Proton implantation and in-situ creep observation fora proton conducting glassunder fuel cell operating conditions

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Intermediate temperature fuel cells (IT-FCs) operating around 300-500°Chaveattracted much attention as next-generation energy source owing to their high conversion efficiency and low fabrication cost.Our group successfully prepareda “fast proton conducting phosphosilicateglass” using conventional melting method, and we confirmed fuel cell operation using H_2 and O_2 at the intermediate temperature (~5 mW/cm^2) [1,2].Likewise typical oxide glasses, our glass has no H^+ (OH groups) just after quenching the melt. However, based on an in-situ FTIR measurement, we found proton implantation into the phosphosilicate glass occurs under fuel cell operating condition [3]. In silicate glasses, it was reported that proton, coming from water, cuts Si-O-Si and generates Si-OH[4].We anticipated such proton implantation affects on mechanical properties of glass. In this study, creep behavior of proton conducting glass in fuel cell atmosphere is reported.

A new indentation apparatus was developed, in which we can control measuring conditions including atmosphere (H_2, N_2, air and relative humidity), temperature, and electrical field. Utilizing this special instrument, we evaluatedin-situ creep behavior of the proton conducting glass under the proton implantation.

Proton conducting glass was prepared by conventional melting method with composition of $7.5Na_2O \cdot 7.5K_2O \cdot 35P_2O_5 \cdot 50SiO_2$(mol%). After polishing the glass with ~1 mm thickness, Pt ring-electrode wassputtered on a side of the glass plate.Atmosphere was controlled by flowing H_2 gas, heating up to 200 ^{o}C, and applying DC 5 V.This condition is similar to the anode reaction of fuel cell ($H_2 \rightarrow 2H^+ + 2e^-$), and proton implantation occurs. We conducted an indentation creep experiment under the reaction. The indenter was used as a counter for the ring-electrode. We also carried out same experiments in N_2 atmosphere as comparison. Humidity effectswerealso investigated usinghumid gas(relative humidity ~1%).

The phosphosilicate glass showed typical creep behavior in N_2 atmosphereat 200 ^{o}C. Interestingly, the creep displacement increases remarkably in H_2 atmosphere, andwe obtained a longer relaxation time for creep in H_2 atmosphere compared with that in N_2. These results suggest that proton implantationaffectssignificantly for mechanical properties of glass. ResultsincludingRaman spectroscopy will be shown and discussed at the presentation.

Reference

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