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Corrosion behavior of cathode current collector materials on molten carbonate fuel cell

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Introduction

The molten carbonate fuel cell (MCFC) uses carbonate salts of alkali metals as electrolyte. It has been considered as a clean source of power generation, because of MCFC's high efficiency and low environmental emission [1-2]. But severe corrosion of current collector at the high operating temperature, 650℃, is a lifetime limiting factor for commercialization. Severe corrosion has occurred on anode, cathode and current collector of each electrode [3]. Especially, corrosion behavior of cathode current collector (CCC) is not yet deeply studied. CCC is mainly made of stainless steel SS 310S and SS 316L. Lithiated oxide and chromate are formed on SS 310S and SS316L under MCFC operating condition. And insoluble lithiated oxides formed on the surface of CCC cause a degradation of electrical conductivity and performance of MCFC. However, the mechanism of the corrosion problem is not yet clearly studied and it is necessary to overcome short lifetime of MCFC. Therefore, the objective of this work is to examine the electrochemical corrosion behavior of CCC materials, SS 310S and SS 316L, in cathode MCFC environment.

Experimental

The hot corrosion reactor for the test was established with SS 310S and SS 316L working electrode, gold wire counter electrode, gold wire as a reference electrode under 67 vol.% CO_2 and 33 vol.% O_2 condition and gas injection pipe line. Corrosion potential test, potentio-dynamic test and impedance spectroscopy test was conducted at 650 ℃, 62:38 = Li_2Co_3:K_2CO_3 electrolyte, and 67 vol. % Air + 33 vol. % CO_2 gas condition for maximum 12 hour respectively. Scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) are used to examine morphology on the surface and cross section of the CCC with chemical composition across the cross section of the CCC.

Results and discussion

Corrosion potential (E_{corr}) of SS 310S is noble to that of SS 316L during immersion and after 6 h, SS 310S create protective oxide layer as confirmed by the low corrosion current density (i_{corr}) compared with that of SS 316L (see Fig.1 and Fig. 2).

Protective oxide layer of SS 310S is found to be duplex layers, composed of inner Cr rich lithium oxide and outer Fe rich lithium oxide, as confirmed by SEM-EDS analysis.

The high protectiveness of SS 310S is due to the Cr enriched lithium oxide, which is confirmed by the impedance test (see Fig. 3).

References

[1] Corrosion Science 41 (1999) 1497-1513
[2] Journal of Power Sources 83 (1999) 32-40
[3] Journal of Power Sources 195 (2010) 6988-6996

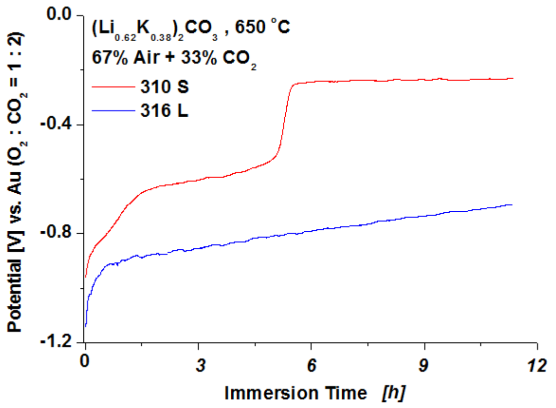

Fig. 1 Corrosion potential test response of SS 301S, SS 316L

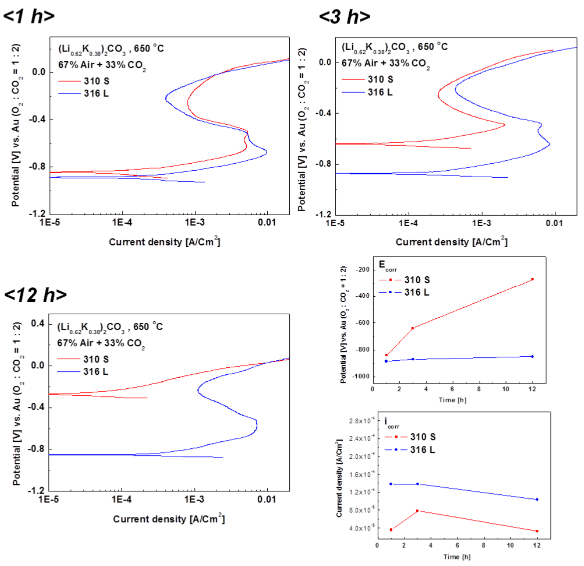

Fig. 2 Polarization response of SS 310S, SS 316L

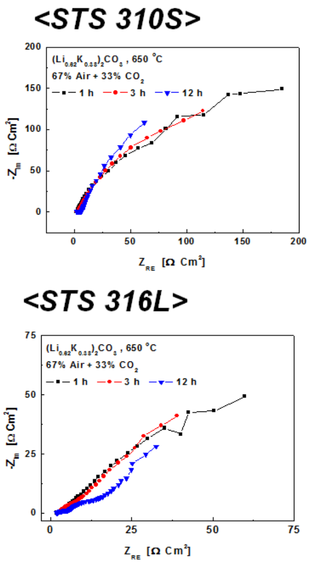

Fig. 3 Impedance data of SS 310S, SS 316L