Femtosecond laser microstructuration of carbon electrodes for water electrolysis

Water electrolysis has been for decades one of the most studied field when hydrogen gas production is targeted. Various electrode materials have been tested ranging from carbon to noble metals but today most researches are focusing on the use of catalysts (platinum, oxides, …) or surface chemical grafting to increase gas production. Less efforts have been devoted to study the physical parameters of the electrode like the roughness that could be an adequate strategy to modulate gas generation at the electrode/electrolyte interface. For that purpose, microstructuration of carbon electrode surfaces has been achieved by micromachining through femtosecond laser ablation, allowing the fast formation of fine features in the micrometer range on electrodes. It has been observed that nucleation sites of gas bubbles could be spatially defined by selective patterning through laser irradiation and ablation. Different microstructuration patterns have been correlated with their effects on bubbles nucleation, release and flowing in the electrolyte by fast camera imaging. Especially, when grid-like structures have been employed, nucleation occurs mainly in the laser irradiated regions i.e. lines, whose thickness could allow to limit bubbles size and collapsing with others surrounding gas bubbles. Electrochemical measurements and gas phase mass spectrometry of evolved gas at each electrode have been conducted to evaluate microstructuration effects on gas production. Optimization of laser induced microstructuration of electrode surfaces could lead to enhance the production of hydrogen or oxygen gas by water electrolysis, and could also be used in conjunction with catalysts.