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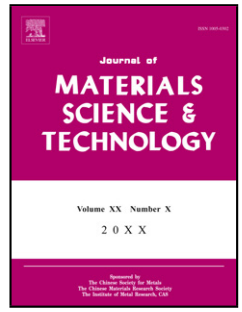

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Authors: Zongying Han, Zhibin Yang, Minfang Han

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Cell-protecting regeneration from anode carbon deposition using in situ produced oxygen and steam: a combined experimental and theoretical study

Zongying Han [1,2,3], Zhibin Yang [1], Minfang Han [1,2,*]

[1] *Union Research Center of Fuel Cell, School of Chemical and Environmental Engineering, China University of Mining and Technology, Beijing 100083, China*

[2] *Department of Energy and Power Engineering, Tsinghua University, Beijing 100084, China*

[3] *College of Chemical and Environmental Engineering, Shandong University of Science and Technology, Qingdao 266590, China*

* Corresponding author.

E-mail address: hanminfang@mail.tsinghua.edu.cn (Minfang Han).

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Carbon deposition is a primary concern during the operation of solid oxide fuel cells (SOFCs) fueled with hydrocarbon fuels, leading to cell degradation and even cell damage. Carbon elimination is expected to be a promising approach to prolong cell life. This work reports on a combined experimental and theoretical investigation of cell regeneration from anode carbon deposition of tubular SOFCs fabricated by phase-inversion and co-sintering techniques. The as-prepared cell exhibits a maximum power density of 0.20 W cm^{-2} at 800 °C fueling with wet CH_4, but fails to stable operation due to severe carbon deposition. Based on thermodynamic predictions, a successive cell-protecting regeneration process is proposed to eliminate deposited carbon without oxidizing Ni catalysts, during which CH_4 and H_2 fuels are provided in circulation. Through a total of 35 cycling tests, cell performance can always successfully restore to the initial level. The possible carbon elimination mechanism is investigated in detail based on thermodynamic and first-principle calculations. The feasibility of carbon elimination using in situ produced oxygen or steam through electrochemical reaction has been revealed, providing a novel continuous operation mode for hydrocarbon-based SOFCs.