World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:18, No:02, 2024

Effect of Preoxidation on the Effectiveness of Gd_2O_3 Nanoparticles Applied as a Source of Active Element in the Crofer 22 APU Coated with a Protective-conducting Spinel Layer

Authors : Łukasz Mazur, Kamil Domaradzki, Maciej Bik, Tomasz Brylewski, Aleksander Gil

Abstract : Interconnects used in solid oxide fuel and electrolyzer cells ($SOFC_s$/SOECs) serve several important functions, and therefore interconnect materials must exhibit certain properties. Their thermal expansion coefficient needs to match that of the ceramic components of these devices – the electrolyte, anode and cathode. Interconnects also provide structural rigidity to the entire device, which is why interconnect materials must exhibit sufficient mechanical strength at high temperatures. Gas-tightness is also a prerequisite since they separate gas reagents, and they also must provide very good electrical contact between neighboring cells over the entire operating time. High-chromium ferritic steels meets these requirements to a high degree but are affected by the formation of a Cr_2O_3 scale, which leads to increased electrical resistance. The final criterion for interconnect materials is chemical inertness in relation to the remaining cell components. In the case of ferritic steels, this has proved difficult due to the formation of volatile and reactive oxyhydroxides observed when Cr_2O3 is exposed to oxygen and water vapor. This process is particularly harmful on the cathode side in SOFCs and the anode side in SOECs. To mitigate this, protective-conducting ceramic coatings can be deposited on an interconnect's surface. The area-specific resistance (ASR) of a single interconnect cannot exceed 0.1 □□m-2 at any point of the device's operation. The rate at which the CrO_3 scale grows on ferritic steels can be reduced significantly via the so-called reactive element effect (REE). Research has shown that the deposition of Gd_2O_3 nanoparticles on the surface of the Crofer 22 APU, already modified using a protective-conducting spinel layer, further improves the oxidation resistance of this steel. However, the deposition of the manganese-cobalt spinel layer is a rather complex process and is performed at high temperatures in reducing and oxidizing atmospheres. There was thus reason to believe that this process may reduce the effectiveness of Gd_2O_3 nanoparticles added as an active element source. The objective of the present study was, therefore, to determine any potential impact by introducing a preoxidation stage after the nanoparticle deposition and before the steel is coated with the spinel. This should have allowed the nanoparticles to incorporate into the interior of the scale formed on the steel. Different samples were oxidized for 7000 h in air at 1073 K under quasi-isothermal conditions. The phase composition, chemical composition, and microstructure of the oxidation products formed on the samples were determined using X-ray diffraction, Raman spectroscopy, and scanning electron microscopy combined with energy-dispersive X-ray spectroscopy. A four-point, two-probe DC method was applied to measure ASR. It was found that coating deposition does indeed reduce the beneficial effect of Gd_2O_3 addition, since the smallest mass gain and the lowest ASR value were determined for the sample for which the additional preoxidation stage had been performed. It can be assumed that during this stage, gadolinium incorporates into and segregates at grain boundaries in the thin Cr_2O_3 that is forming. This allows the Gd_2O_3 nanoparticles to be a more effective source of the active element.

Keywords : interconnects, oxide nanoparticles, reactive element effect, SOEC, SOFC
Conference Title : ICNNTFEA 2024 : International Conference on Nanotechnology, Nanomaterials and Thin Films for Energy Applications
Conference Location : Rio de Janeiro, Brazil
Conference Dates : February 01-02, 2024