IMPEDANCE MEASUREMENT AND SIMULATION ON A DISK TYPE SOFC UNDER POWER GENERATION

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Ac impedance measurements under constant dc current conditions were carried out using practical size planar disc-type SOFC employing doped $LaGaO_3$ as a solid electrolyte(Fig.1). Under practical conditions of relatively high fuel utilization(Uf), considerable difference in the composition of the inlet and outlet gas brings about the in-plane variation of Nernst potential as well as current density leading to the appearance of gas conversion impedance(GCI)[1)].

Simulations of ac impedance behavior were also carried out. In the simulation a pure resistance was assumed as a reaction impedance and the diffusion perpendicular to the gas flowing plane was considered to be sufficiently fast. Fig.2 shows the calculated complex impedance plots at various Uf neglecting the electronic conductance in the electrolyte.

The impedances with changing parameters such as gas flow rate, gas pressure, channel height were also calculated. Also the influence of the existence of in-plane gas diffusion and the electronic conductance in the electrolyte to the ac impedance behaviors were calculated and shown to work negatively for SOFC operation.

Experimental results using 56.8cm^2 cell(85 mm dia.) at constant gas flow rate of 3ml/min./cm^2 are shown in Fig.3 where the impedance of the cathode was negligible. Despite the appearance of the impedance corresponding to the electrochemical reactions at high frequency side, semi-circular impedance behaviors which vary with Uf at lower frequency region were observed as predicted by the simulation. The behaviors were shown to be represented by RC parallel circuit. Also the high frequency side intersection with the real axis shifts toward the high impedance side as Uf becomes larger. The shift was shown to be attributable to the variation of the gas concentration by another set of experiments in which Uf was kept constant under various hydrogen flow rate by changing current density at each measurement. Although the current density was varied in the set of experiments as is the case of Fig.3, the high frequency intercept almost remained the same and didn't show any trend of shift with current density.

The time constants calculated from the characteristic frequencies (frequencies at Z"=min.) are shown to be related to the gas volume adjacent to the electrode(the period for fuel gas to pass through the cell). Experimentally obtained time constants were almost close to the value estimated by the simulations.

To conclude the ac impedance behaviors were calculated using practical size disk type SOFC model where the gas concentration varies considerably. Some of the calculated behaviors were confirmed experimentally.

1) S.Primdahl et al., Solid Oxide Fuel Cells V, Electrochem. Proc. 97-40(1997)pp.530-539.

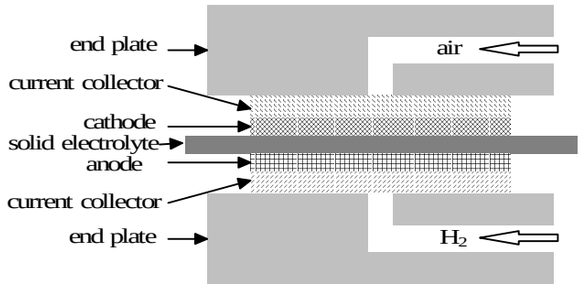

Fig.1 Schematic of the experimental cell set up.

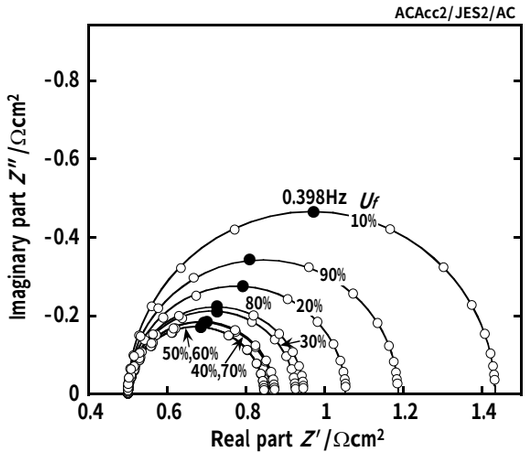

Fig.2 Simulated behavior of ac impedance at various fuel utilizations. (1023K, H_2:3ml/min./cm^2, air:15ml/min./cm^2)

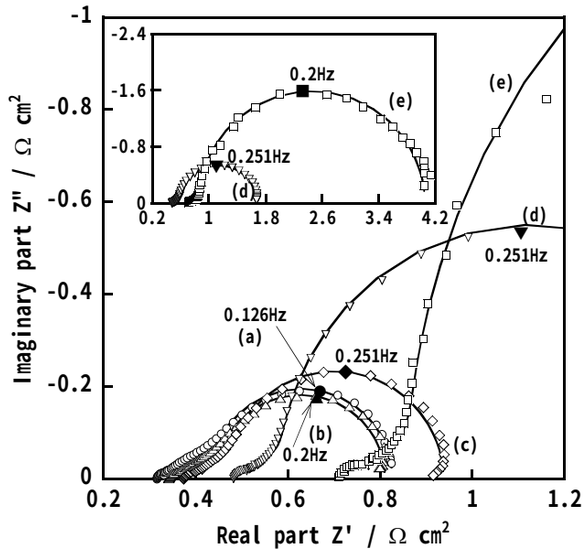

Fig.3 Experimentally obtained complex impedance plot of SOFC(56.8cm^2) with various fuel utilization under constant fuel gas flow rate at 1023K.
(a):Uf=4.1%(1.0A), (b):Uf=23.3%(5.67A),
(c):Uf=46.5%(11.35A), (d):Uf=69.8%(17.0A),
(e):Uf=80.0%(19.5A)