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Intermediate temperature synthesis and SOFC anode application of cerium silicate-based oxy-apatites

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Oxy-apatites based on rare earth silicates (A10x(SiO4)6O_2±x, A=rare earth cation) are of increasing interest for solid oxide fuel cell (SOFC) application due to the high conductivity at moderate temperatures (<1000 K). Here, we report on the intermediate-temperature synthesis (973 K) of thin film oxy-apatites and high total conductivity of the cerium silicate-based apatites at temperatures <750 K: the Ce4.67 (SiO4)3O-based apatites (~80 nm-thick) were synthesized at 973 K at very low oxygen partial pressure (p(O_2)<10-17 atm) and the incorporation of ZnO into the cerium silicate system leads to the high total conductivity of ~0.05-0.2 S/cm. The formation of oxy-apatites was identified by *in-situ* conductivity measurements as a function of p(O2), x-ray diffraction analysis and x-ray photoelectron spectroscopy. In particular, the *in-situ* conductivity measurements confirm that the dominant conduction mechanisms of this class of materials are mainly dependent on oxygen interstitials. Since these materials are prepared at low p(O_2) and are stable in reducing atmospheres, Ce4.67(SiO4)3O-based thin film apatites exhibiting high conductivity are of relevance as anodes for intermediate temperature thin film SOFC application. In order to evaluate the performance of the apatite anode in SOFC devices, thin film apatites were grown on Sc-stabilized ZrO_2/LSCF electrolyte/cathode substrates. Bilayer anode of apatite/Pt and Ni-apatite composite anode were also utilized in the identical electrolyte/cathode system and the performance were compared. The noteworthy SOFC performance (e.g., peak power density of ~100 mW/cm^2 at 748K) and superior stability were observed in Ni-apatite SOFCs due to higher catalytic activity and low contact resistance at the electrolyte/anode interface compared to those with a single layer apatite anode and bilayers of apatite/Pt anode. The present study demonstrating intermediate temperature synthesis of Ce4.67 (SiO4)3O-based oxy-apatites and their high conductivity may significantly contribute to the field of intermediate temperature thin film SOFC applications.

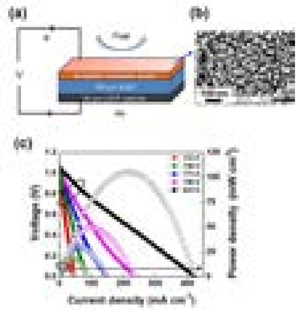

Figure.1: (a) Schematic of the SOFC structure of Ni-apatite/ScSZ/LSCF. The Ni-apatite composite anode is formed in-situ by co-sputtering precursor oxides and metal layers followed by annealing in controlled environment and can be monitored by evolution of the open circuit voltage. (b) SEM microstructure of Ni-apatite composite anode showing a porous structure, (c) Voltage (solid symbols) and power density (hollow symbols) as functions of current density for the SOFC operated at temperatures ranging from 723 to 823 K with 97% H_2–3% H_2O as fuel and air as oxidant.

Biography

Sunghwan Lee is currently an Assistant Professor at Baylor University since fall 2015. He earned a Doctoral degree in Materials Science at Brown University where he focused on transparent oxide semiconductors and their high mobility thin film transistor (TFT) devices. He has spent two and a half years for his Postdoctoral research in Chemical Engineering at MIT in Materials Science/Applied Physics at Harvard University where he was working on various projects in the field of transparent flexible electronics and energy conversion devices such as TFTs, solar cells, and fuel cells based on the materials of CVD-grown conjugated polymers and oxide ion conductors.

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