PEMFC on line diagnosis via acoustic emission measurements

B. Legros, P.-X. Thivel*, Y Bultel, R.P. Nogueira

Laboratory of electrochemistry and physico-chemistry of materials and interfaces

(LEPMI)

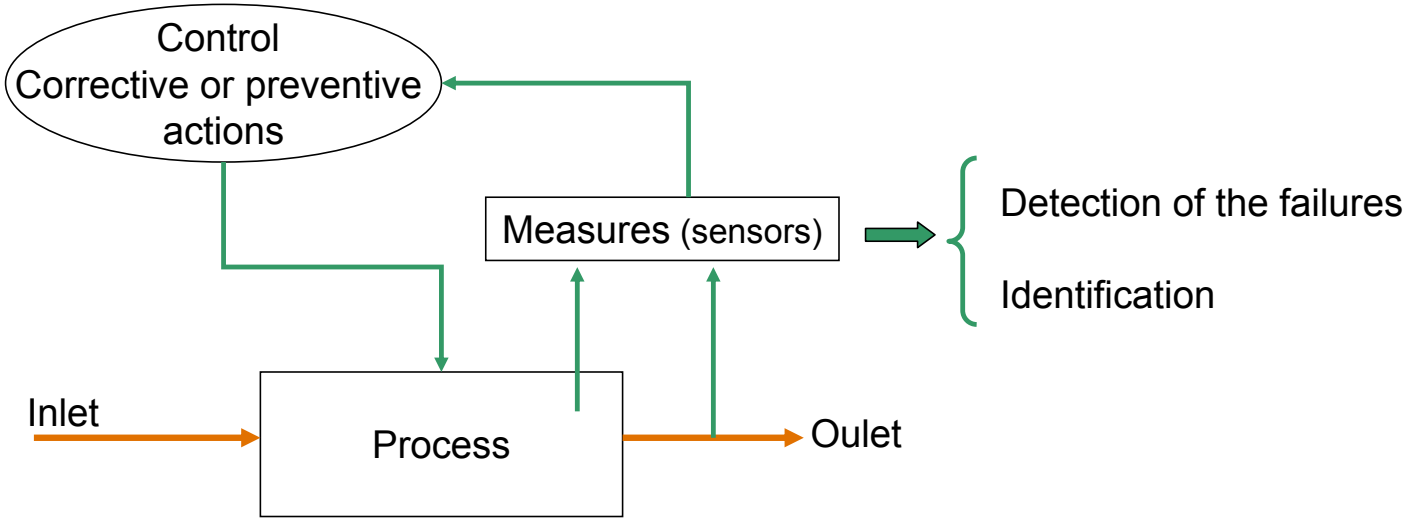
Science and engineering of materials and process

(SIMAP)

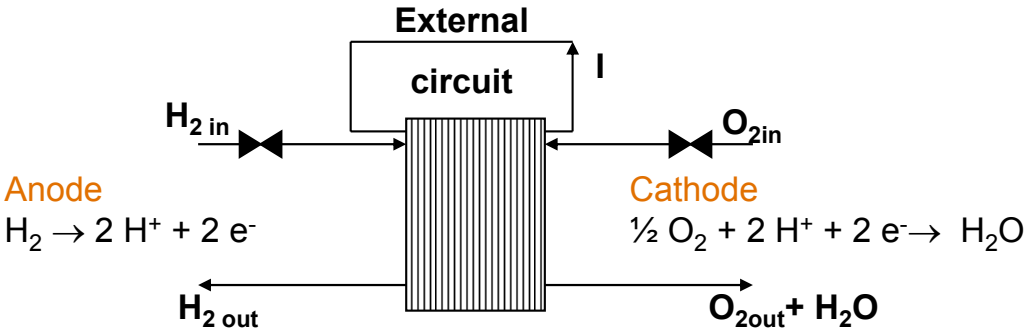
* Ass. Prof : University Joseph Fourier, Grenoble, France.

- Diagnosis, state of health ?
- Acoustic emission
- Nafion membrane dehydration
- Fuel cell (one cell of 25 cm^2)
- Conclusions
- Future research activities within diagnostic tools for fuel cell technologies

Diagnosis, state of health ?



- **Fuel cell**

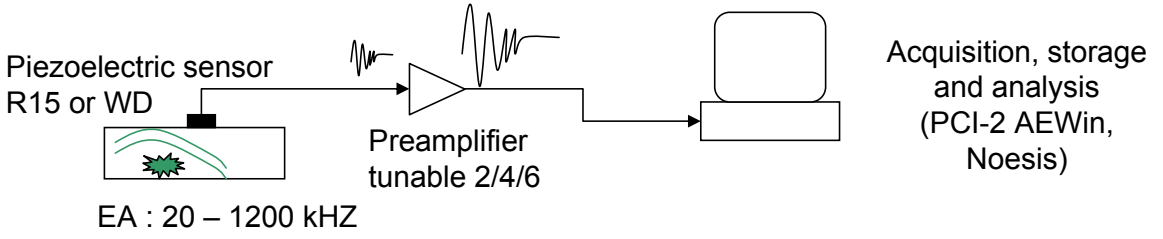


$H_2 + ½\ O_2 \rightarrow H_2O$

- **Development of diagnosis strategies**
  - Reliability
  - Durability
- "**Monitoring**" in real-time and "in situ" of fuel cell under operation

Acoustic emission

AE energy release within a material in the form of a transient elastic waves.

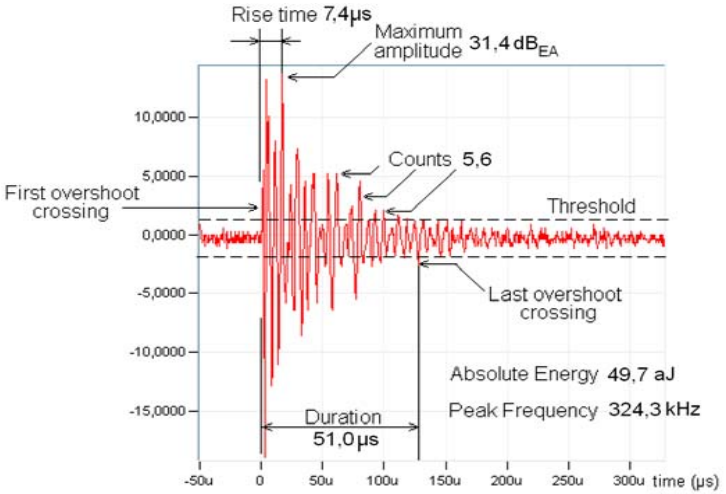


EURO PHYSICAL ACOUSTICS SA

AE a promising tool to non destructive analysis of the fuel cell ?

Acoustic emission

- Number of events
- For each event :
  - amplitude
  - rise time
  - duration of the event
  - number of counts



Characteristic signal of phenomena or failure

Monitoring in real-time and "in situ"

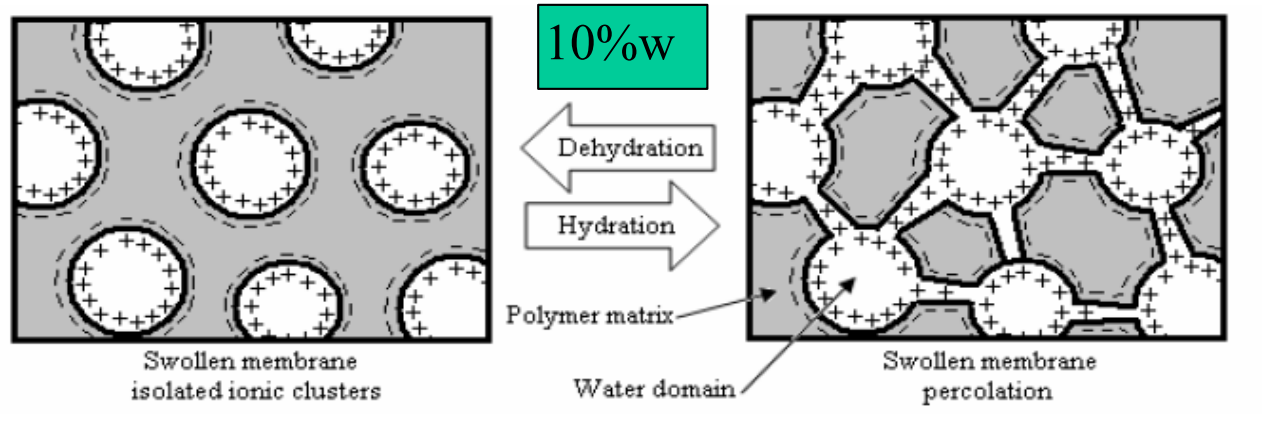
Two studied scales:

- Nafion membrane dehydration,

- Fuel cell (one cell of 25 cm^2).

Nafion membrane dehydration

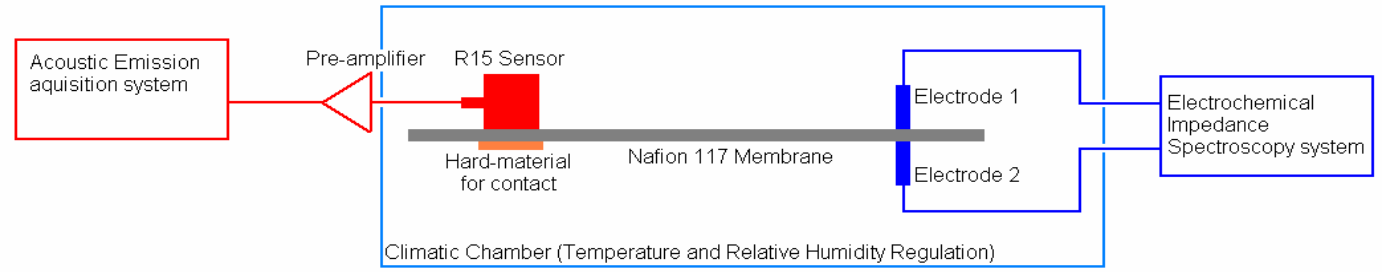
Nafion : polymeric matrix where SO_3 groups form ionic clusters, connected to each other by channels.
Structure very different according to the degree from hydration



Nafion membrane dehydration

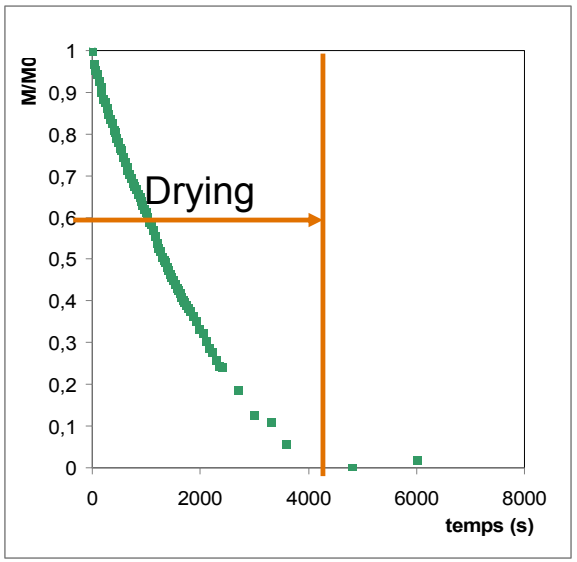
Follow-up of the dehydration of Nafion by :

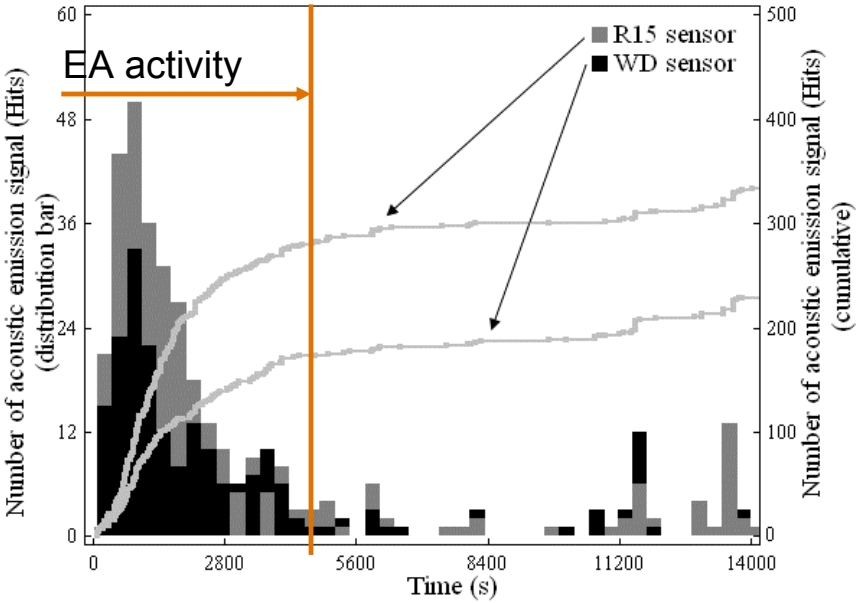
- *acoustic emission*
- *mass loss measurement*
- *electrochemical impedance spectroscopy*



Nafion membrane dehydration

Follow-up of the mass of the membrane and the EA according to time

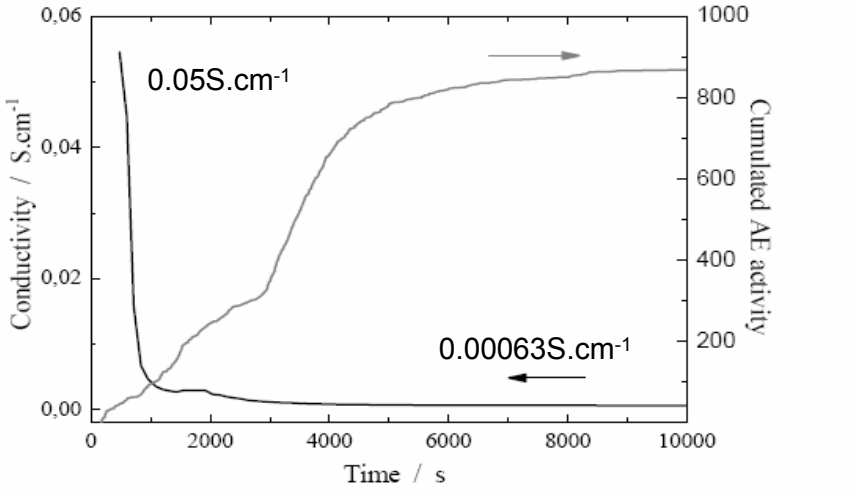




B. Legros, R. P. Nogueira, P. -X. Thivel, S. Maximovitch, F. Druart, Y. Bultel, M. Boinet, " Initial results for the application of the acoustic emission technique on a PEMFC Membrane", Fundamentals and Developments of Fuel Cell Conference, Nancy, 10-12 décembre (2008),

Nafion membrane dehydration

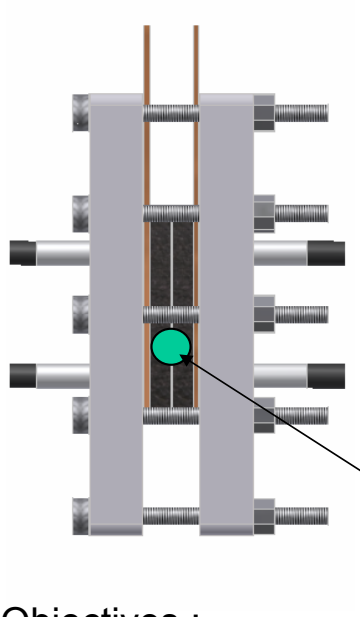
Follow-up of the conductivity (EIS) and the EA according to time

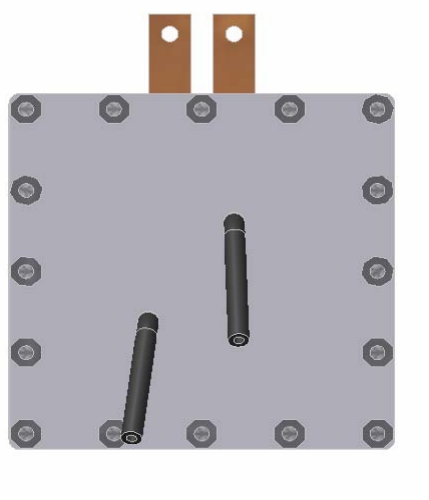


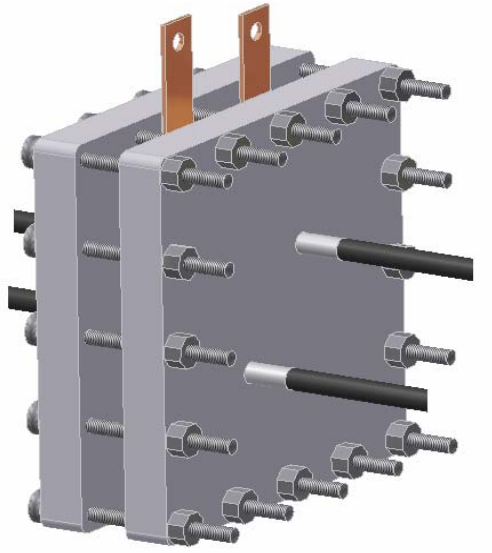
Membrane conductivity (left) and cumulated AE activity (right) versus drying time at 70° C and 10% RH.

B. Legros, P-X Thivel, Y Bultel, M Boinet, R Nogueira, "Electrochemical impedance and acoustic emission survey of water desorption in Nafion membranes", *Electrochemical and solide state letters*, 12 (7) B116-B118 (2009)

Fuel cell (one cell of 25 cm²)





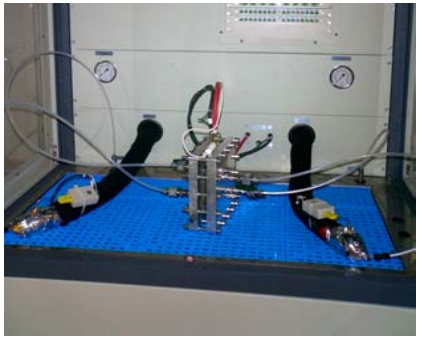


EA sensor : in contact with bipolar plate

Objectives :

- To approach the source of acoustic emission events
- To ensure an effective acoustic coupling

Fuel cell (one cell of 25 cm²)

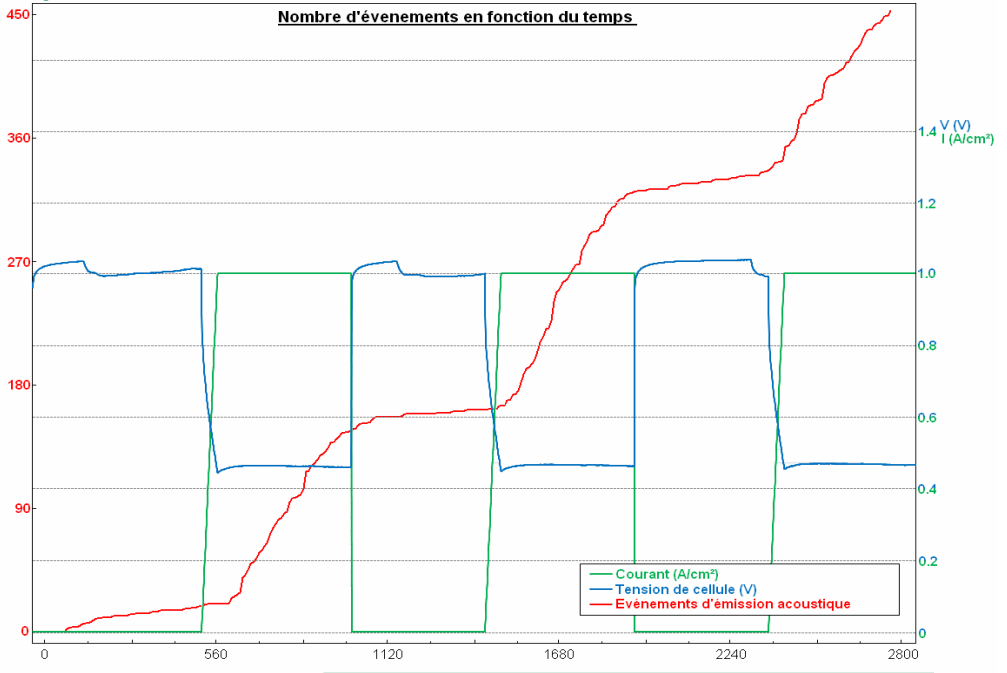


α_{O2} = 1,7

α_{H2} = 1,7

Set point

V = 0,43 V I = 25 A



Results are still under analysis

Conclusions

- Diagnosis of the state of the membrane
  - Hydration/Swelling of the membrane
- Diagnosis of PEMFC under operative conditions
  - Specific activity under current condition
- Perspectives
  - Cracking in the assembly ?
  - Water droplet formation and flooding ?
  - Heating point ?

Merci de votre attention

Takk for oppmerksomheten

Thanks for your attention