Green energy, towards a sustainable and bright future, manufacturing of low catalyst loading proton exchange membrane electrolyzer technology

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Proton exchange membrane (PEM) water electrolysis is a low temperature, low carbon footprint technology for the production of high purity hydrogen. PEM electrolyzers can operate at higher current densities and higher pressures with lower gas crossover and a more compact physical footprint than other water electrolysis processes such as alkaline electrolyzers and solid oxide electrolyzers. However, PEM electrolyzers require expensive, noble metal catalysts and a considerable effort is currently underway to minimize catalyst loading to reduce cost, which crucial for the penetration of PEM electrolysis technology into the market. [1]

Ir or IrO_2 is generally recognized as the state-of-the-art electrocatalyst for oxygen evolution reaction (OER) at the anode, while Pt remains the best candidate for the hydrogen evolution reaction (HER) at the cathode [1,2]. The catalyst loading on the cathode is typically at least 0.5-1.0 mg/cm^2, whereas the anode catalyst loading is around 2 mg/cm^2 [1].

Reactive spray deposition technology (RSDT) has proven to be a cost-effective method for producing high performance PEM electrolyzer membrane electrode assemblies (MEAs) [3,4]. RSDT is a flame-based method that combines catalyst synthesis and processing in a single step and has the flexibility in optimizing the catalyst composition, making gradient and other complex structures possible. This has allowed our team to reduce the cathode Pt loading below 0.2 mg/cm^2 with enhanced performance compared to the standard baseline(Figure 1 a).

Xu and Scott studied the effect of ionomer content in the catalyst layer on PEM electrolysis using decal transfer method and the optimum ionomer content for cathode was found to be 20% [5]. However, at such low Pt loading, we found that the catalyst layer structure and ionomer content becomes more important than catalyst loading, meaning that each catalyst formulation needs to be carefully controlled. Since RSDT is a dry deposition process, the catalyst layer formation mechanism can be different from catalyst-ink spraying and drying process. Therefore, in this talk we will focus on the role of the catalyst layer pore structure and I/C ratio in dictating the performance of RSDT-derived PEM electrolyzer MEAs.

In order to ensure safe operation of a PEMWE system, the electrolyzer is usually either operated at conditions that minimize the H2 crossover, or it incorporates a mitigation strategy that effectively reduces the H2 crossover through the membrane. Among the existing fabrication processes, RSDT is the most advanced methodology for fabrication of either recombination layers (RLs) that prevents hydrogen cross over or low loaded catalyst layers (CLs) for advanced PEMWEs.

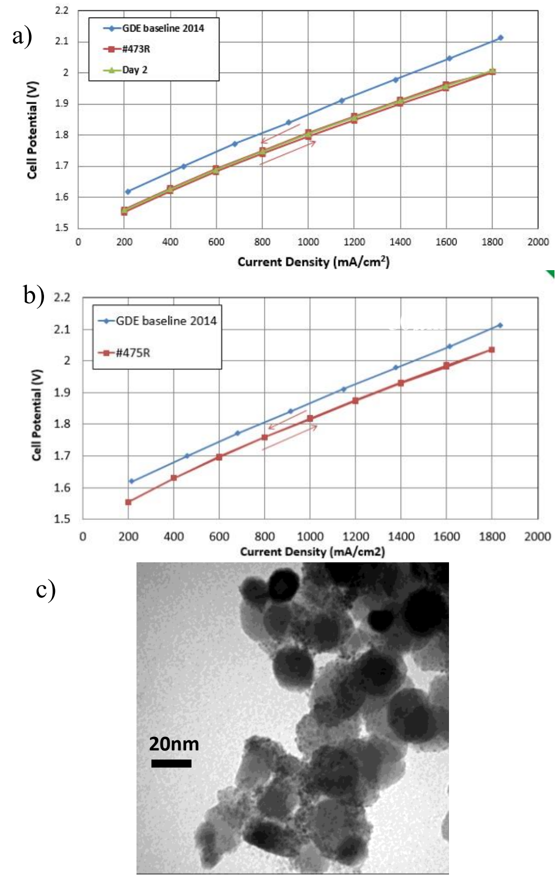

Figure 1. a) PEM electrolyzer performance using RSDT fabricated Pt/C as cathode and Ir/IrO_2; b) electrolyzer performance using RSDT fabricated Ir/IrO_2 supported on ITO as anode and Pt/C as cathode; c) TEM micrograph of Ir/IrO_2 supported on ITO nanoparticles

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