Simultaneous Visualization of Oxygen Partial Pressure and Current Density in Running PEFC

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The reactions inside a fuel cell during the power generation are inhomogeneous, which may lead to decreasing the cell performance and enhancing the MEA degradation. It is therefore important to elucidate the distributions of physical and chemical parameters inside fuel cells, such as temperature, oxygen partial pressure ($p(O_2)$), water concentration, CO_2 concentration, etc. We have so far visualized the distributions of $p(O_2)$[1-3] and water droplets[3-4] during the power generation and CO_2 concentration[5] during the degradation. A new visualization system has now been developed, which enables us to understand the distribution of $p(O_2)$ and current density simultaneously in a running PEFC.

To visualize inside the cell, we fabricated a special see-through cell with a cathode plate made of a transparent acrylic resin. This cell also has nine segmented current collectors both at the cathode and the anode (Fig.1). The potentials of the current collectors are controlled to be the same by the external circuit so that the nine collectors could be treated as a single one. As an oxygen sensor, we used a luminescent dye compound, PtTFPP ([tetrakis(pentafluorophenyl)porphyrinato] platinum]),[1] which absorbs 390-nm blue light and emits 650-nm red light; the emission intensity lowers as $p(O_2)$ increases. This dye film was coated on the surface of the GDL. During the visualization, the excitation light (wavelength = 407 nm) from a diode laser was diffused, spread and distributed uniformly onto the cell. The emission from the dye through the transparent window was filtered (> 600 nm), and images were captured with a CCD camera (500 x 500 pixel, 1 pixel ≒ 0.15 mm) (Fig.2). Meanwhile, the current density obtained at each current collector was recorded.

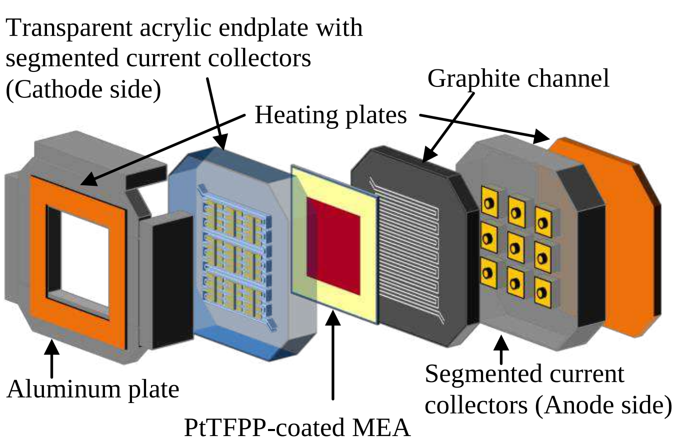

Fig.1 See-through cell

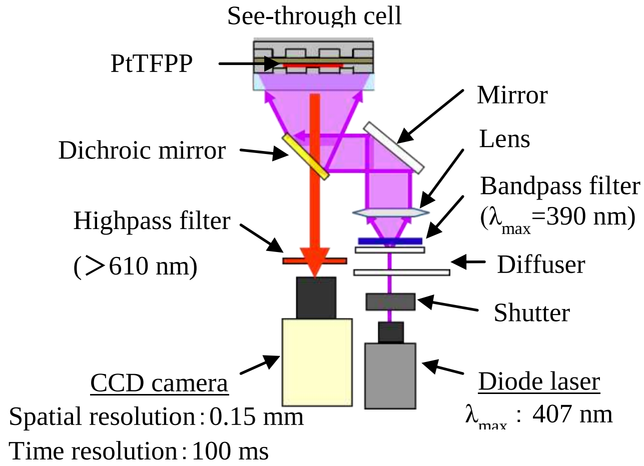

Fig.2 Visualization system

Fig.3 shows the distributions of $p(O_2)$ at the cathode and the current density at 53% RH at 80 °C (a) and 40 °C (b). Oxygen utilization (U_{O2}) was set at 20%. $p(O_2)$ decreased from the entrance to the exit. The current density at 80 °C was uniformly distributed, whereas at 40 °C, the current density was higher near the exit than that near the entrance, which could be explained by the higher proton conductivity of the membrane near the exit caused by the generated water.

This technique is expected for the improvement of MEAs, cell designing, and the operating conditions.

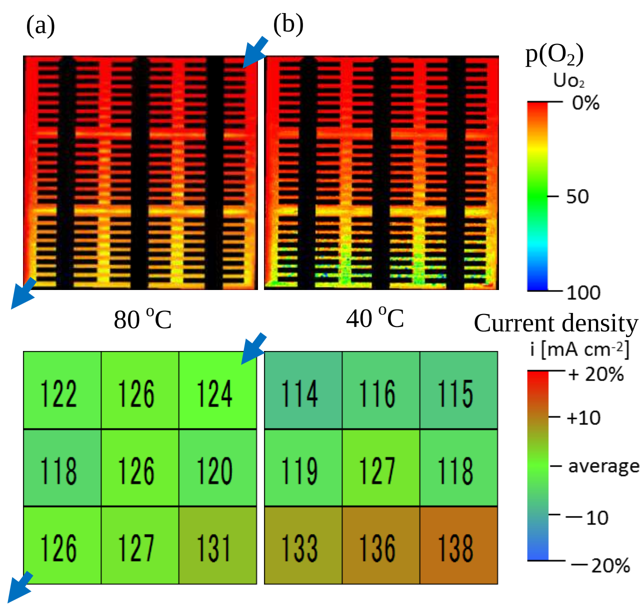

Fig.3 Distributions of $p(O_2)$ and the current density at 80 °C (a) and 40 °C (b). Relative humidity = 53% RH; gas flow rate = 300 ml min^{-1}; oxygen utilization = 20%.

Acknowledgements
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