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Surface structuration of proton exchange membrane for low Pt loaded fuel cell in the frame of the LAVOISIER project

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This study aimed to structure the surface of proton exchange membranes by creating regular and ordered micrometric (sometimes nanometric) patterns associated with Pt nanoclusters synthesized by magnetron sputtering. The membranes were hot pressed against molds previously structured by two laser micromaching [1] (pulsed Ti-sapphire femtosecond laser) or by plasma etching through a patterned polymeric mask, in order to form wavelets, bumps, pillars and cylindrical holes on their surface. Once pressed, the thickness of the Nafion NRE 211 membrane is lightly decreased and is no longer constant over the entire surface. At the top of the bumps, pillars or holes, the thickness increases, while in the valleys, the thickness drops. The figure shows the SEM (scanning electron microscopy) micrographs of the two membranes after pressing. These membranes were associated with thin catalyst layers (25 ε $g_{Pt}cm^{-2}$) performed by plasma sputtering, inserted into fuel cells, tested in operation at different temperatures and H_2/O_2 pressures and compared to pristine membrane. Whatever the structuration process, the fuel cell with structured membranes are more efficient than fuel cell with pristine coated membrane. Moreover, the achieved power densities seem to be very dependent on the size of the patterns for both architecture. In all case the improvement appears to be (mainly) due to an increase of the exchange current density and of the membrane conductivity, thanks to the specific surface area increase. In addition to the size, the shape of the patterns is also a determining parameter. Indeed, the membrane with the pillars induces a better fuel cell operation. The origin of this result is still discussed. In summary, this study showed that the structuration of the membrane made it possible to increase the low Pt loaded fuel cell performances and that the shape/size of the patterns and the location of the Pt catalyst directly influenced the fuel cell operation.

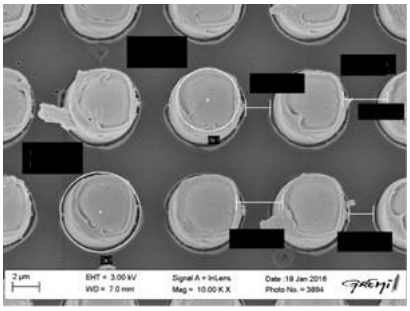
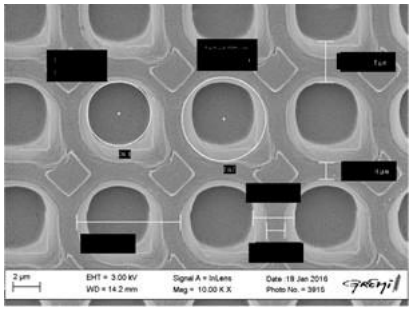

(a)

(b)

Figure : SEM micrograph of two membrane surface with pillars (a) and cilindrical holes (b)

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