Visualization of Gas Bubble Behavior of a Regenerative Fuel Cell in Electrolysis Mode by Soft X-ray radiography

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Regenerative fuel cells (RFC) are candidates for hydrogen energy to become common in daily life since it lowers the first investment cost by combining two different devices into one. Most of the research is dedicated only to fuel cells in hydrogen energy technologies. However each system (fuel cell and electrolyzer) has its own problems especially in two-phase phenomena such as flooding for fuel cells and water accumulation in the cathode due to electro-osmotic drag for electrolyzers. Each proton accompanies with 3.5 - 4 water molecules to the cathode [1]. Hence water accumulates in the cathode chamber. Moreover, there appear extra problems when two systems put together in one device such as removal of accumulated water after electrolysis mode and so on.

In-plane visualization experiments with an electrolysis cell proved that the water accumulation in the cathode reduces hydrogen mass transport, hence lowers the cell efficiency [2]. To understand the gas evolution mechanism further experiments with higher temporal and spatial resolution were required. Therefore soft X-Ray visualization experiments have been performed with a special cell design (Figure 1). Soft X-Ray visualization experiments were developed and performed for PEM fuel cells [3-6]. The experimental setup was modified slightly to perform experiments in electrolysis mode (Figure 2).

The cell was visualized in electrolysis mode at different operating conditions in this study. The RFC has 5 channels to deliver water to the catalyst layer and has active area of 0.2 mm X 2 mm. Both anode and cathode chambers were filled with water and during the visualization period water was not pumped to the cell. The cell images were taken at different temporal resolutions of 1, 2, 3 Hz and at different optical magnifications. The images were processed with ImageJ, analyzed and prepared for publication.

The gas bubble evolution was observed from the catalyst layer through diffusion layer to the channels. Figure 3 shows a gas bubble generation sequence both in anode and cathode section for two channels at 25 mA/cm^2. For this case, the bubble evolution started at the hydrogen side first, and then the oxygen evolution appeared at the anode. The gas bubbles were evolved under ribs and headed towards to the channels. More gas evolution observed under the ribs at both chambers.

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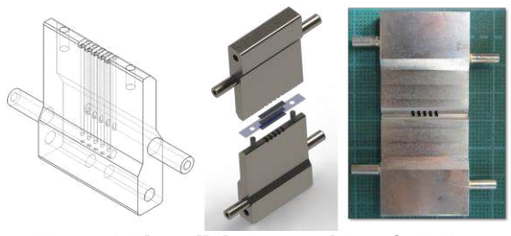

Figure 1.The cell design used in soft X-Ray visualization

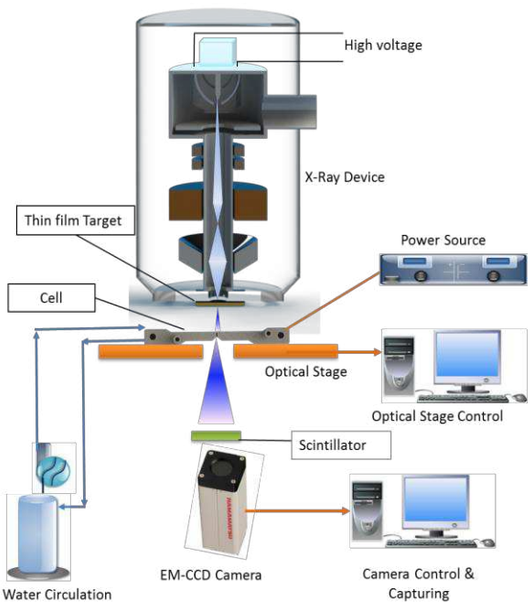

Figure 2. Soft X-Ray experimental setup for through plane visualization

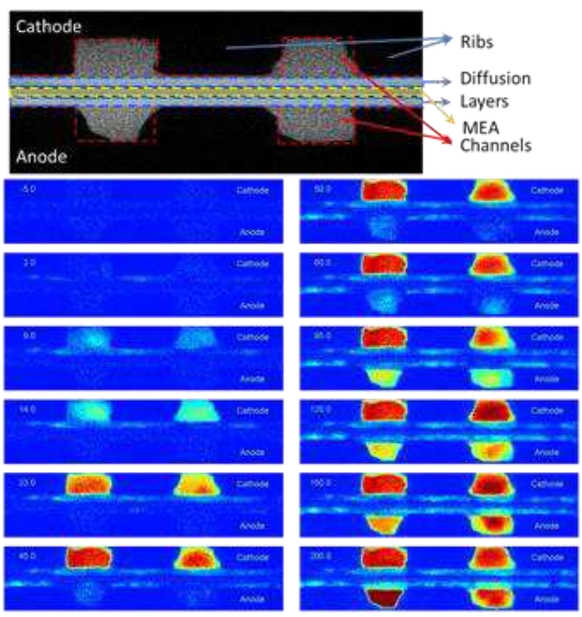

Figure 3. Gas evolution sequence in two channels in RFC in electrolysis mode