Unraveling the Space Charge Layer Effect at Ni/$BaZr_{0.9}Y_{0.1}O_{3-\delta}$ Interfaces in Protonic Ceramic Fuel Cells

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ABSTRACT:

The special role of the interfaces, whose importance is clearly demonstrated in the field of semiconductors, is still poorly understood in cases where solid ionic conductors are involved. In this study, the interface of a solid proton conductor $BaZr_{0.9}Y_{0.1}O_{3-\delta}$ (BZY10) to a metal phase (Ni), consisting of a charged core and an adjacent space charge layer (SCL) with opposite charges, was investigated for protonic ceramic fuel cell (PCFC) applications. Considering the H_2 redox reaction (HRR) at Ni/BZY10 interfaces, this SCL would affect the participant concentration of the charge transfer (CT) process. The resulting SCL resistance (R_{SCL}) was estimated to be $d\phi_{inter} / dj$ using a modified Tafel equation, where the ϕ_{inter} (electrical potential at the Ni/BZY10 interface) values are always positive even under U (applied bias) < -200 mV. This result implies the existence of segregated protons in the core layer of interfaces. The polarization resistance (R_p) under positive bias (Hydrogen oxidation reaction, HOR) is much bigger than that under negative bias (Hydrogen oxidation reaction, HER). The HRR at the Ni/BZY10 electrode interface shows preference to go into electrolysis mode rather than fuel cell mode. At high positive bias (0.3 V), the ratio of R_{SCL} / R_p is ~50%, indicating the significant SCL effect on the HOR. This study will be a first-time quantitative demonstration of the SCL effect at metal/solid ionic conductor interface, explained according to the CT resistance of the HRR.