Membrane ‘nano-fasteners’ key to next-generation fuel cells

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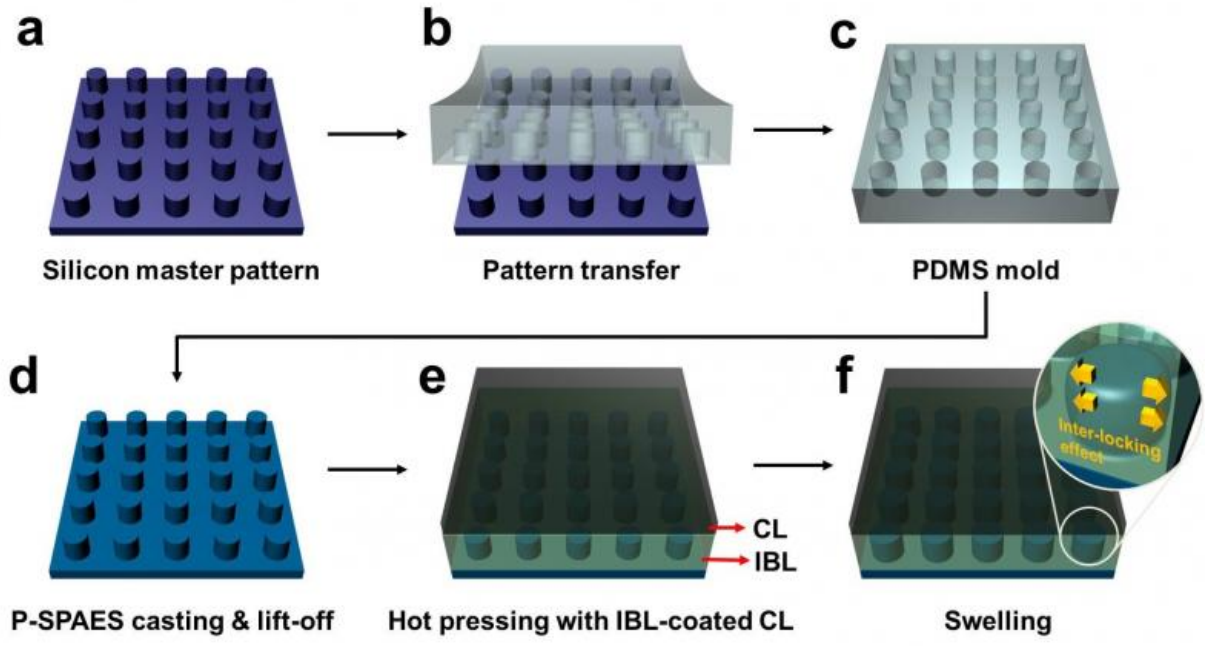

Schematic diagram of the fabrication of the pillar P-SPAES membrane and its working principle of interlocking effects. Credit: KAIST

Scientists at Korea Advanced Institute of Science and Technology (KAIST) have developed a new way of making fuel cell membranes using nanoscale fasteners, paving the way for lower-cost, higher-efficiency and more easily manufactured fuel cells.

The internal workings of fuel cells vary, but basically all types mix hydrogen and oxygen to produce a chemical reaction that delivers usable electricity and exhausts ordinary water as a by-product. One of the most efficient types is the proton exchange membrane (PEM) fuel cell, which operates at low enough temperatures to be used in homes and vehicles.

To generate electricity, PEM fuel cells rely on two chemical compartments separated by a permeable catalyst membrane. This membrane acts as an electrolyte; a negative electrode is bonded to one side of the membrane and a positive electrode is bonded to the other. The electrolyte membrane is often based on a polymer of perfluorosulfonic acid. Due to its high cost, however, a less expensive hydrocarbon-based electrolyte membrane has attracted interest in this technology sector.

Until now, the challenge in adopting such a hydrocarbon membrane has been that the interface between the electrode and hydrocarbon membrane is weak. This causes the membrane to delaminate relatively easily, falling apart and losing efficiency with use.

Professor Hee-Tak Kim of the Department of Chemical and Biomolecular Engineering at the Korea Advanced Institute of Science and Technology (KAIST) and his research team have developed a new fastening system that bonds the two materials mechanically rather than chemically. This opens the way to the development of fuel cell membranes that are less expensive, easier to manufacture, stronger and more efficient.

The researchers achieved this by moulding a pattern of tiny cylindrical pillars on the face of the hydrocarbon membrane. The pillars protrude into a softened skin of the electrode with heat. The mechanical bond sets and strengthens as the material cools and absorbs water. The pillar-patterned hydrocarbon membrane is cast using silicone moulds.

Professor Kim said, "This physically fastened bond is almost five times stronger and harder to separate than current bonds between the same layers."

The new interlocking method also appears to offer a way to bond many types of hydrocarbon membranes that, until now, have been rejected because they couldn't be fastened robustly. This would make hydrocarbon membranes practical for a number of applications beyond fuel cells such as rechargeable "redox flow" batteries.

Provided by The Korea Advanced Institute of Science and Technology (KAIST)