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Sol-gel synthesis of gadolinia-doped ceria diffusion barriers for intermediate temperature solid oxide cells

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Bi-layers of a gadolinia-doped ceria (GDC)/yttria-stabilized zirconia (YSZ) have been suggested as an alternative electrolyte for the reduced-temperature operation of solid oxide cells (SOCs). One problem arises from the formation of a barrier layer on YSZ electrolytes is that it becomes difficult to achieve a dense GDC layer below 1400°C. In this study, a technology for manufacturing dense diffusion barriers below 1000°C by the sol-gel process using metal (i.e., Gd and Ce) alkoxide precursors was developed. Gadolinia-doped ceria (GDC) sols were synthesized by the controlled hydrolysis and condensation of cerium(IV) isopropoxide with each gadolinia doping agent. The crystallinity of a GDC sol using gadolinium(III) isopropoxide as the doping agent was five to six times stronger than that when using gadolinium(III) nitrate hydrate as the doping agent. The GDC diffusion barrier was fully densified by infiltration of a GDC sol into a porous GDC structure under heat treatment at 1000°C. The performance of a cell was highly improved from 0.60 W/cm^2 to 0.92 W/cm^2 at 750°C by densification of the diffusion barrier. EIS results suggest that the improved performance is mainly due to the reduced Ohmic resistance through the composite electrolyte (i.e., YSZ/GDC). Finally, the degradation of a single cell with a dense GDC was maintained below 1.72%/1000 h, which was lower than that of a cell with a porous GDC (7.69%/1000 h). Based on these results, it can be concluded that the enhancement of the performance and durability of a single cell with a dense GDC was the result of reduced Ohmic resistance through the composite electrolyte.

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Development of new hybrid material of inorganic nanosheets and metal-organic frameworks

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New hybrid materials of exfoliated layered double hydroxide nanosheet (LDH NSs) and metal-organic frameworks (MOFs) were successfully synthesized. A colloidal suspension of LDH NSs was firstly prepared through hydrothermal reaction for powdery LDH (i.e., MgAl- NiAl-, and CoAl-LDH) and its exfoliation process in organic solvents (e.g. formamide and dimethylformamide). The MOF/LDH hybrid materials could be developed by the crystal growth of MOF in the colloidal suspension of LDH Ns. The obtained hybrid materials were systematically characterized by various tools such as powder XRD, SEM, TEM, BET, FT-IR, NMR, etc. The hybridization with layered inorganic nanosheets enhanced the structural stability of MOF, which is attributable due the strong coupling of MOF with functional groups on the surface of robust inorganic nanosheet. Gas adsorption and permeability test were carried out on hybrid materials and it was found that its performances were better than those shown by individuals. In addition, we tested photocatalytic ability of environmental remediation and water splitting. In this presentation, synthesis procedure and mechanism, structural formation, several applications for the hybrid materials will be discussed in detail. Obviously, the present study demonstrates the advantages of the hybridization with inorganic nanosheet not only in improving the structural stability of MOF but also in optimizing the functionality of this material.

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