Development of coated aluminum bipolar plates for PEM fuel cells

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Context

A fuel cell is a device that uses hydrogen and oxygen to produce electricity and water. As a fuel cell does not emit any air pollutant, it is considered as a green alternative to electromechanical systems.

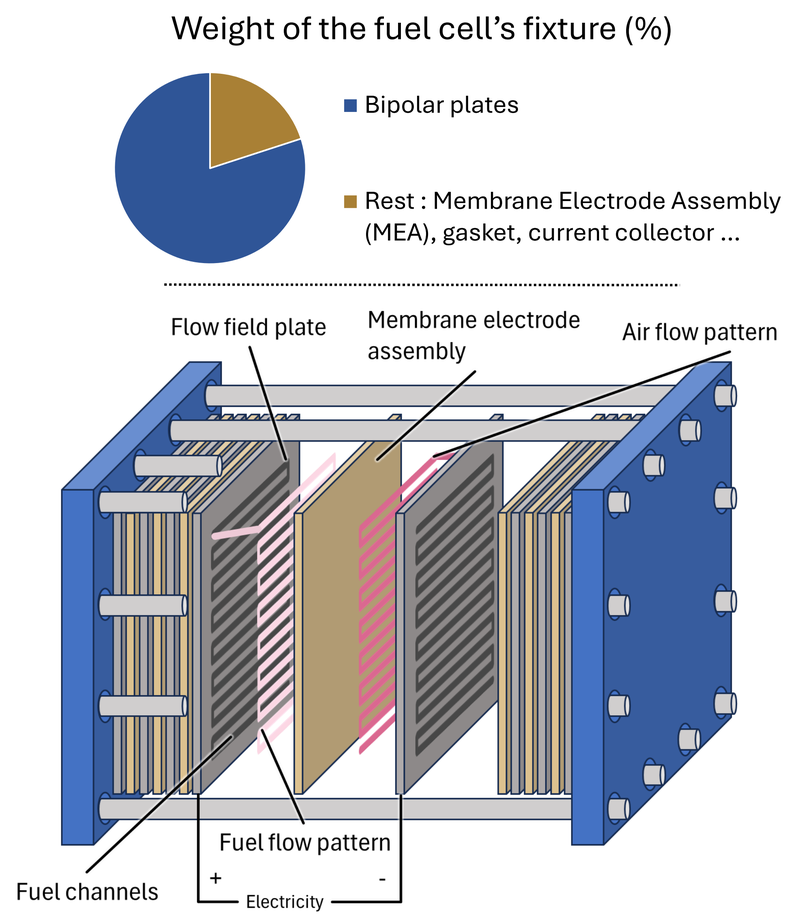
Proton Exchange Membrane (PEM) fuel cells are suitable for mobile applications because they typically operate at temperatures below 100°C and can be very compact.

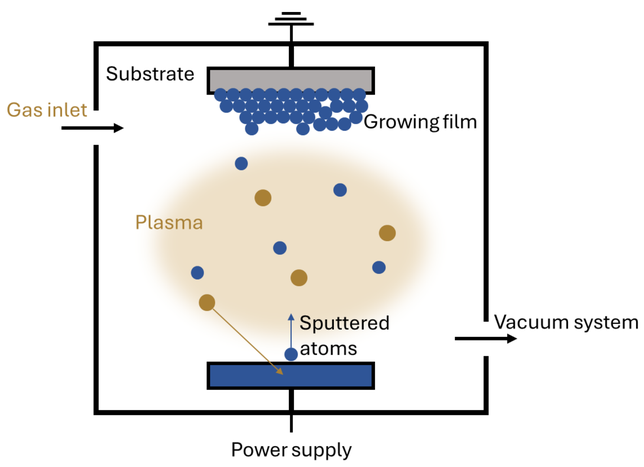
Bipolar plates are key components of PEM fuel cells. They supply the oxygen flow on one side and the hydrogen flow on the other side of the Membrane Electrode Assembly (MEA).

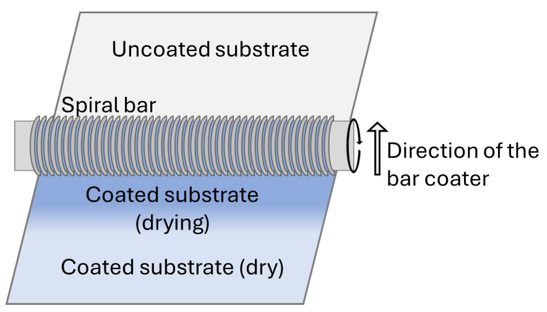
For the good functioning of the PEM fuel cell, they must check all these criteria :

- Homogeneous distribution of the gas
- Electrically conductive
- Good removal of the water from the device
- Resistant to acidic environment and humidity at temperatures up to 100°C
- Lightweight and resistant to vibrations

Currently, bipolar plates are constituted of coated stainless steel or titanium. To decrease the cost, and the weight of the fuel cell assembly, the aim of this PhD thesis is to **produce lightweight coated aluminum bipolar plates**.







Production of coated aluminum plates

The coating can be produced by two techniques or a combination of both :

- Dry coating : Physical Vapor Deposition (**PVD**),
- **Wet chemistry** : spiral bar coating.

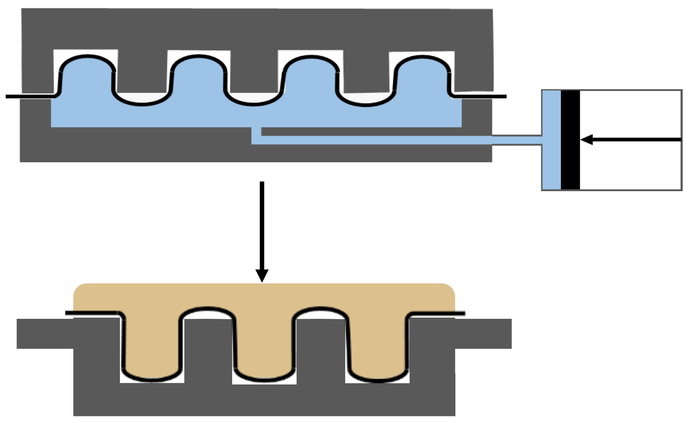
After the coating process, characterization techniques must be performed to ensure the **adherence** of the coating to the substrate, and its **corrosion resistance** and compare them to those of standards. The material characterization techniques are X-Ray Photoemission Spectroscopy (XPS), Scanning Electron Microscopy (SEM), X-Ray Diffraction (XRD), and others. The deformation characterization will be done by using the Marciniak test, where a plate is deformed by a punch, to see if the coating tends to crack or rip. Corrosion tests and electrochemical tests, such as Interfacial Contact Resistance (ICR) will also be done.

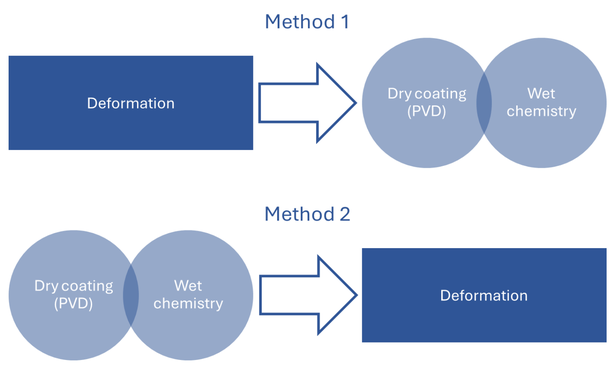
Deformation of aluminum plates

The deformation of the plate can be done by multiple techniques but only two of them will be investigated : **hydroforming** and **rubber punching**.

All metals don't act the same when it comes to deformation. Some of them are easy to break, as others are more flexible. It is therefore important to chose the material carefully. **Preliminary tests** will be conducted to test the deformation characteristics of some aluminum alloys, to select the most suitable one.

The main objective of this step is to produce deformed metallic plates that could fit as bipolar plates for PEM fuel cell.





Production of coated and deformed metal plates

Two methods are to be considered when it comes to the production of coated metal bipolar plates. **The plate can be deformed before or after the coating treatment.**

The first method is less efficient for industrial applications, as the coating needs to be done by batch. The second method of production is the easiest one to use when producing bipolar plates at a high-speed rate, as the coating can be implemented in a roll-to-roll process. This method is nonetheless more challenging to use, because the coating must withstand the deformation process.

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