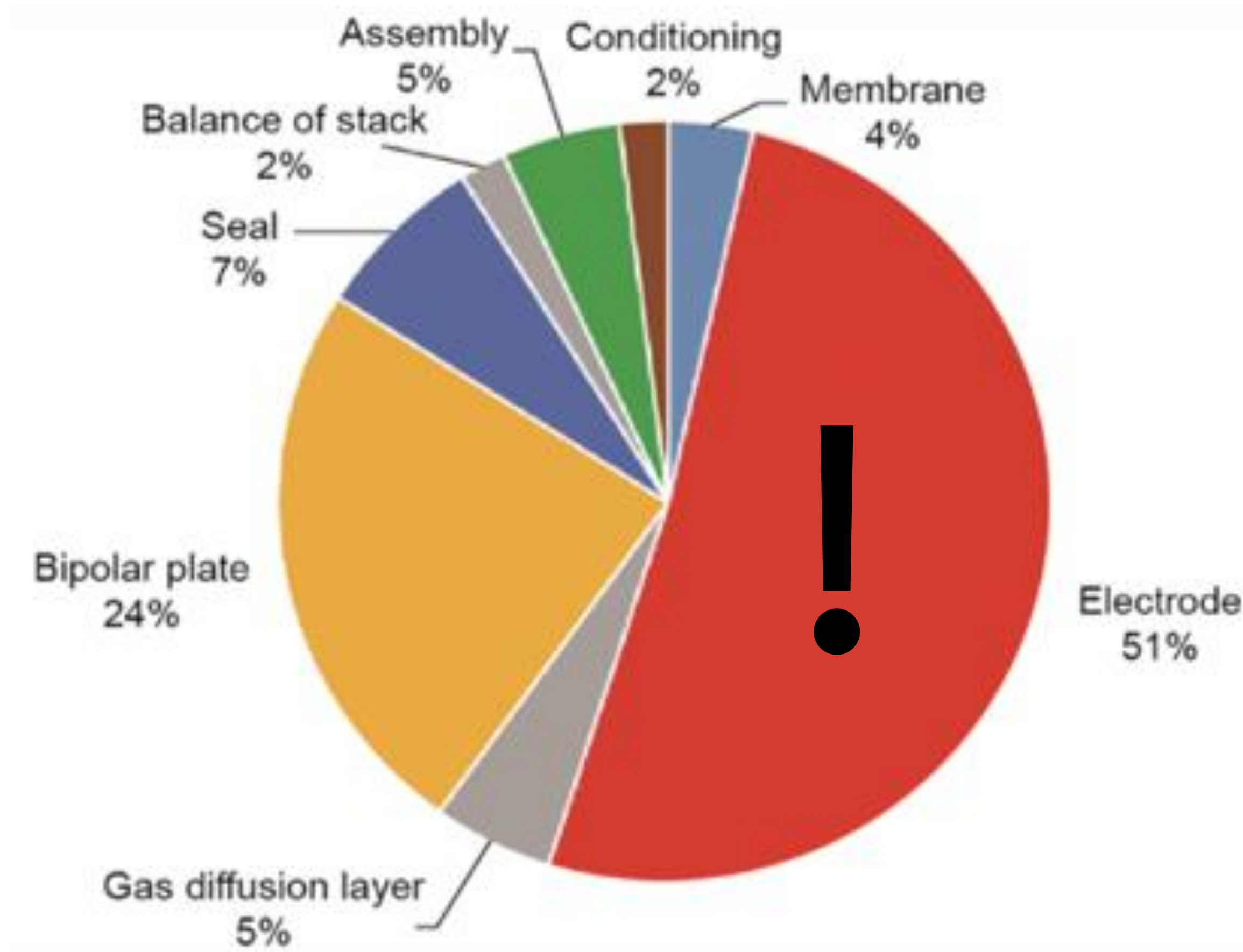
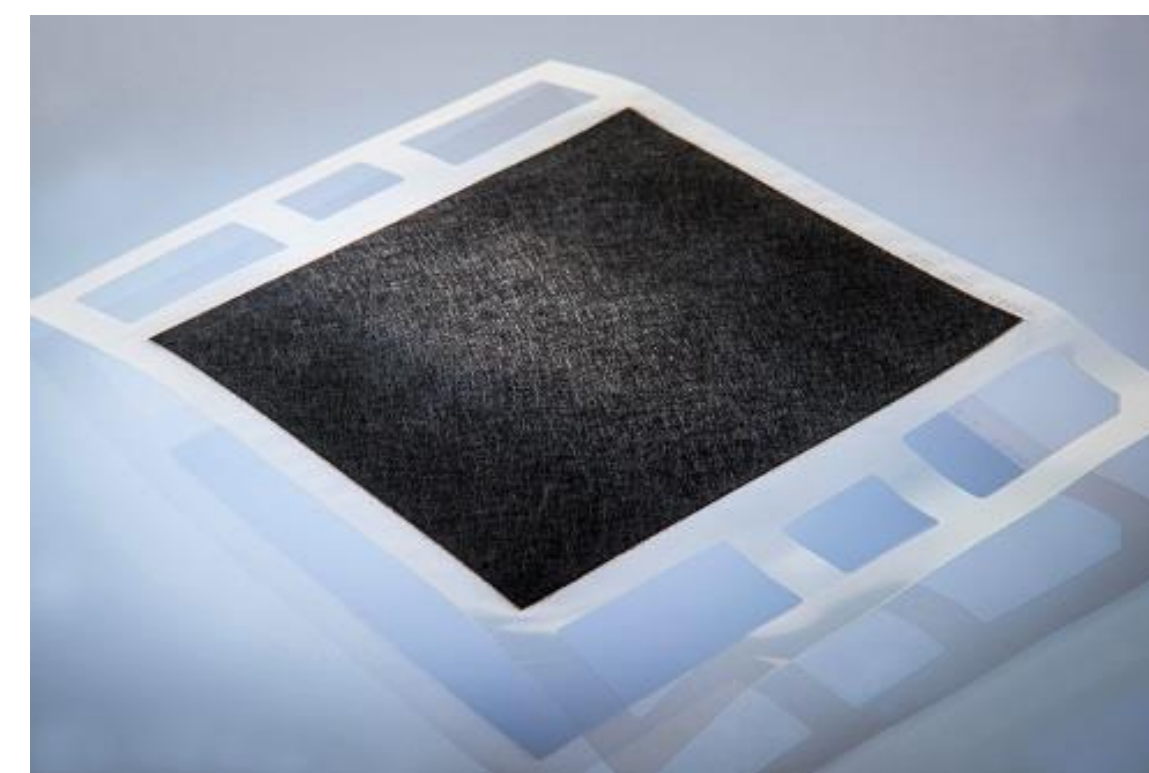


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HOW TO REDUCE THE COST OF FUEL CELL?

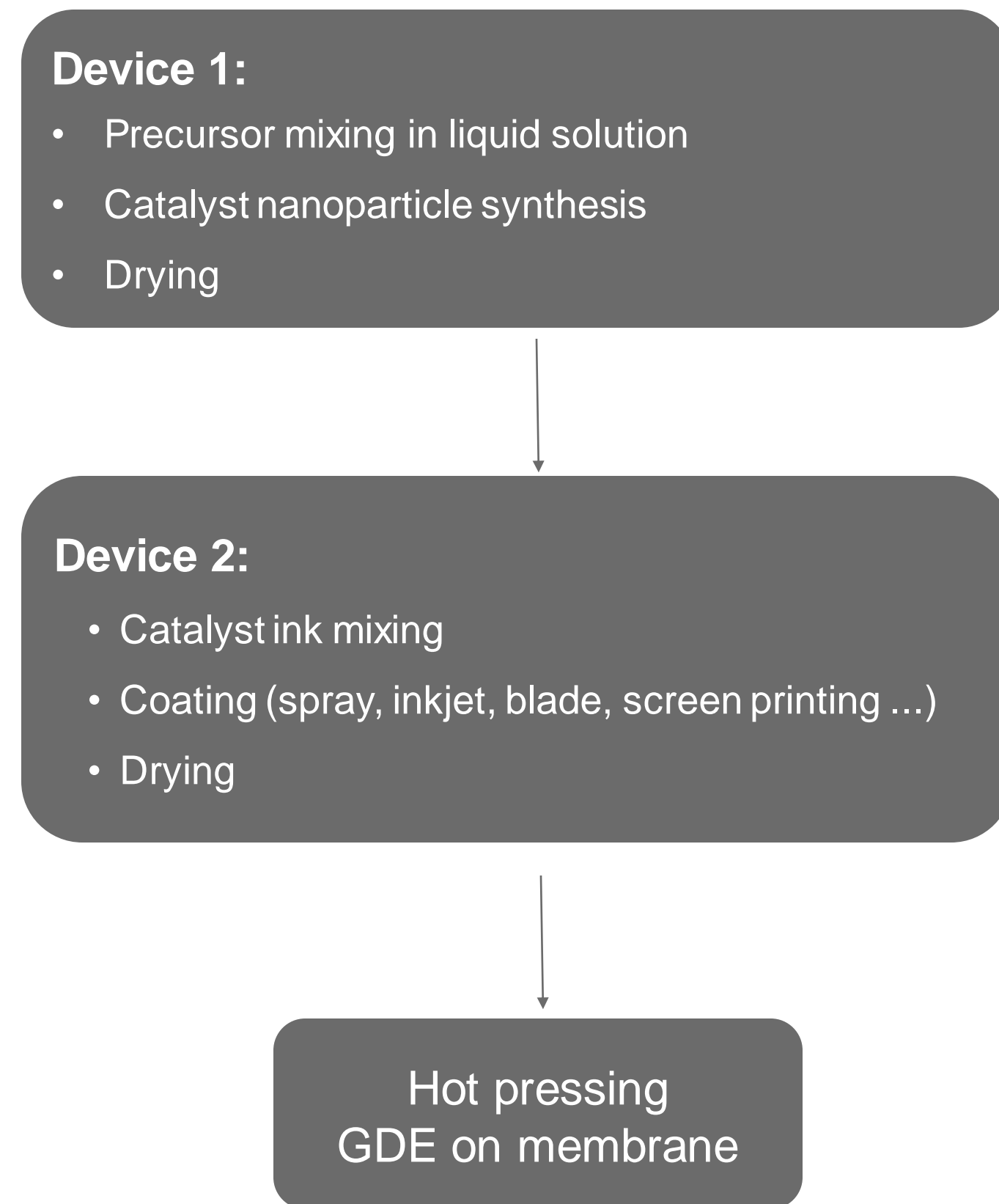


MEA
=
membrane-electrode assembly

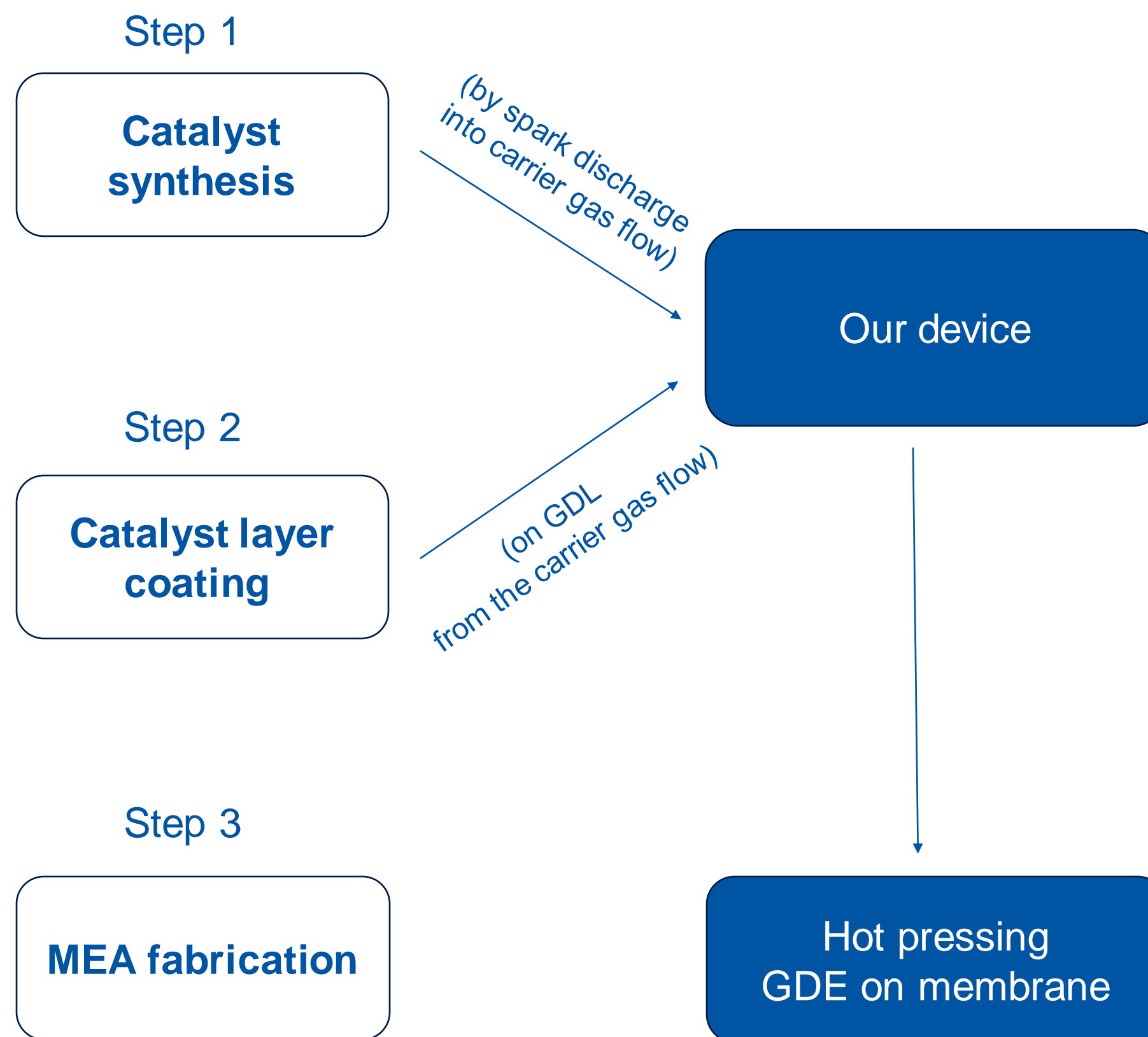


MEA PROCESS COMPARISON

MEA standard process (GDE-based)

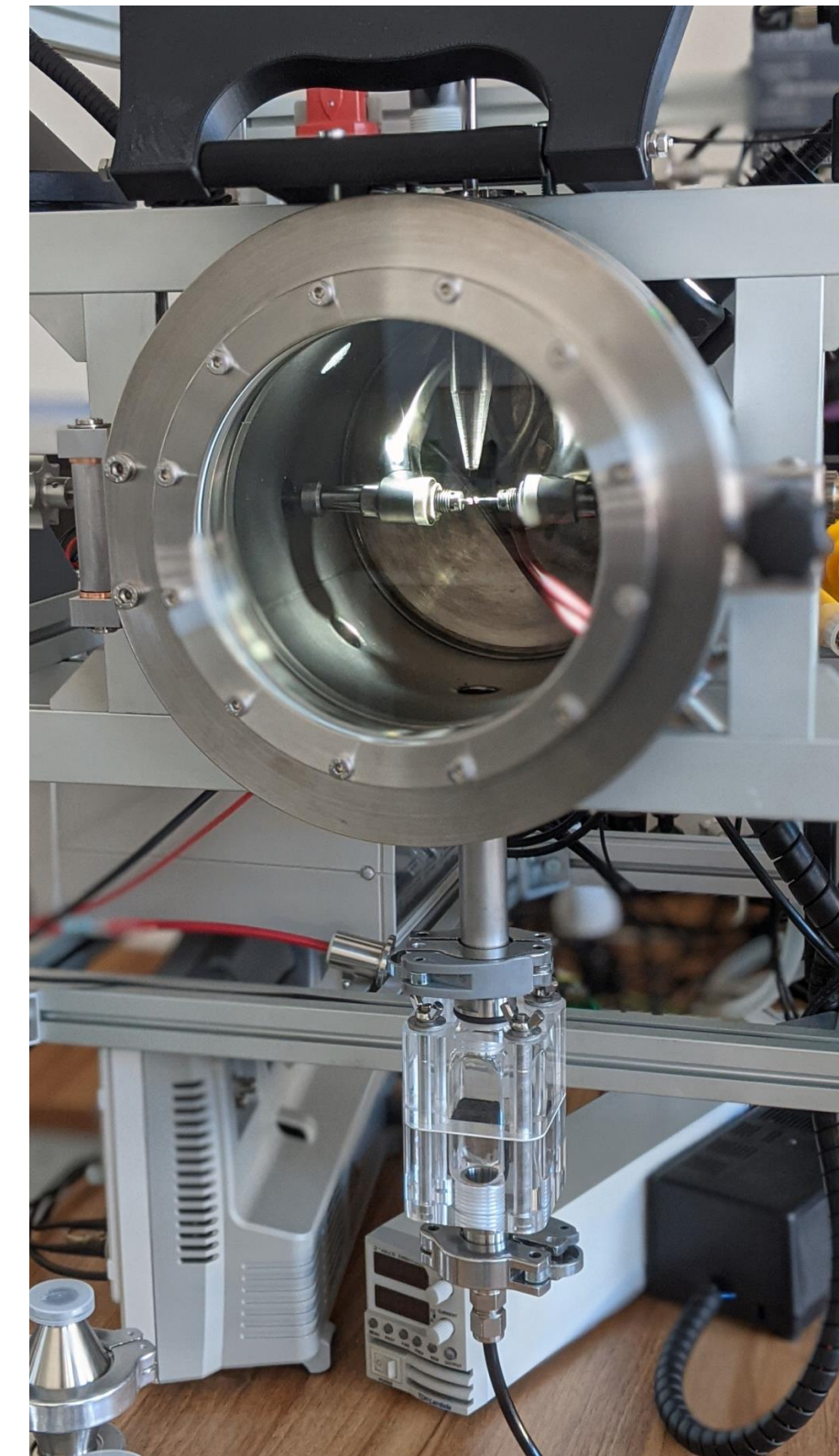


Our MEA process

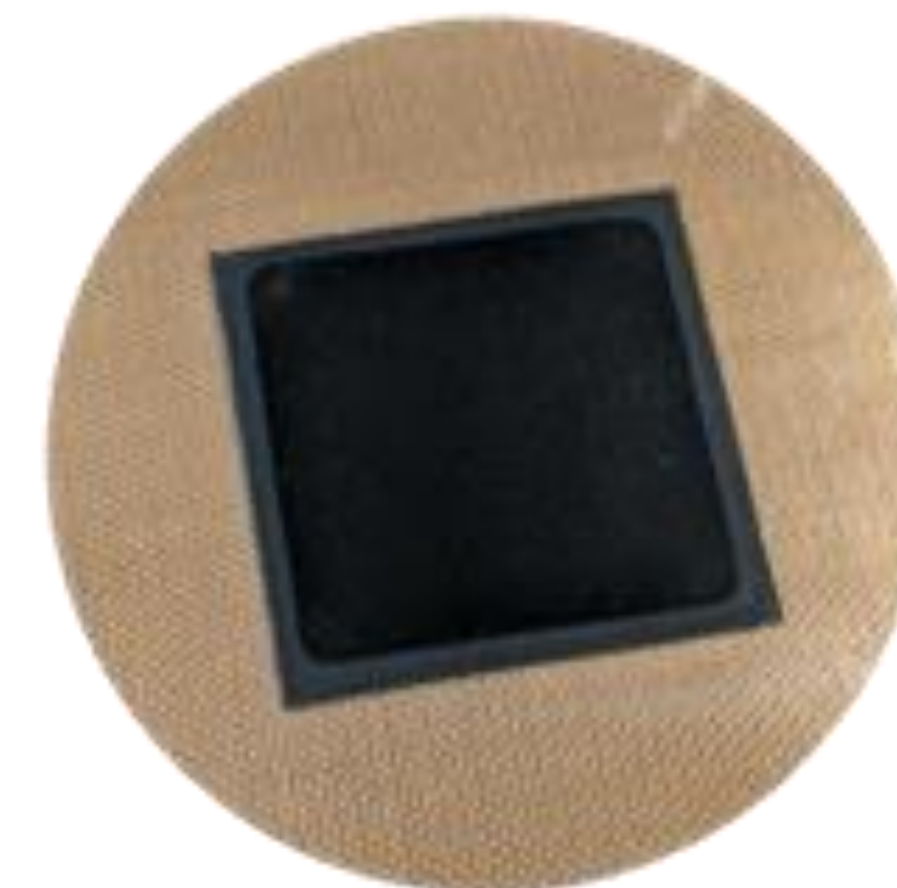
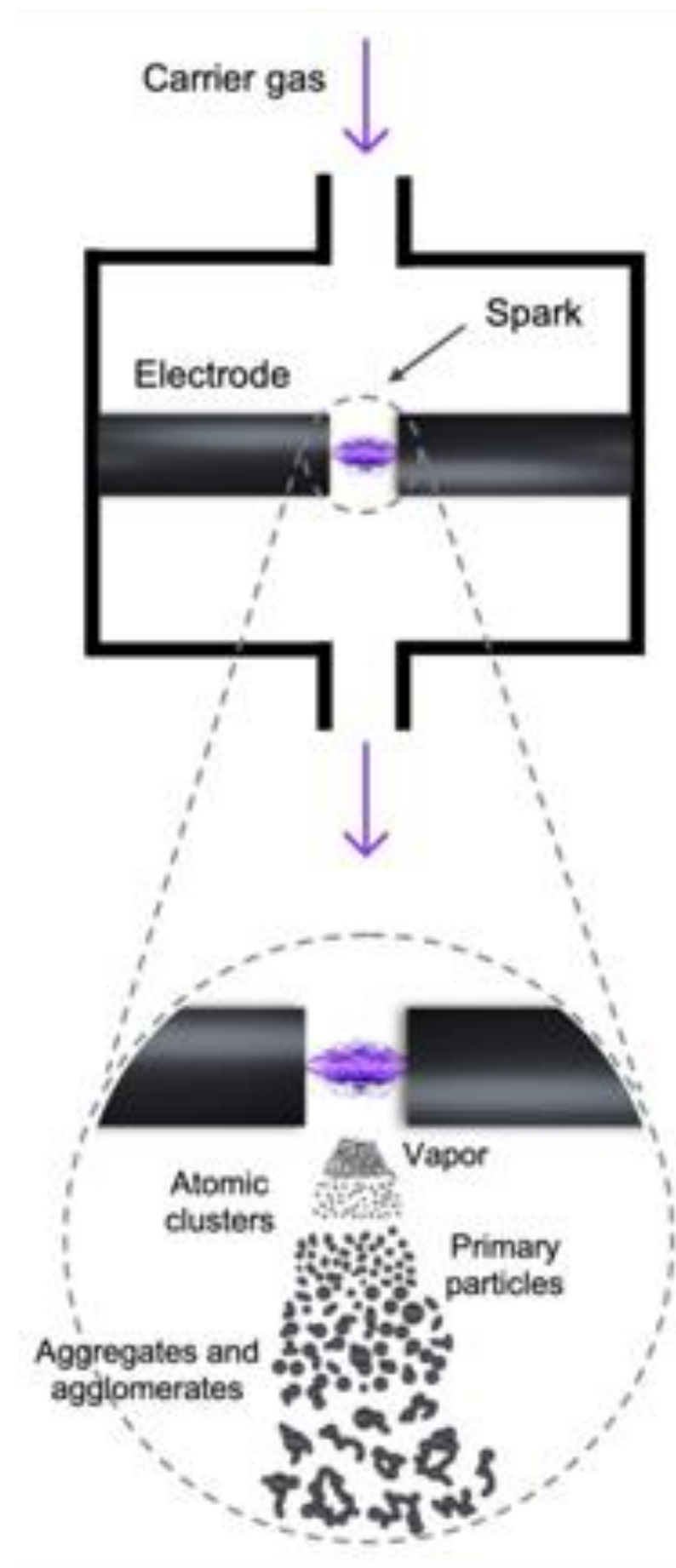
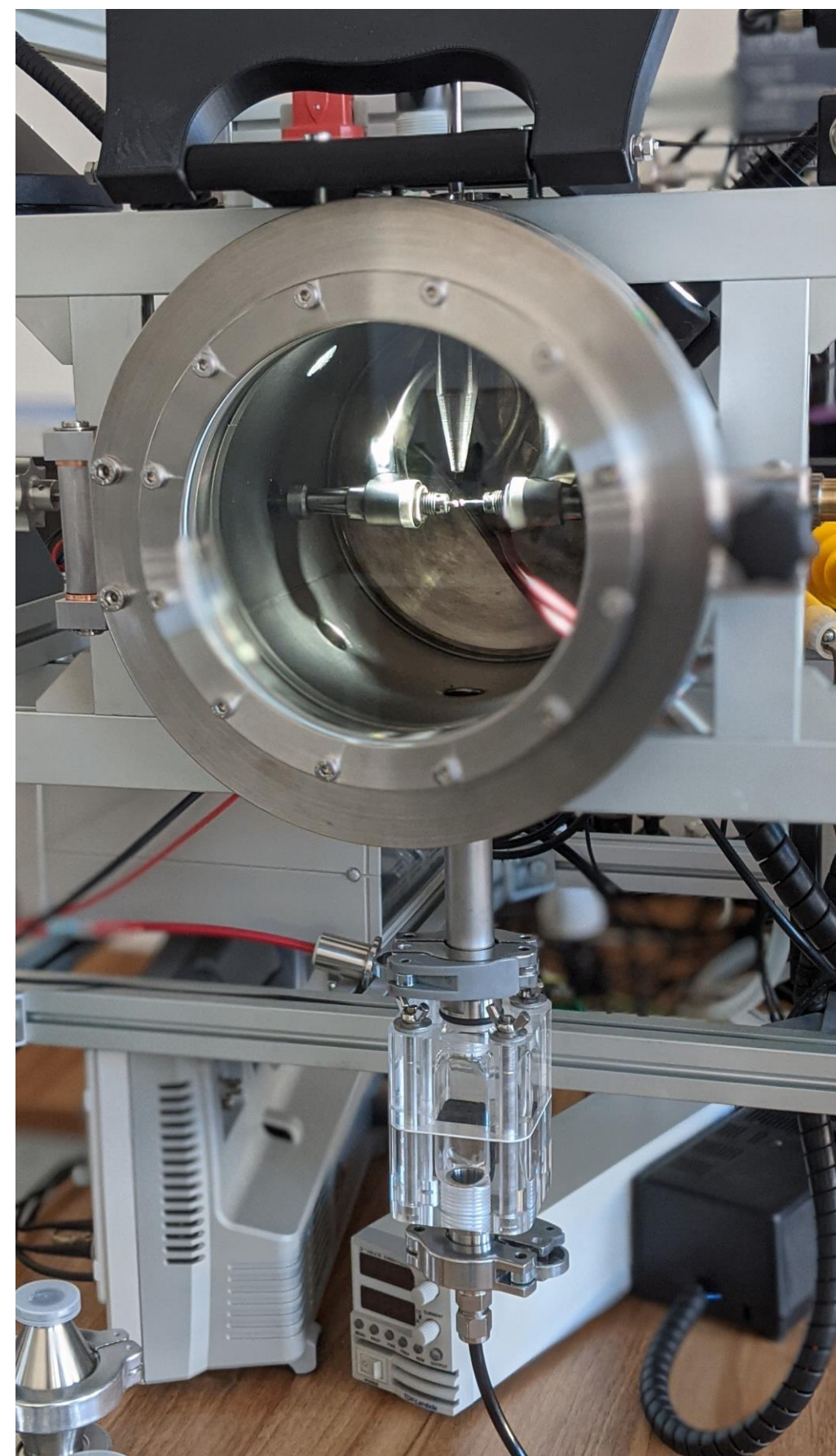


ONE DEVICE

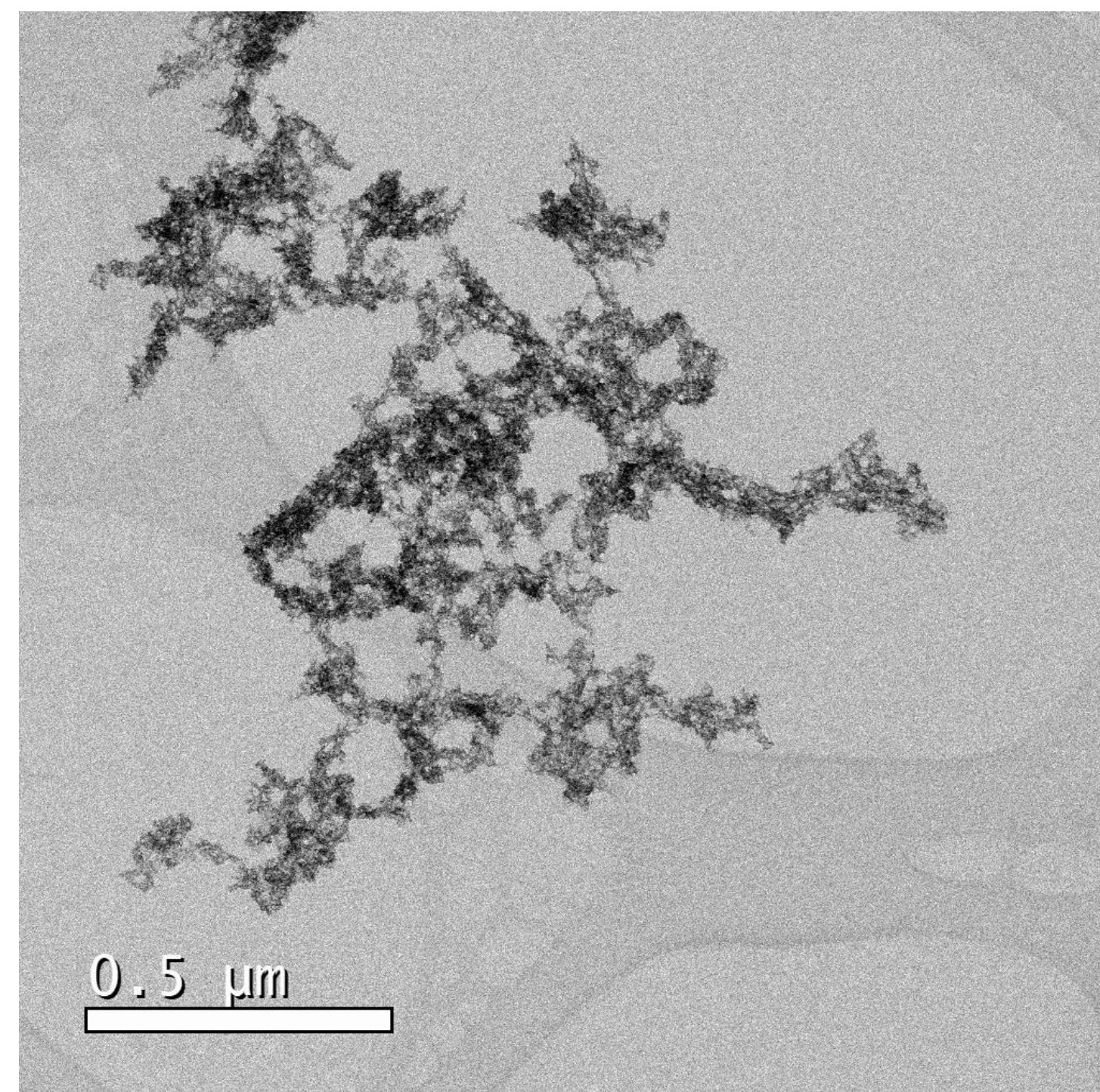
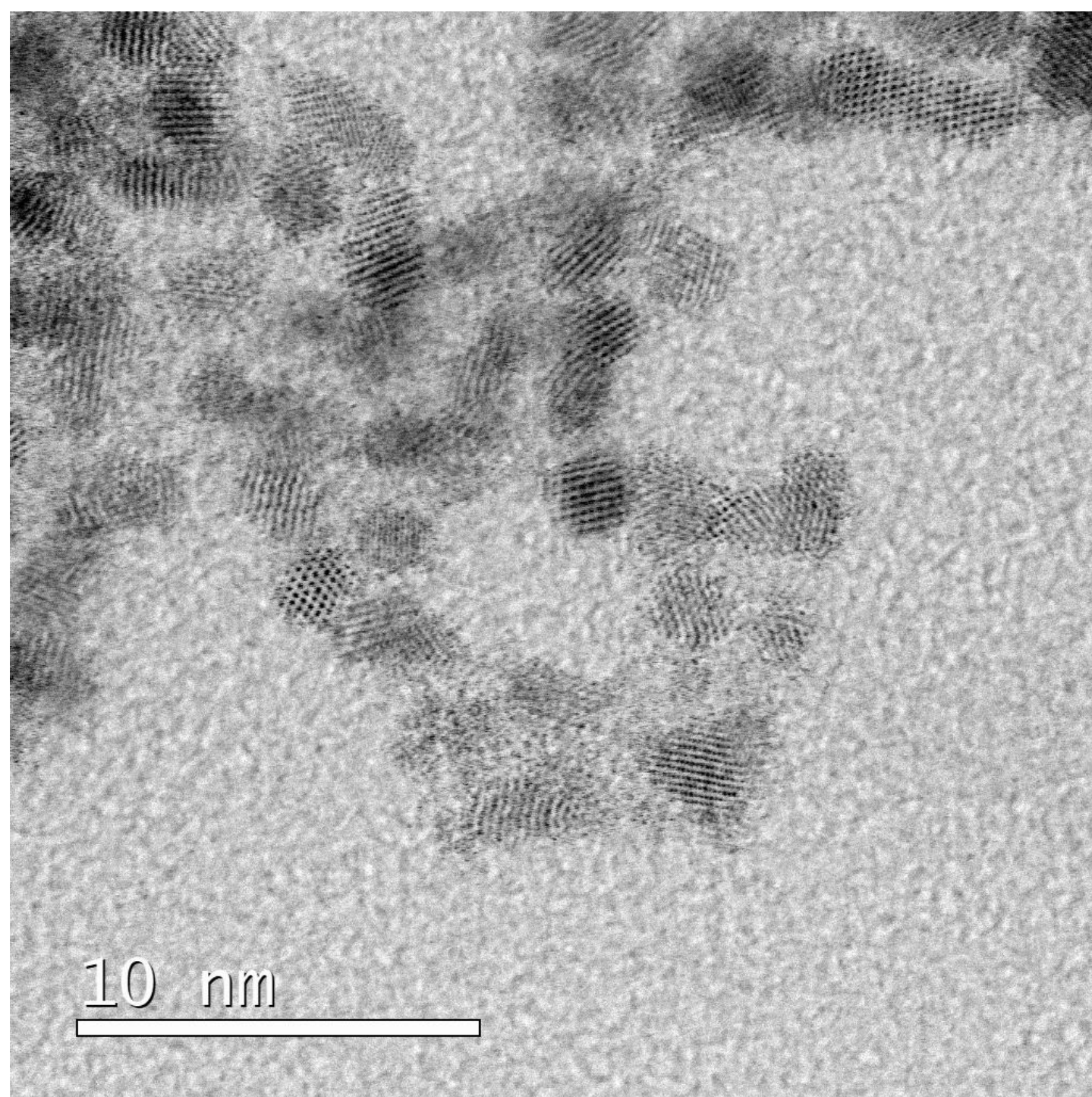
for nanomaterial synthesis
and deposition



SYNTHESIS AND DEPOSITION

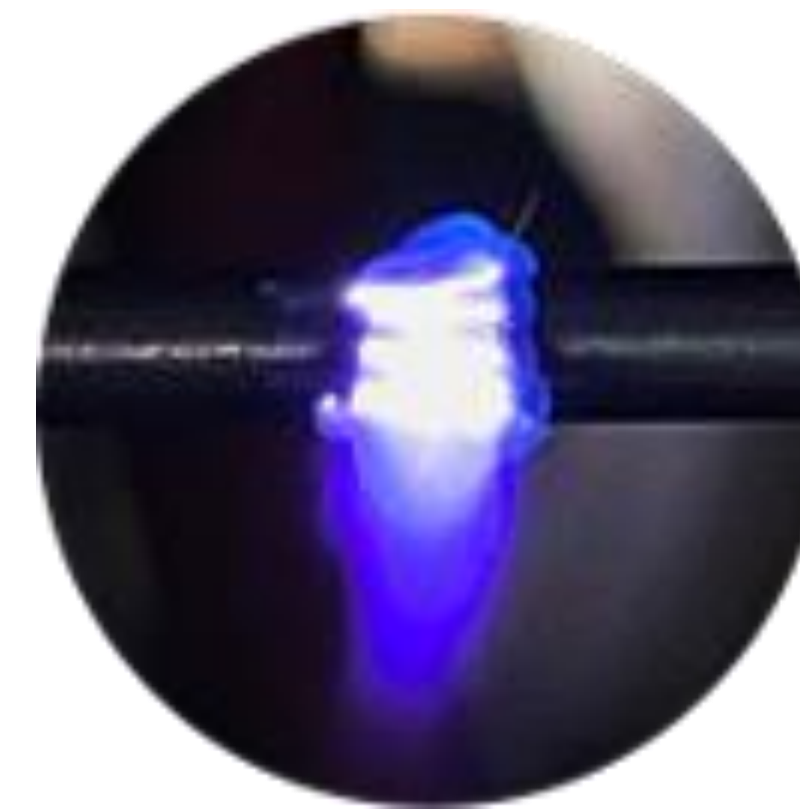


PLATINUM NANOPOWDER BY SPARK SYNTHESIS



BENEFITS OF SPARK SYNTHESIS

- Gas-phase synthesis process (no liquids involved)
- High-purity nanoparticles (99.95%), low waste
- Uniform and reproducible layer deposition
- Scalability by multiple parallel spark units
- Nanoalloy mixing or hybrid structures (Pt with other metals or Pt on C)



IMPLEMENTATION AREAS

Catalyst layers for hydrogen technologies

- **PEM fuel cells**
- PEM electrolyzers
- Electrochemical hydrogen compressor

Supercapacitors

- Metal-oxide electrode nanomaterials

Gas sensors

- Chemiresistive nanomaterials

Research and development

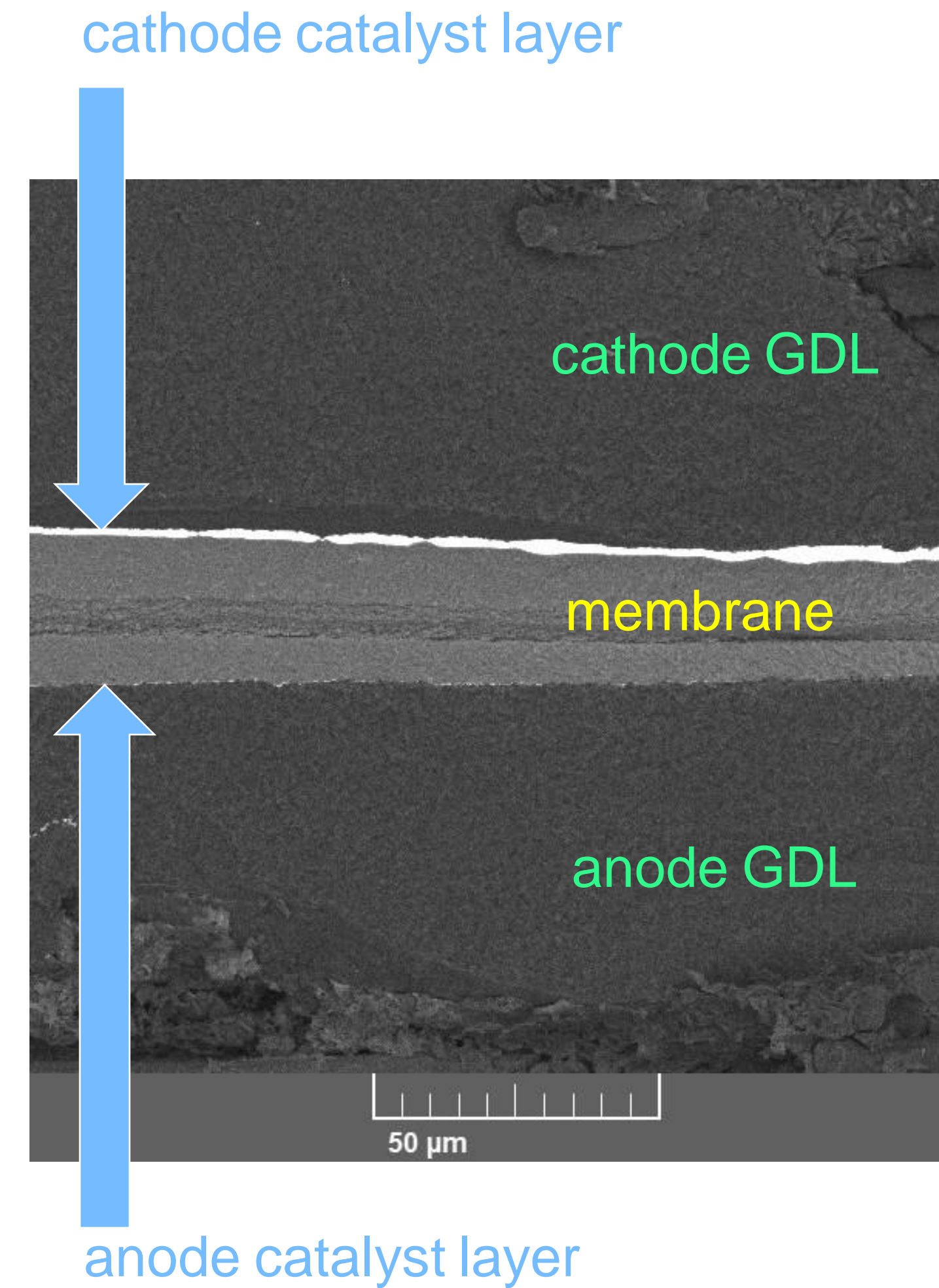
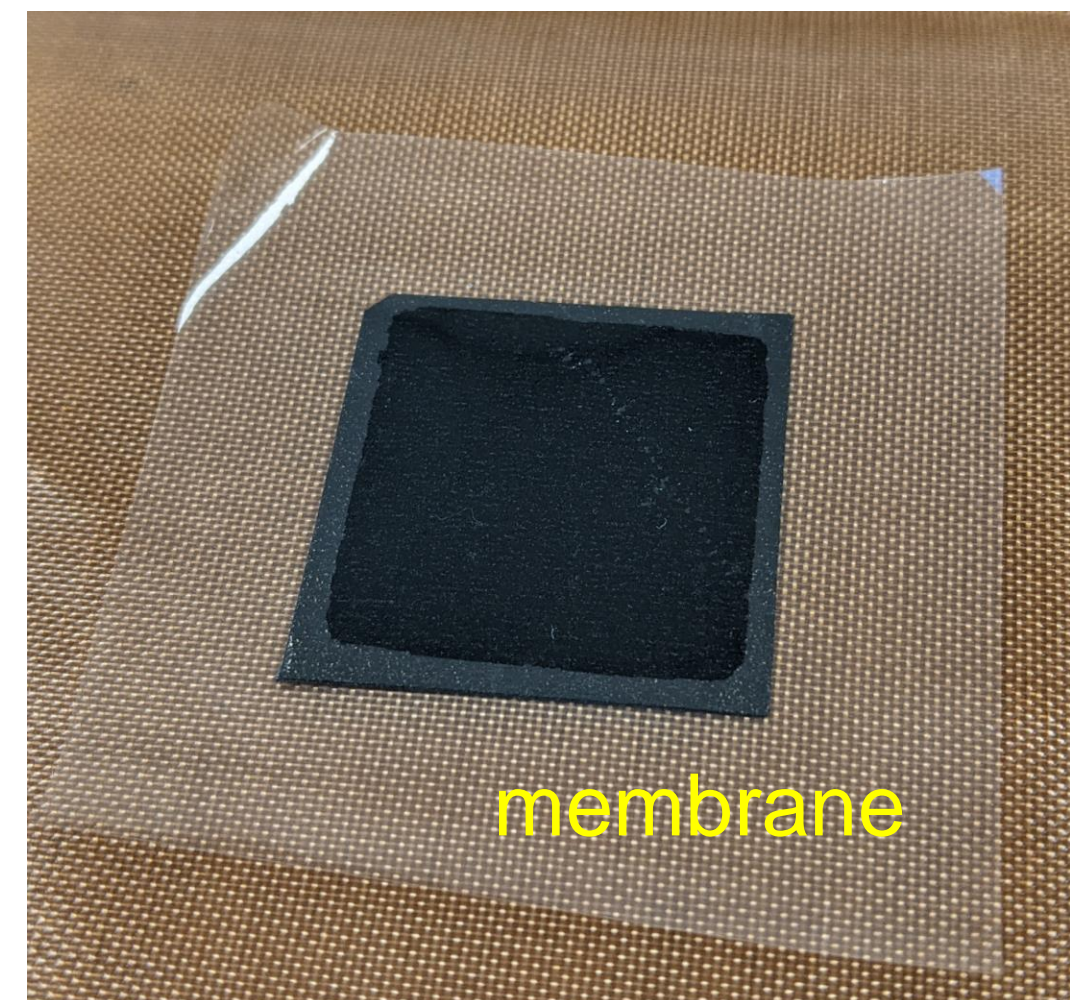
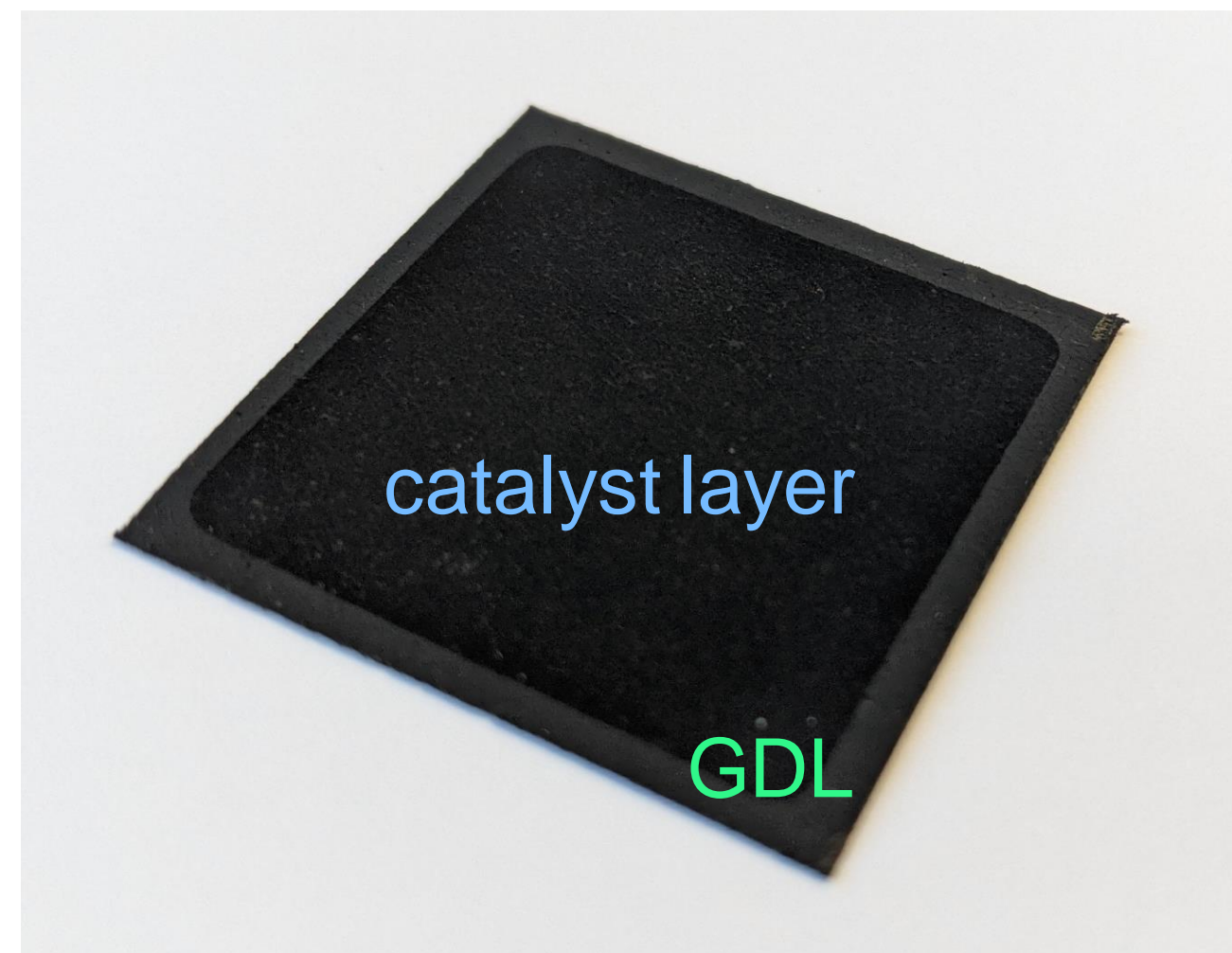
(spectroscopy, catalytic synthesis ...)

- Synthesis of new nanostructured materials and deposition of functional layers

CATALYST LAYER DEPOSITION

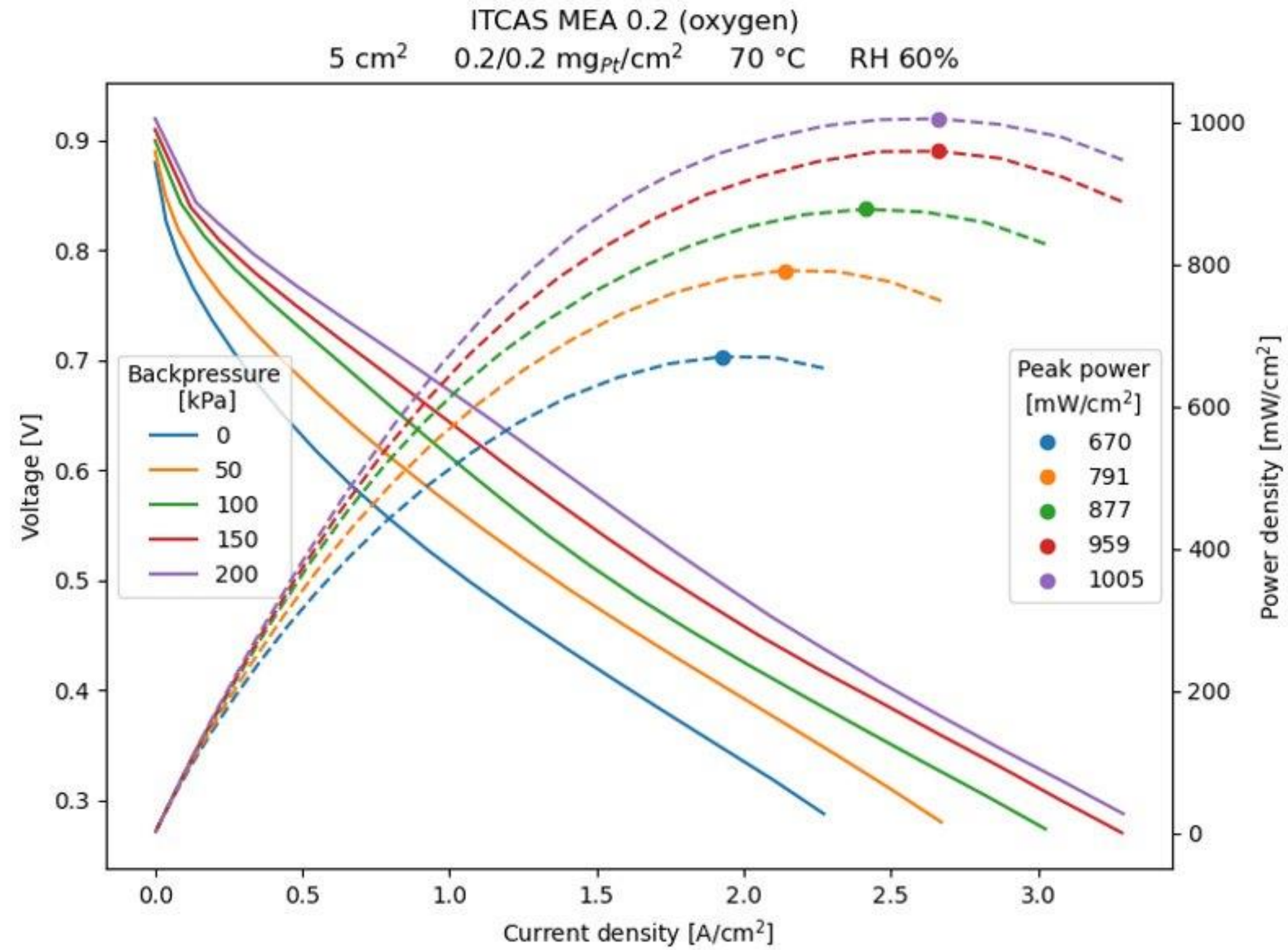
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MEA FABRICATION



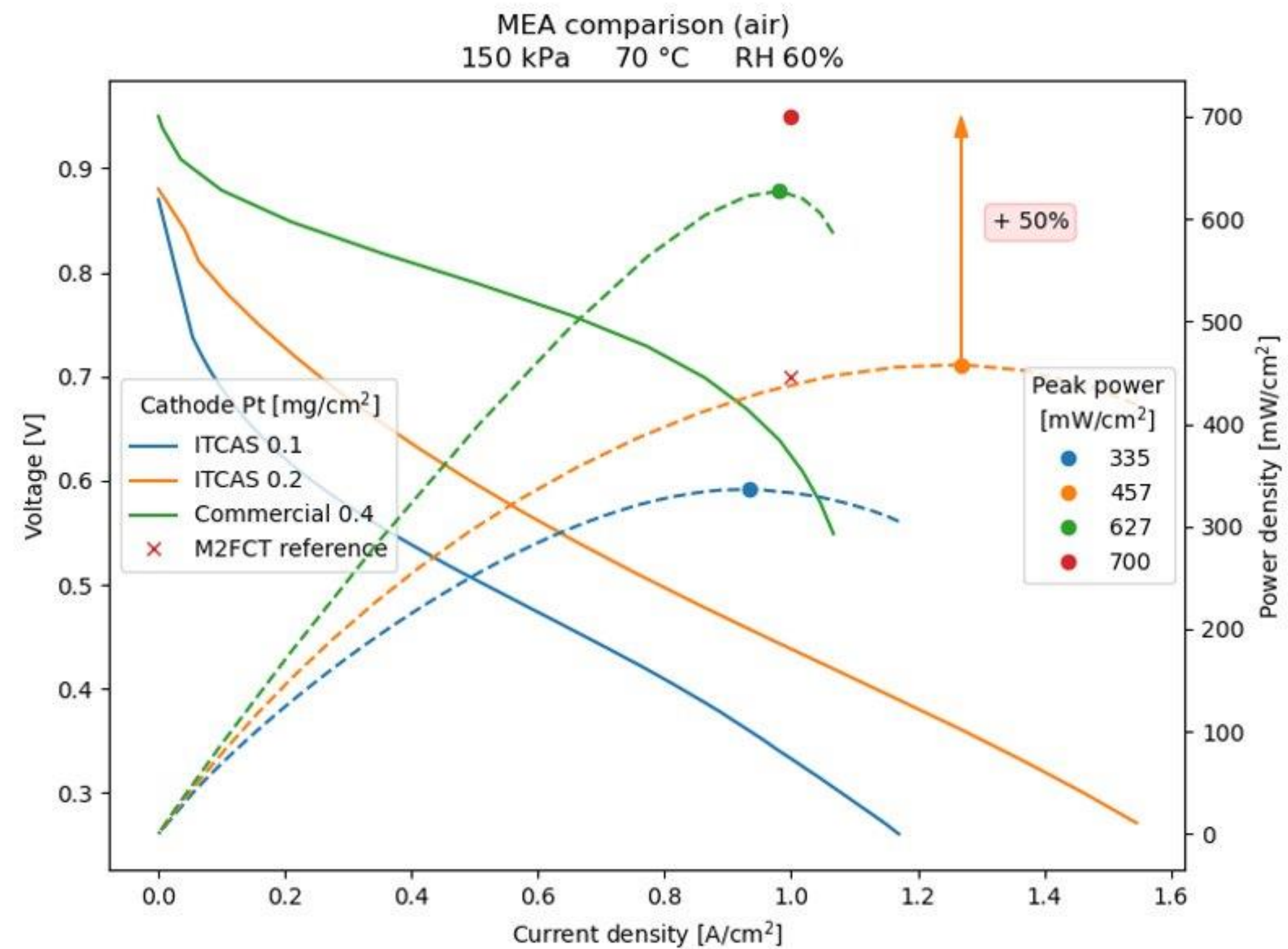
MEA PERFORMANCE

Single cell test (with Nafion HP)



MEA TARGET

Improvement of catalyst layer fabrication
by optimizing the catalyst-to-ionomer
ratio in the catalyst layer



NEAR-TERM GOALS

Commercialization of a laboratory catalyst layer (GDE) deposition system (prototype-to-market)



But first:

- Modular design (spark chamber + deposition chamber + pulsed power unit)
- Optimization and manufacture of spark chamber and deposition chamber
- Optimization and manufacture of high-voltage pulsed power unit
- Control software for process control, monitoring, and automation
- Technical and safety standards compliance

LONG-TERM VISION

Cooperation with research institutions and stack developers on catalyst layer optimization

- Fuel cells
- Electrolyzers

Production scale-up

- Large active area MEAs
- Kg-scale catalyst nanomaterial production

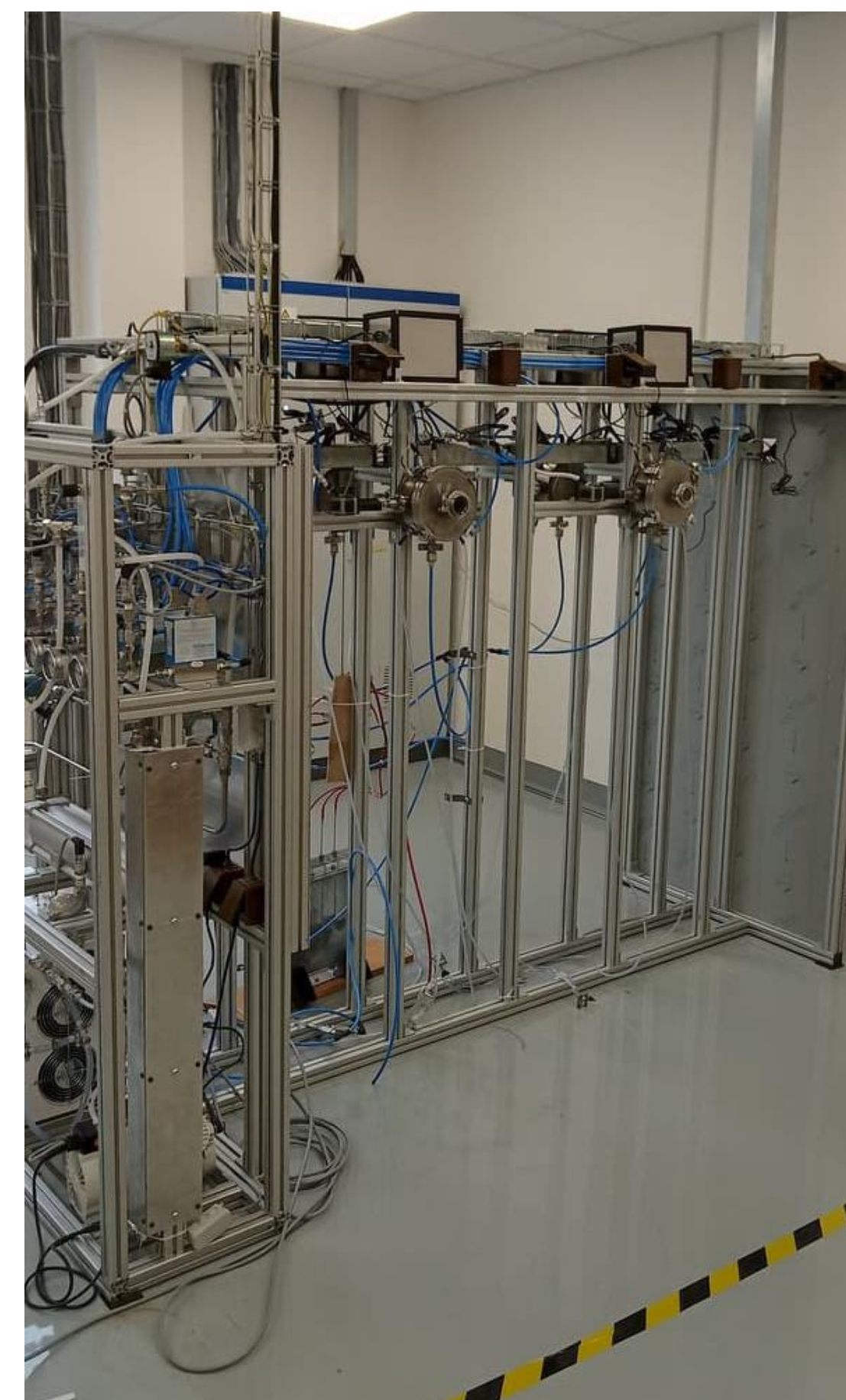
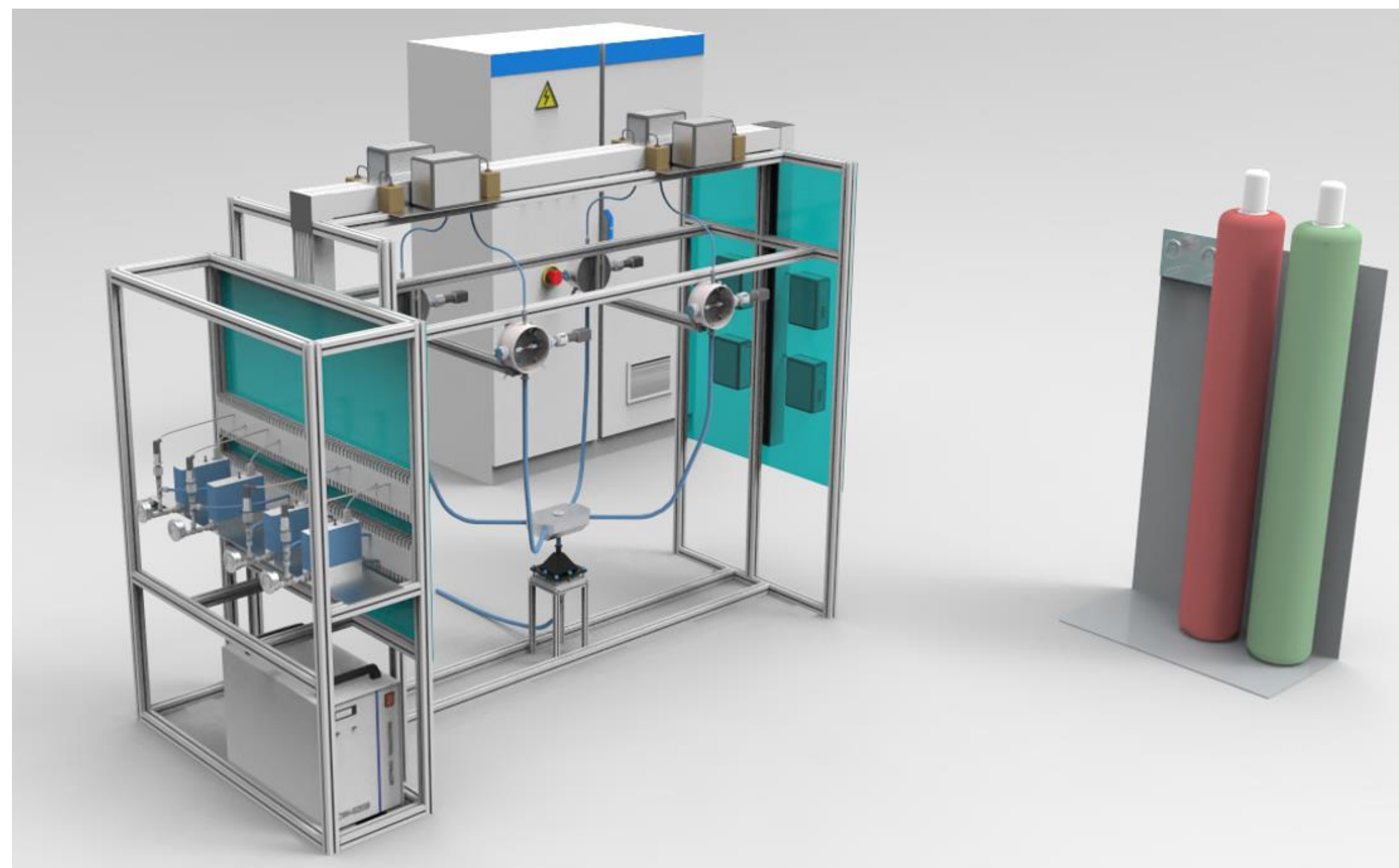
PRODUCTION SCALE-UP OUTLOOK

- **Multiple discharge chambers in parallel**
 - 1-4 cells tested in semi-operation
- **Larger deposition areas**
 - increase of MEA active area from 5 cm² to 100 cm²
- **Multiple spark ablation sources fed into a single deposition chamber**
- **Increase of the spark frequency**

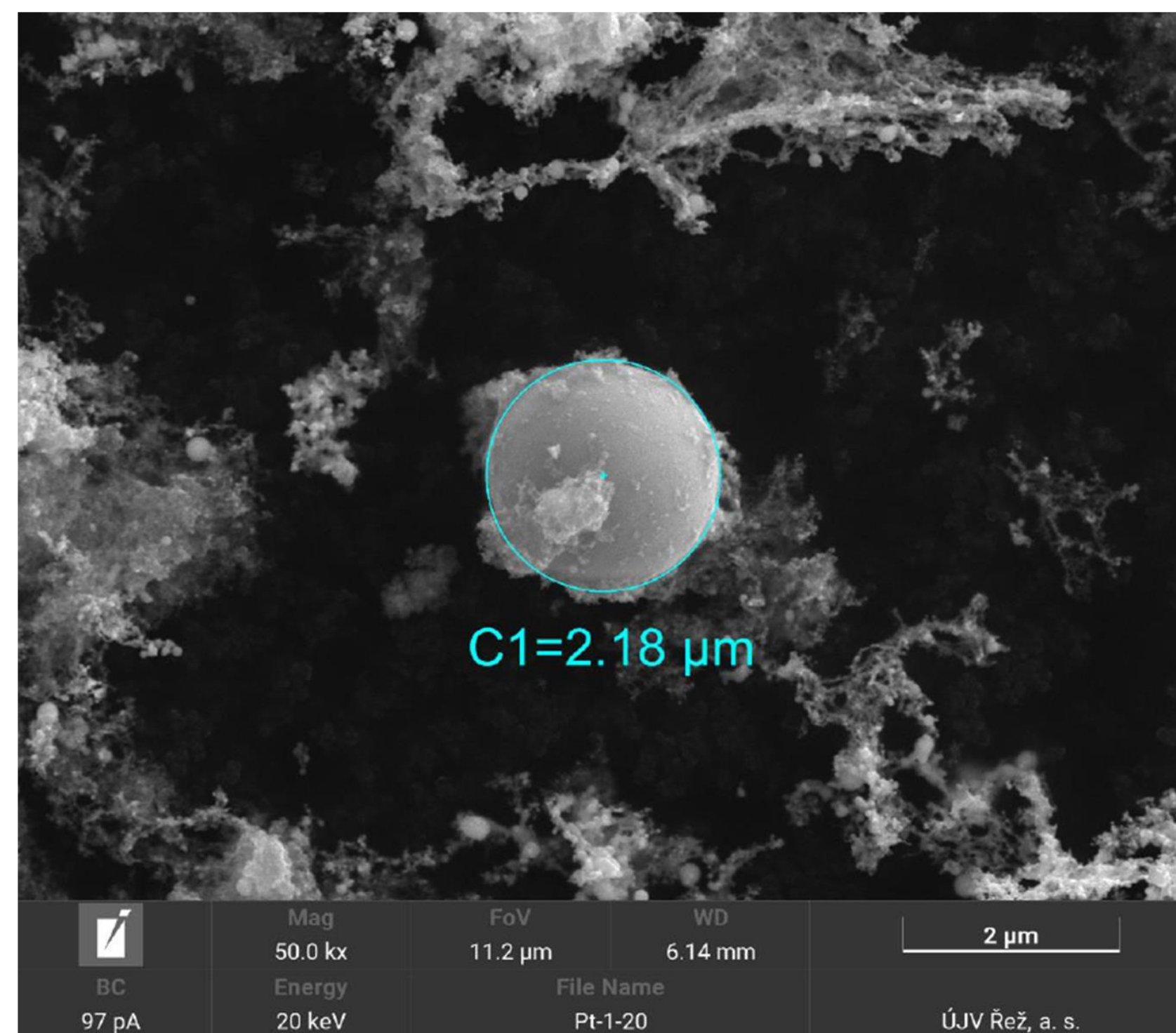
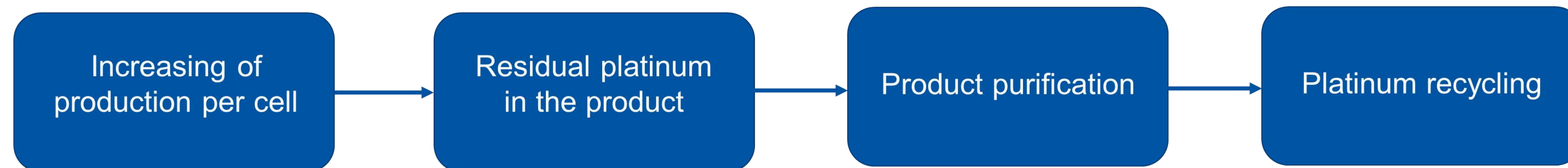
SEMI-OPERATION SCALE

Long-term test operation (1000+ operating hours)

A total of 35g of nanocatalyst was produced



PRODUCTION SCALE-UP CHALLENGES



HOW YOU CAN GET INVOLVED



Commercialization

- Ask questions or pre-order our laboratory research device for your own nanomaterial research
- Test our GDEs or MEAs for PEMFC or suggest other applications (PEMEL, EHC ...)
- Investment



Research and development

- Expansion, simplification and automation of the production process
- Increasing safety of operation
- Establish techniques to tackle scale-up challenges

Thank you for your attention



NUCLEAR
RESEARCH
INSTITUTE

UJV contact:

Aleš Doucek
ÚJV Rež, a. s.
Ales.Doucek@ujv.cz

ITCAS contact:

Tomáš Němec
Institute of Thermomechanics, Czech Academy of Sciences, v. v. i.
nemec@it.cas.cz



UJV Group
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