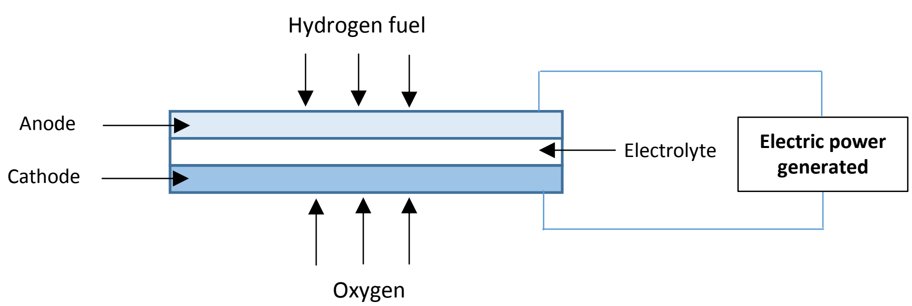
ETCHING OF FUEL CELL PLATES

A fuel cell is a device that converts chemical energy directly into electrical energy. The technology was invented and demonstrated in 1839 by Christian Schoenbein and Sir William Grove, but due to the invention of the combustion engine, progress in the development of fuel cells was slow. Interest in fuel cells was re-ignited in the 1950s leading to the development of proton exchange fuel cells in 1959 by General Electrics in the US for use by NASA. The oil crisis in the 1970s prompted further work to develop new types of fuel cells. Research into fuel cells has intensified in recent years fuelled by the need to decarbonize energy production. The first fuel cell car was launched in 2008 by Honda.

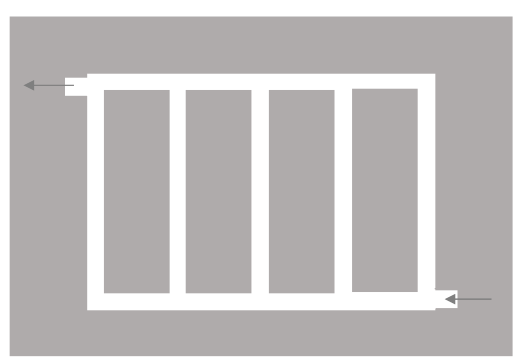
In a hydrogen fuel cell, hydrogen serves as the fuel and is reacted with oxygen to produce water and energy. The cell consists of two electrodes – a cathode and an anode – and an electrolyte sandwiched between the two electrodes. Hydrogen reacts at the anode generating a proton and an electron. The proton travels through the electrolyte to the cathode and the electron travels through the external circuit to the cathode. The proton and the electron then react with oxygen at the cathode. Electric power is generated by this flow of electrons from the anode to the cathode.



The electrodes are usually made of small platinum particles (which act as a catalyst to promote the reaction) supported on porous carbon. However, due to a number of disadvantages including the high cost of platinum, other electrode materials are now being developed.

One of the main types of fuel cells is the Polymer Electrolyte Membrane (PEM) fuel cell, also known as the Proton Exchange Membrane fuel cell. As the name suggests, PEM fuel cells employ a polymer membrane as the electrolyte. The major potential application of PEM fuel cells is as replacement for internal combustion engines in light-duty vehicles.

A fuel cell unit is made up of a series or stack of cells. Cell interconnection can be achieved using ‘bipolar plates’. In this method, a bipolar plate is used to make connections all over the surface of one cathode and the anode of the next cell. In addition to connecting adjacent cells, the bipolar plate serves as a means of feeding hydrogen to the anode and oxygen to the cathode. Grooves or channels on the surface of the bipolar plate allow the gases to flow over the



surface of the electrodes. These channels are designed to offer a large surface area for adequate gas flow while at the same time maintaining a sufficient contact surface area between the bipolar plate and the electrodes to which it is connected.

Photochemical etching can be used to create channels on bipolar plates. Different flow patterns can be etched such as parallel, serpentine, or grid channels using low-cost photo-tooling and in short turnaround times.

Bipolar plates are usually made of graphite, metal alloys, or composite materials. While graphite is lighter than any metal and is not prone to corrosion, it is also brittle and porous and has significantly lower electrical and thermal conductivities compared to metals. Metals, on the other hand, are characterized by very high conductivities. Their corrosion resistance can be enhanced using conductive coatings. For example, titanium is a light metal with very good corrosion resistance which can be further improved by coating the metal with a titanium nitride protective finish. Aluminium, which is another attractive metal for fuel cell plates due in large part to its low density (40% lighter than titanium), can be coated with chromium nitride.

Advanced Chemical Etching can manufacture photo chemically etched fuel cell flow plates using aluminium, titanium or stainless steel. The process can be used to produce different prototype designs for the purpose of optimizing the flow pattern. The process can accommodate low, medium or large volume production. Metal plates up to 2 mm in thickness can be etched. The channel width to depth ratio is typically 2:1. Metal plates can be etched from both sides simultaneously.

Photochemical etching can also be used to create micro-channels for miniaturized fuel cells. There is currently a lot of interest in developing miniaturized fuel cell technology driven by advances in microfabrication technologies and also by the need to improve the performance of energy storage technologies for portable electronic devices. Photochemical etching of metal plates offers a cost-effective way of producing macro- or micro-channels for fuel cells. In particular, the new ACmE and TiME processes for etching aluminium and titanium offer excellent quality and consistency.