



Gas-Diffusion Electrocrystallization

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The project has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement N° 958302

PEACOC's value chain for PM recycling



First-of-its-kind, low-cost and eco-friendly technologies for efficient recovery of Au, Ag and PGMs from waste.

Mitigate Europe's dependency on import of critical raw materials from third countries.

Precious metal source

- Automotive catalysts (Pt, Pd, Rh)
- Printed circuit boards (Au)
- Solar Panels (Ag)

Physical pretreatment / conditioning

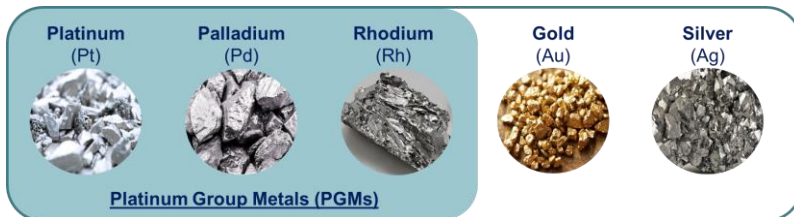
Leaching
MWAL

Recovery

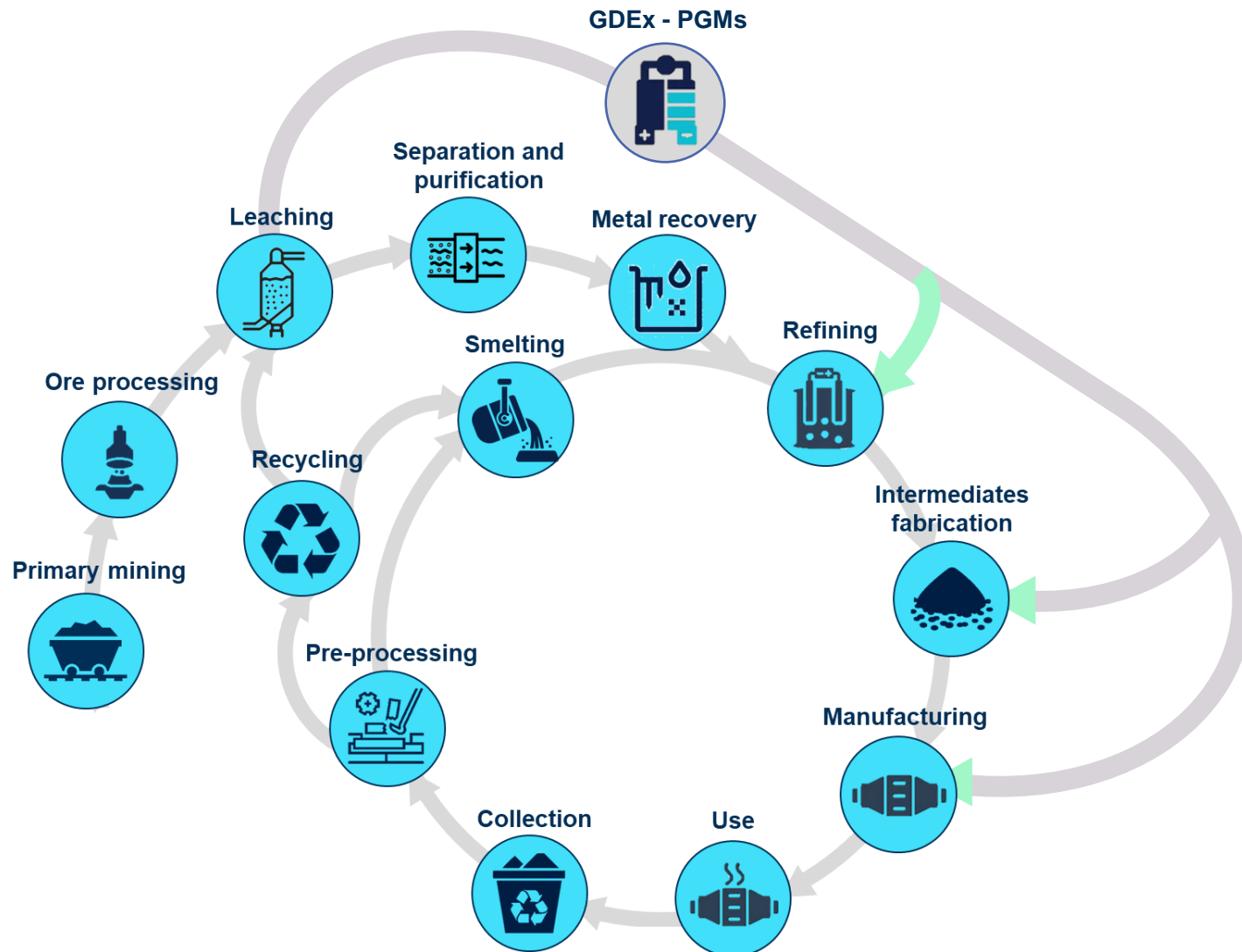
Refining

Same or new applications of the recycled materials

GDEx

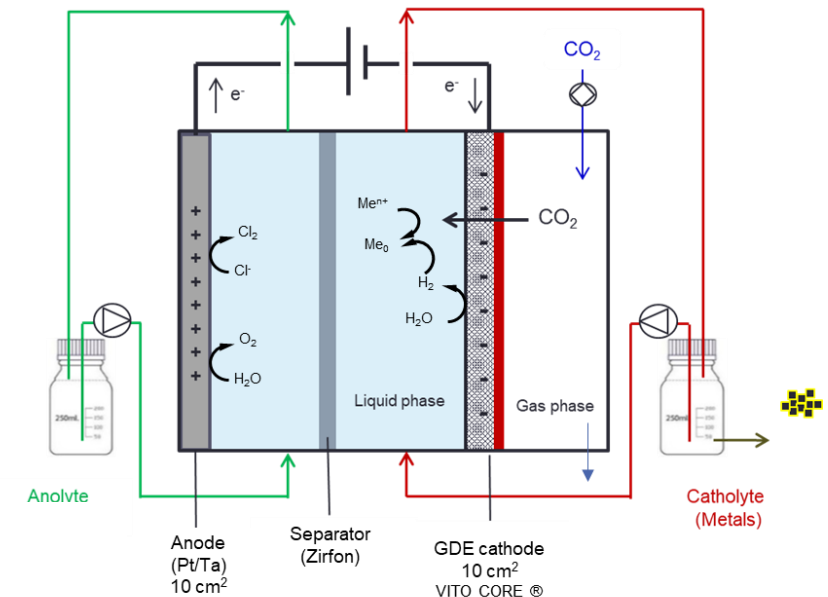


Gas-diffusion electrocrystallization (GDEx)

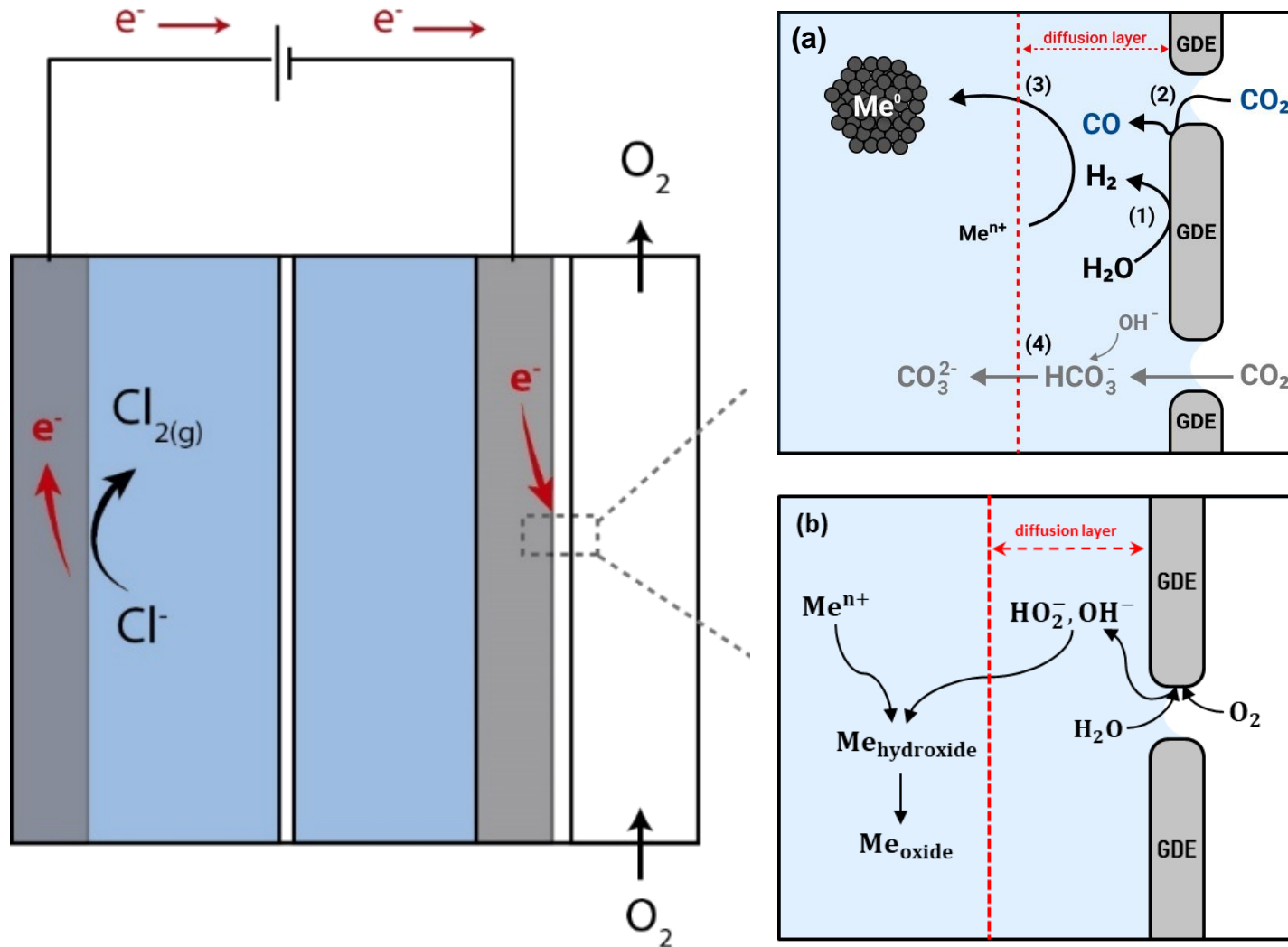


GDEx recovery – PGMs

A sustainable electrochemical process that selectively converts low-grade PGMs from complex PGMs-bearing liquid streams (e.g., leachates) into upcycled products that can be re-integrated into the PGMs value chain.



Gas-diffusion electrocrystallization (GDEx)



GDEx was presented as a great EU-funded innovation by the European Commission for its application on PGM recovery

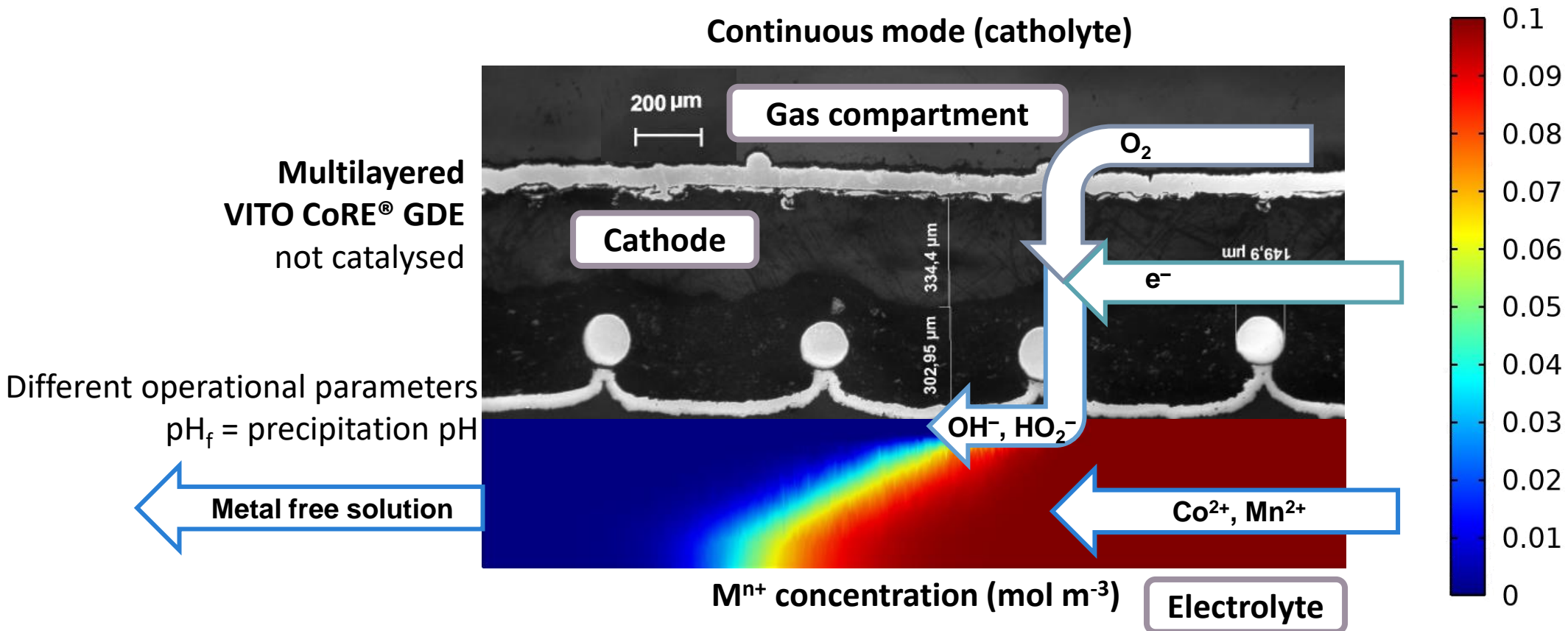
“**GDEx** is an electrochemical process for the synthesis of metallic and/or metal oxide nanoparticles, where reducing or oxidizing agents are produced *in-situ* during the electrochemical reduction (or oxidation) of a gas in a gas-diffusion electrode.

Fig 1. Schematics of GDEx operation depending on gas supplied: (a) CO₂, (b) O₂.

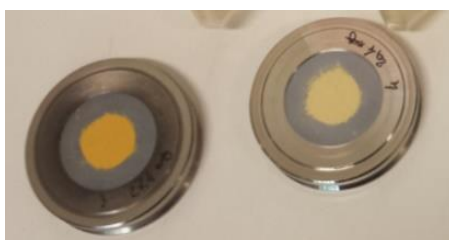
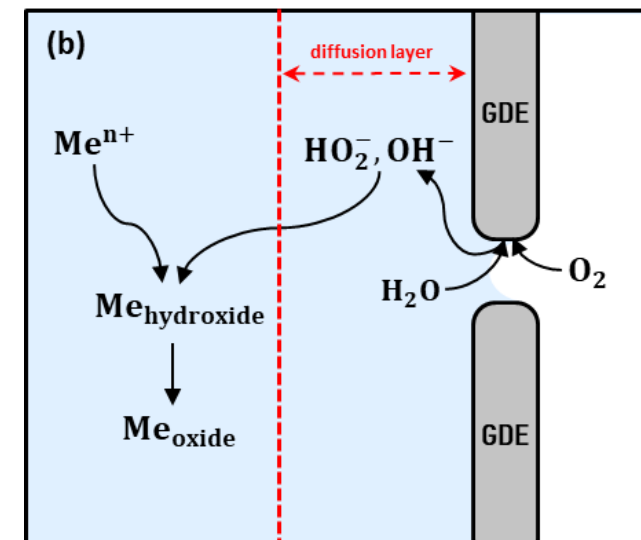
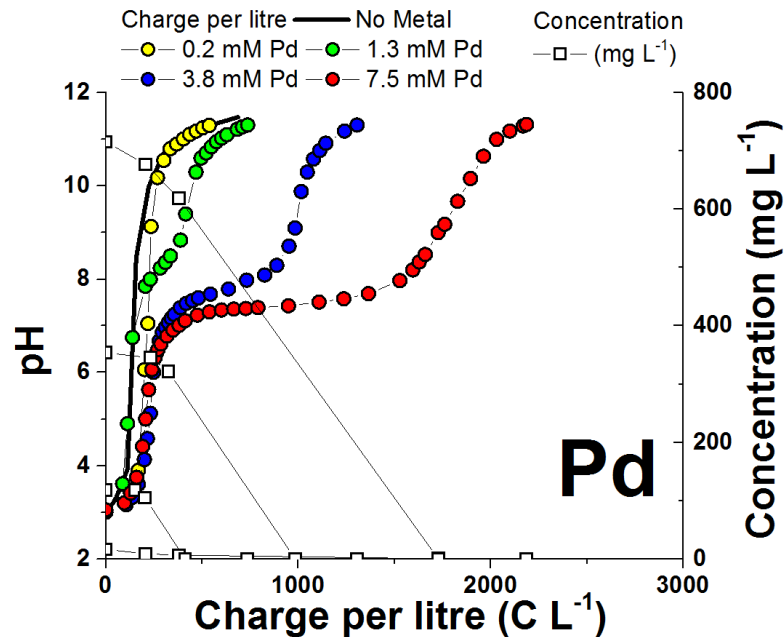
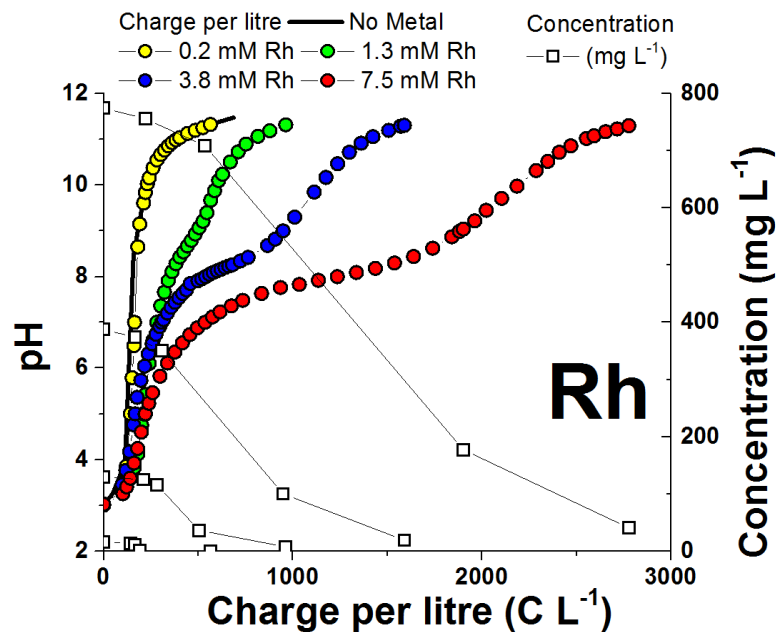
Gas-diffusion electrocrystallization (GDEx)

Gas-diffusion electrode in a flow cell

Addition of selected metal ions in catholyte inlet
Continuous mode (catholyte)



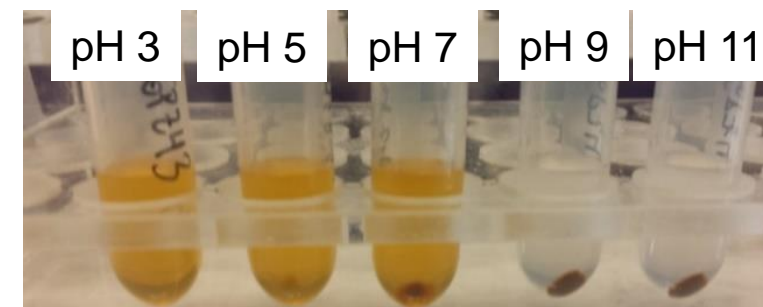
GDEx – O₂ as gas feed-stock



Rh₂O₃ recovery through GDEx

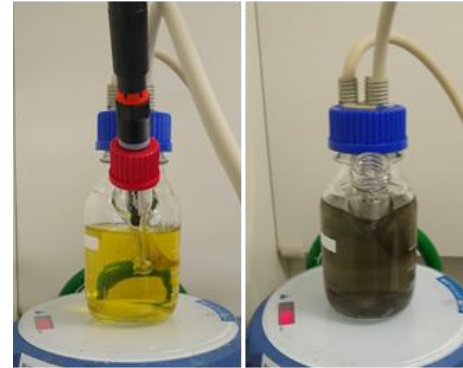
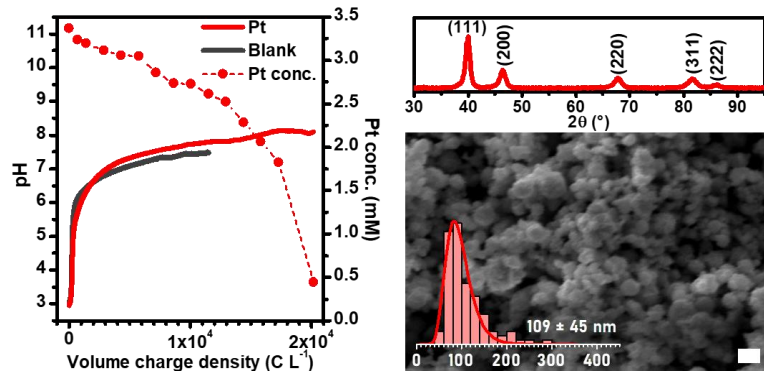


PdO recovery through GDEx



GDEx for direct PGM recovery and NP synthesis

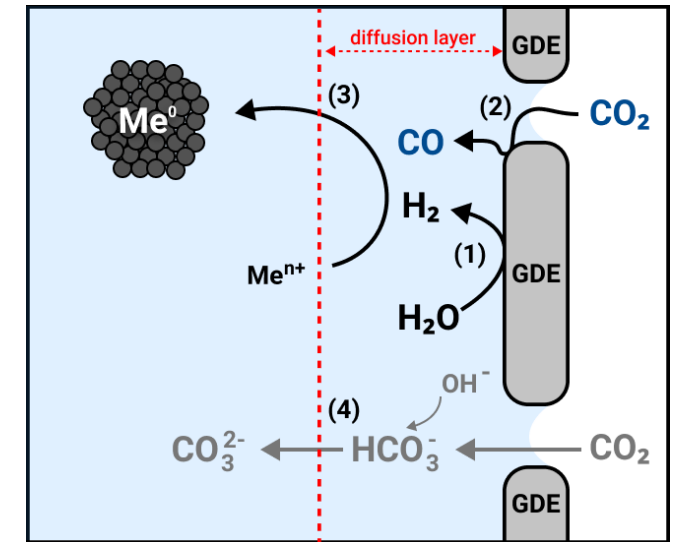
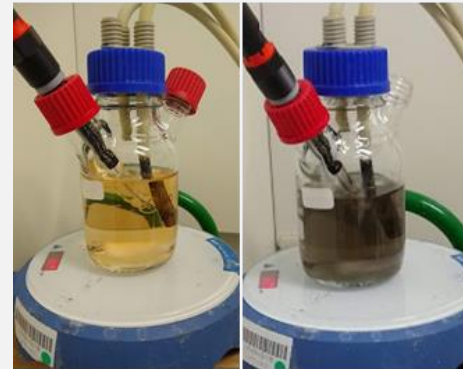
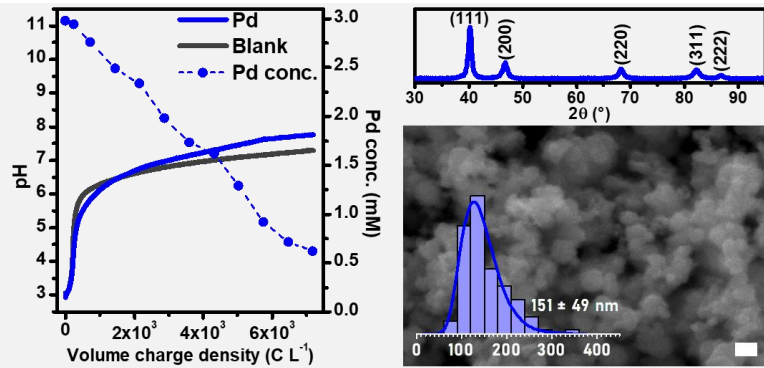
Pt



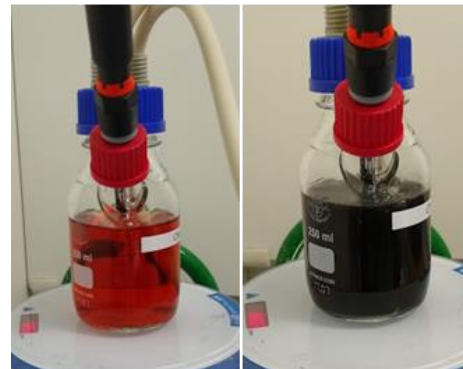
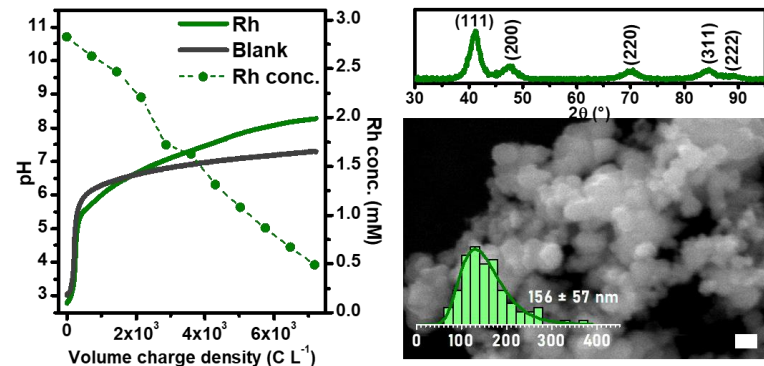
GDEx – CO₂ as gas feed-stock

✓ Effective PGM recovery from synthetic solutions and synthesis of metallic nanoparticles

Pd



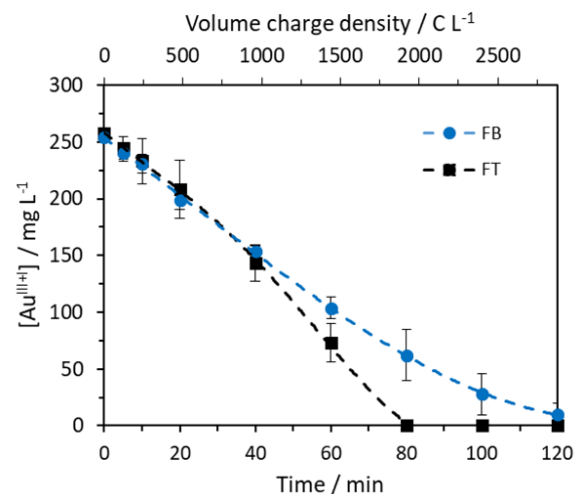
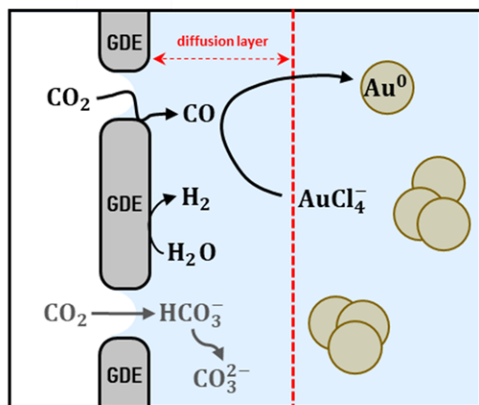
Rh



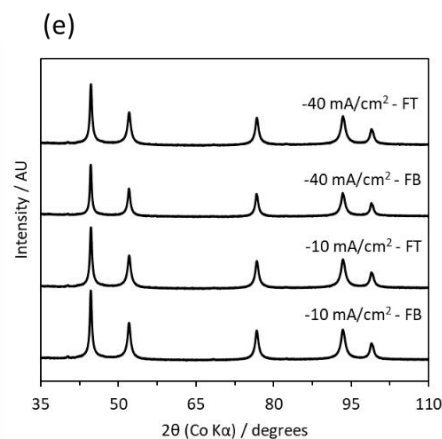
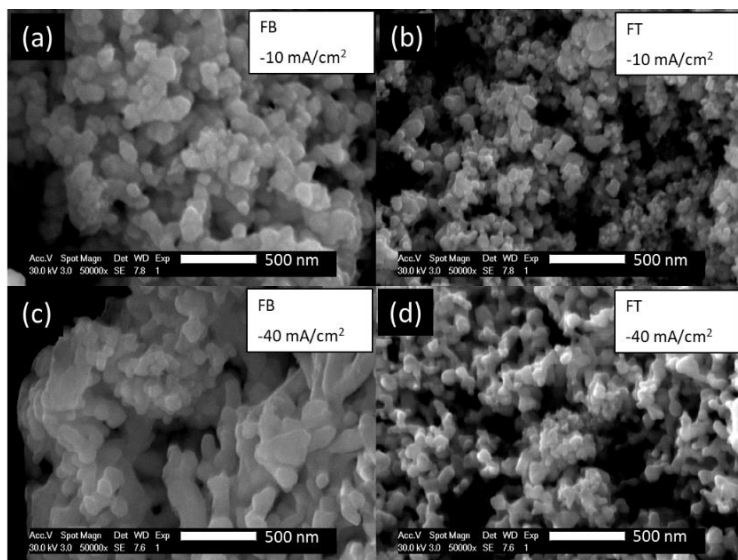
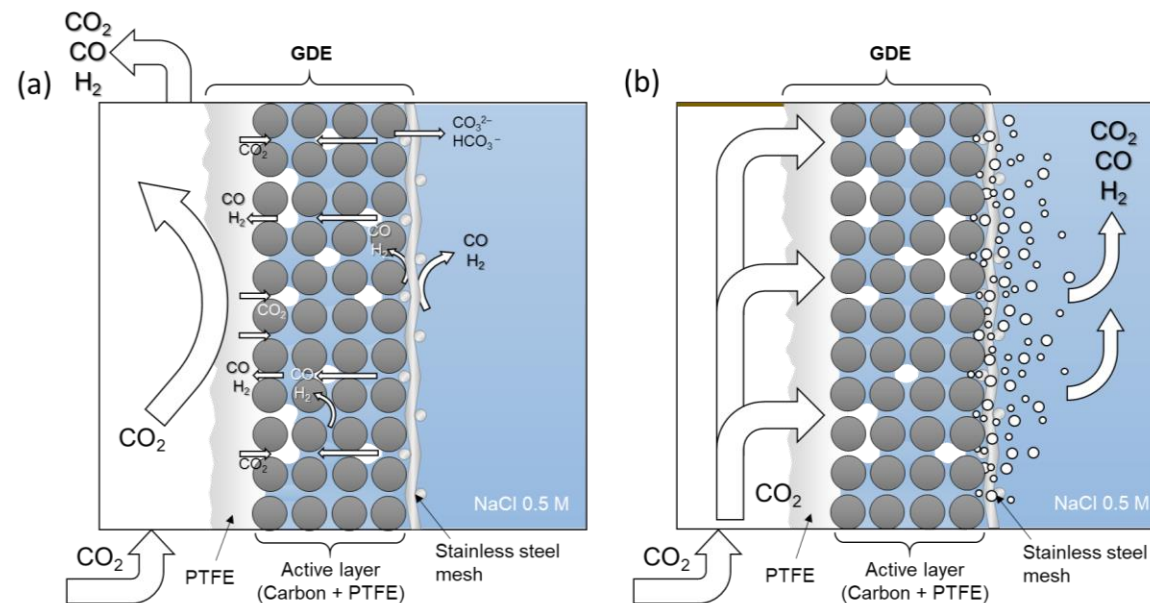
- Martinez Mora, O., G. Pozo, L. F. Leon-Fernandez, J. Fransaer and X. Dominguez-Benetton (2023). "Synthesis of platinum group metal nanoparticles assisted by CO₂ reduction and H₂ cogeneration at gas-diffusion electrodes." *RSC Sustainability*.

GDEx for direct Au (and Ag) recovery and NP synthesis

Optimization of operating conditions for Au recovery and direct NP synthesis



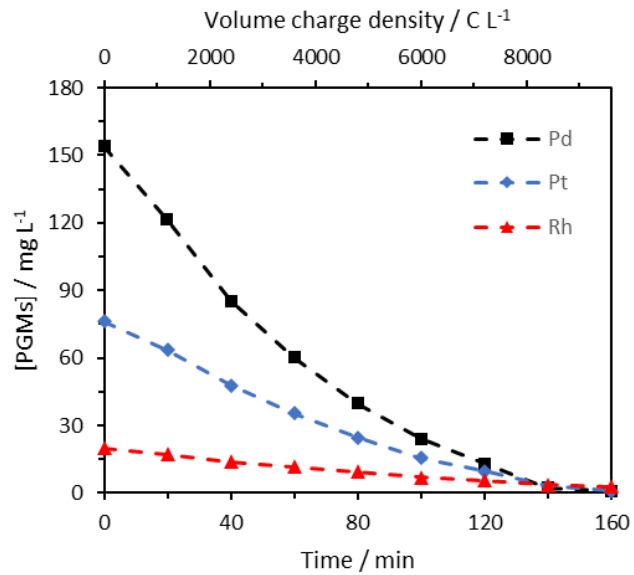
GDEx – CO₂ as gas feed-stock



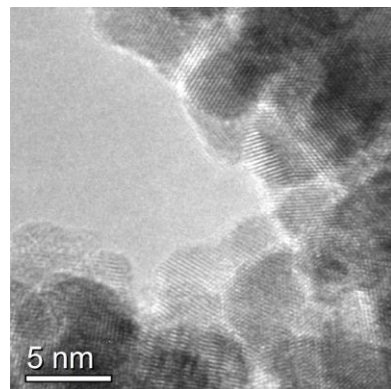
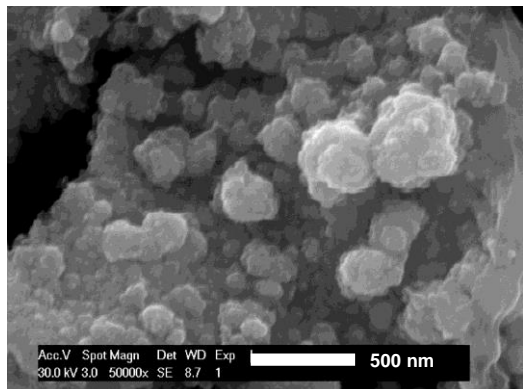
1. L.F. Leon-Fernandez, Martinez Mora, A. Caballero-Ortiz, J. Fransaer and X. Dominguez-Benetton (2023). "Mechanism and kinetics of gold recovery and Au nanoparticle synthesis by Gas-Diffusion Electrocrystallization (GDEx)" *Electrochimica Acta*.

GDEx applied to relevant industrial streams

MWAL Leachates from automotive catalysts

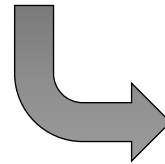


- ✓ Pd, Pt, Rh
- ✓ 15 – 170 ppm
- ✓ ↓ pH

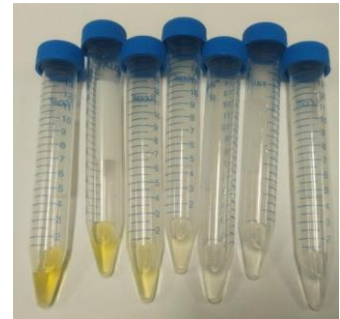


JM samples

Pd, Pt, Rh, Ir, Ru, Os
10 – 100 ppm



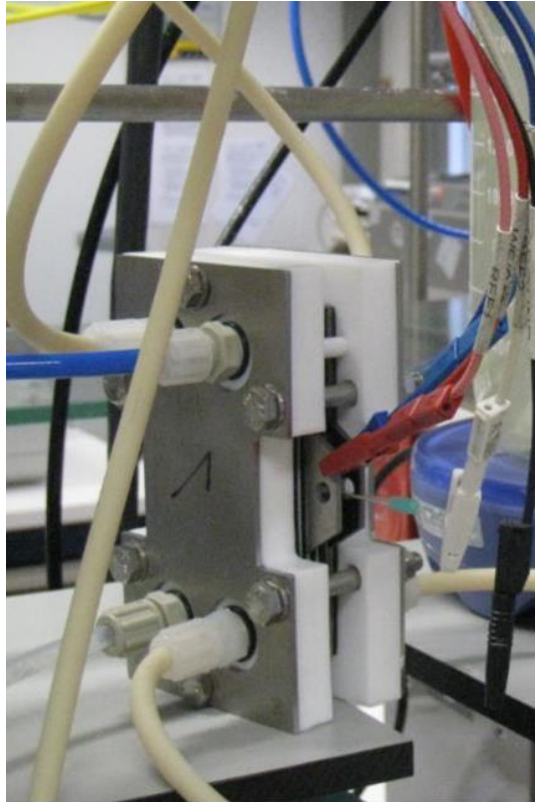
Effective PGM recovery
(>95%)



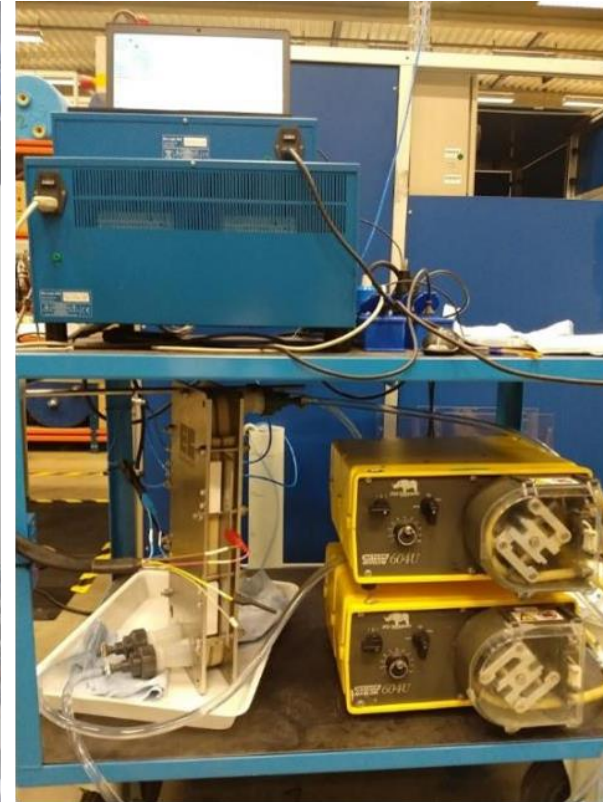
time

Different scales implemented with GDEx

Some reactor configurations



10 cm², 250 mL

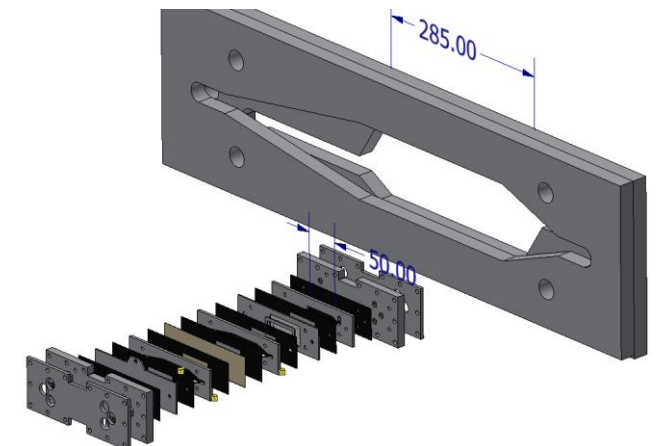
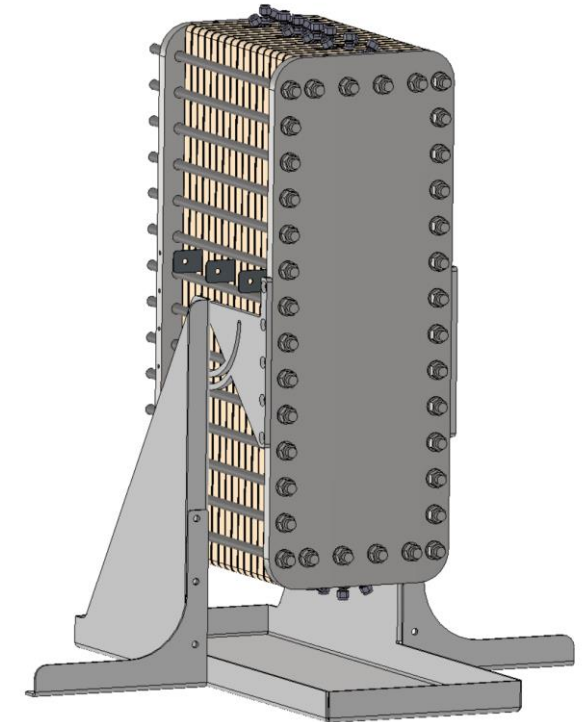
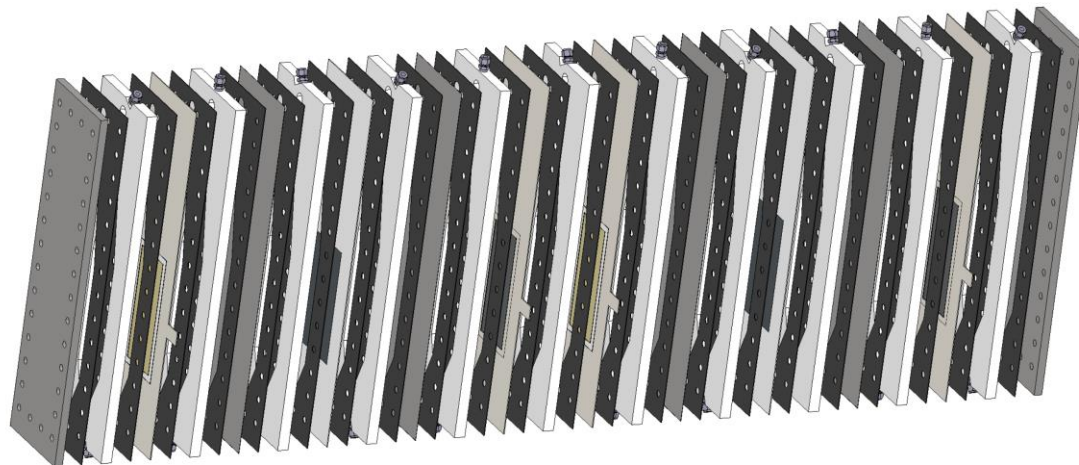


297 cm², 1 m³

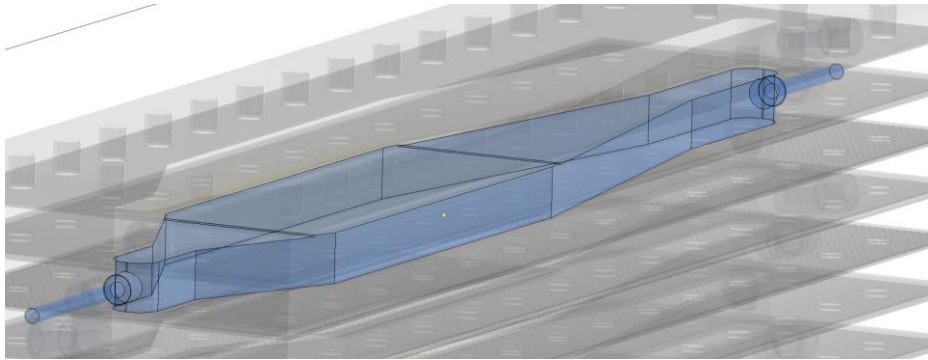
Currently: pilot for 100 L/h for PMs (Pt, Pd, Ru, Au, Ag) recovery

GDEx stack design

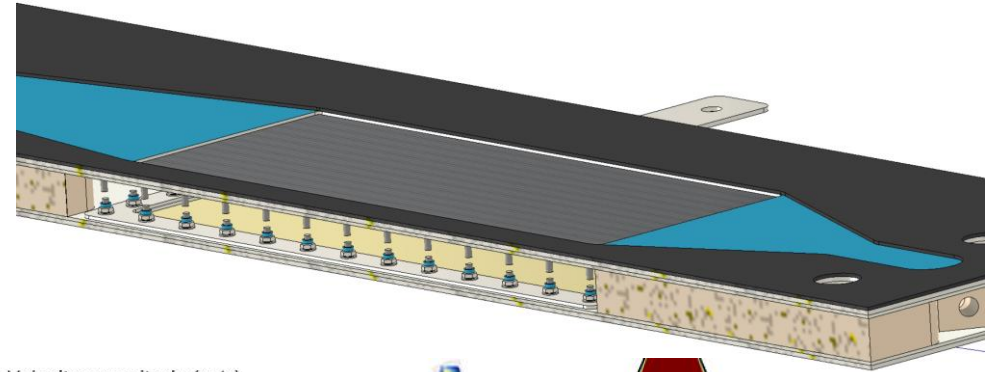
- A stack of 6 cells. 1 Pt/Ta electrode shared by 2 cells. 1 Gas chamber shared by 2 cells.
- Active area 325 cm²/cel
- The GDEx up-scaled unit is designed to operate at a flow rate of 100 L h⁻¹.
- The pilot will be operating in Monolithos Catalysts & Recycling Ltd infrastructures (in Greece).



Cathode and anode chambers

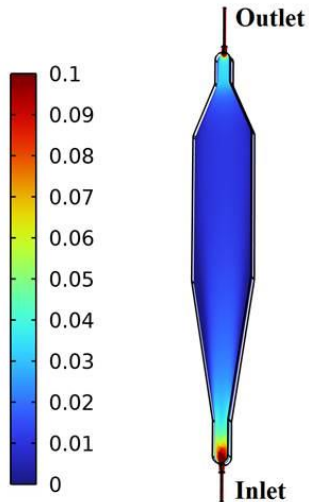


Gas chamber



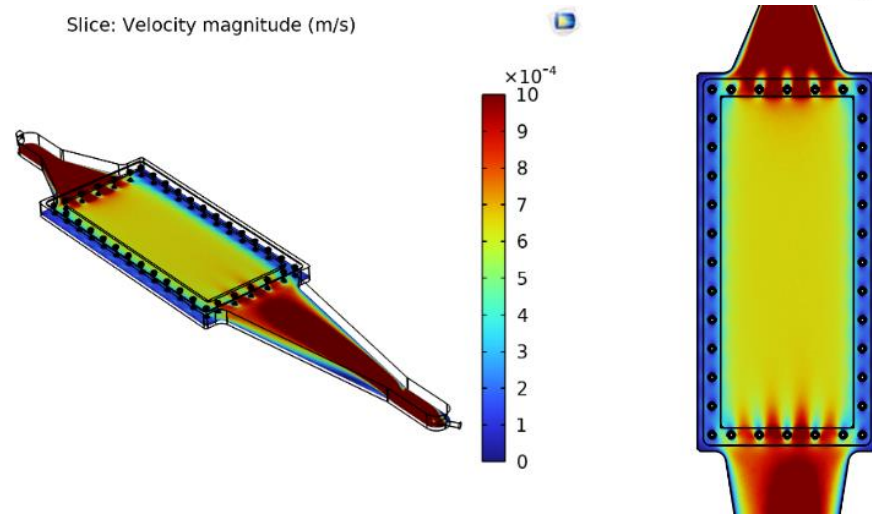
Q_{in}=1000 ml/min

Velocity magnitude (m/s)



- Adequate flow distribution
- Centered channels
- Manifold system to split and distribute catholyte (and anolyte) to the different (unit) cells of the stack

Slice: Velocity magnitude (m/s)



- Bolts to fix the GDE properly and prevent leaks.
- Bolts placed on the side do not disturb the flow



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Horizon 2020
Programme



Xóchitl Domínguez



Jan Fransaer



Omar Martínez



Fero Kukurugya



Jeroen Spooren



Ramin Rabani



Thank you



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