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Surface modified Ni foam as current collector for syngas solid oxide fuel cells with perovskite anode catalyst

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ABSTRACT

Cu surface modified nickel foam is obtained by heating copper coated nickel foam in a reducing atmosphere. $La_{0.75}Sr_{0.25}Cr_{0.5}Mn_{0.5}O_{3-\delta}$ (LSCM) perovskite oxide is prepared using a sol–gel combustion method. The modified foams and LSCM powders exhibit excellent resistance to carbon deposition in syngas at high temperatures. Furthermore, Cu modified foams show better mechanical strength compared to bare Ni foam, which readily cracks after exposure to syngas at high temperature. LSCM retains its perovskite structure during exposure to syngas or carbon monoxide at 900 °C for 10 h. Cu surface modified Ni foam current collector demonstrates good chemical compatibility with LSCM in syngas atmosphere at high temperature. Syngas solid oxide fuel cells (SOFCs) are assembled using Cu modified Ni foam anode current collector, LSCM anode catalyst, YSZ electrolyte, and porous Pt cathode. The present fuel cell provides similar power density to one with gold anode current collector and has excellent stability during operation at 900 °C.

1. Introduction

Hydrogen is commonly considered as the best fuel for power generation in fuel cells due to its highest energy conversion efficiency and clean exhaust (H_2O) [1]. However, the energy and environmental advantages of pure hydrogen as fuel are diminished since there are energy losses and pollution generated from pure hydrogen production processes including steam reforming and purification [2]. Furthermore, pure hydrogen is still relatively expensive even when produced from fossil fuels, which are the main source for commercial hydrogen currently. Alternatively, impure hydrogen, especially sygnas (hydrogen and carbon monoxide mixture), are more readily obtained at lower cost from coal, natural gas, hydrocarbons, biomass, municipal solid waste, etc. It is a practical and promising fuel for fuel cells.

Solid oxide fuel cells (SOFCs) now are increasing in importance as electricity generators since they can directly and efficiently convert readily available carbon-containing fuels such as syngas to power without generation of significant pollution [3–5]. Unfortunately, conventional fuel cell Ni anode catalysts and current collectors result in carbon deposition when exposed to dry syngas at SOFC operating temperatures, which compromises performance of SOFCs [6,7]. Thus it is necessary to develop new anode catalysts and current collectors for solid oxide fuel cells operating with syngas as feed.

Significant effort has been devoted to the development of anode catalysts for SOFCs fed by carbon-containing fuels [8,9].

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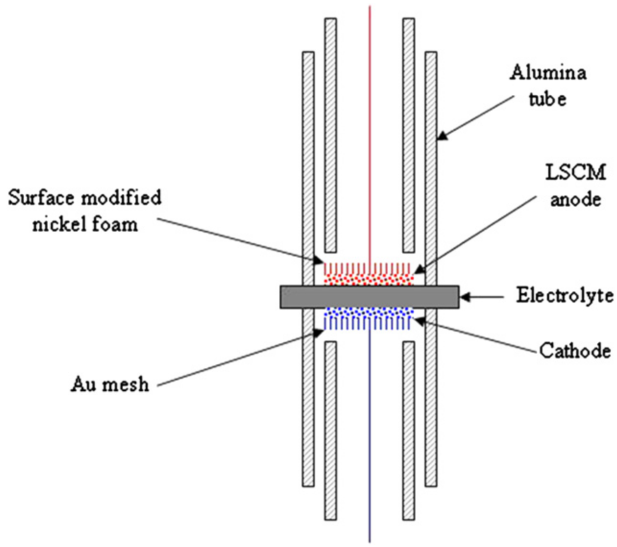

Fig. 1 – Schematic representation of a syngas solid oxide fuel cell with LSCM anode catalyst and surface modified Ni foam current collector.

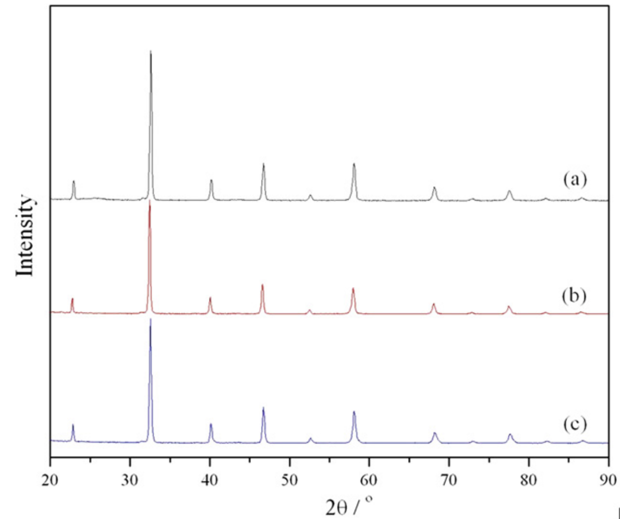

Fig. 3 – XRD patterns of: (a) as-prepared LSCM; (b) after heat treatment in syngas; and (c) after heating in carbon monoxide at 900 °C for 10 h.

For example, $La_{0.75}Sr_{0.25}Cr_{0.5}Mn_{0.5}O_{3-\delta}$ (LSCM) perovskite oxide exhibited excellent redox stability and catalytic activity in both methane and hydrogen SOFCs [10–12]. Nevertheless, there are few reports describing practical coking resistant current collectors for SOFCs using carbon-containing feeds. Silver and gold meshes usually are used as current collectors in experimental SOFCs. Although they have good conductivity and low catalytic activity toward to carbon deposition, they are expensive and so are not economical for use for wide commercialization of SOFCs.

Herein we describe use of low cost Cu surface modified Ni foam, derived from copper coated nickel foam, as coking resistant current collectors for syngas SOFCs with LSCM anode catalyst, and characterization of the current collectors and LSCM exposed to syngas atmosphere at SOFC operating temperature.

2. Experimental

2.1. *Materials preparation*

Copper coated nickel foam was fabricated using electrochemical deposition (plating) of Cu as described in previously [13]. The weight ratio of Cu to Ni was about 1:2 here. The nickel foam used here is a commercial product, INCOFOAM® from Vale Inco Ltd. The Cu surface modified foam was obtained by treatment of copper coated nickel foam in a reducing atmosphere at high temperature.

LSCM powders were prepared using a sol–gel combustion method. Stoichiometric amounts of $La(NO_3)_3$, $Sr(NO_3)_2$, $Cr(NO_3)_3.6H_2O$ and $Mn(NO_3)_2.6H_2O$ salts first were dissolved in

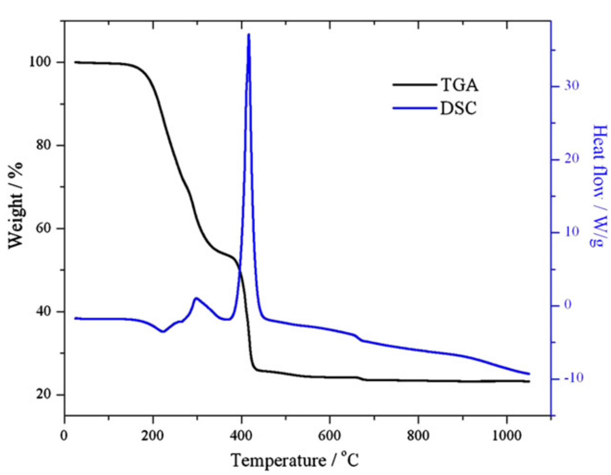

Fig. 2 – TGA–DSC curves for LSCM precursor dry gel.

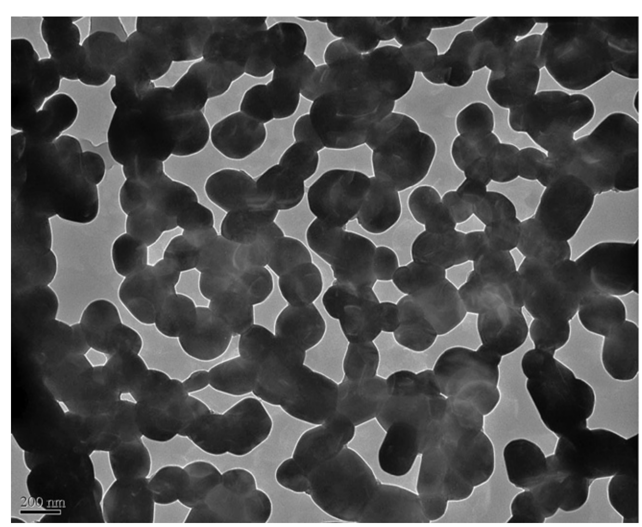

Fig. 4 – TEM image of as-prepared LSCM powders.