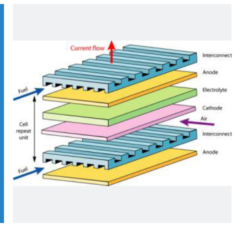
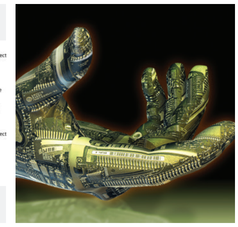
GDOES

Application of RF GDOES to Solid Oxide Fuel Cells (SOFC)





Application Note

Material Science GD31

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Abstract: Examples of application of GDOES to materials used in Solid Oxide Fuel Cells are shown.

Key words
SOFC, Interconnects, high temperature oxidation, Fast elemental depth profiling, Glow Discharge Optical Emission Spectroscopy

Introduction

Solid oxide fuel cells are based on the chemical oxidation of the fuel rather than its combustion and offers high efficiency without forming air pollutants. A unit cell typically provides a voltage of 0.7V, cells are therefore stacked (series connections) to provide useful voltages. Various geometries of cells do exist (planar & circular).

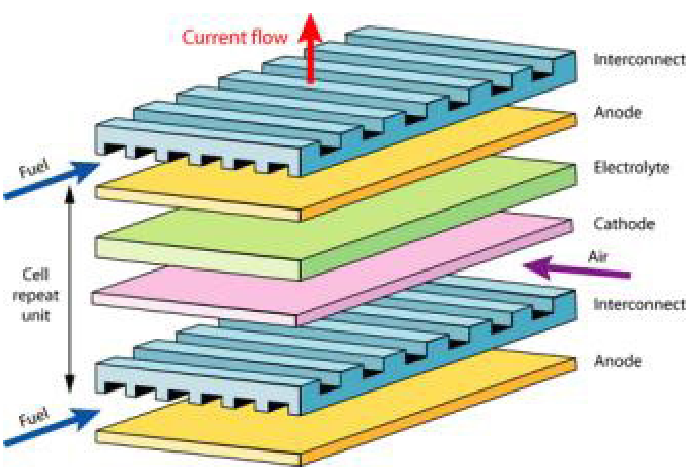

Figure 1: Principle of a SOFC (with planar geometry), ref DoITPoMS, University of Cambridge

The operation temperature of the SOFC is usually high (over 1000°C), the materials in use (ceramic & ceramic coatings on metals) react under these severe conditions and lot of research is therefore needed where GDOES takes a role (ref 1,2,3). New types of cells operating at intermediate temperatures "IT SOFC" (225°C in ref 4 for instances) are also developed leading to new classes of materials to be investigated (Ref 5, 6).

Instrumentation

GDOES provides fast elemental depth profile of materials. Most materials in use being ceramics or ceramic coatings (non conductive) RF is of course mandatory.

Figure 2: Sample compartment of the GD Profiler 2

Most of the published results obtained with GDOES are related to the interconnect materials (metals and coated metals) and were done on flat samples used in planar geometries. However some work to study Cr poisoning was also successfully done on porous ceramics with tubular geometries by using a dedicated source and small sample holder.

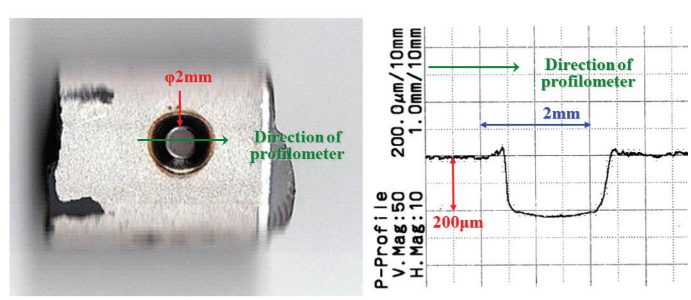

Figure 3: Deep crater obtained on a porous ceramic

Results

The first result is extracted from Ref 1. Metallic interconnects separate fuel and air and assure electronic conduction. Due to the high operating temperatures oxide layers are formed which, on one hand, protect the metal from further oxidation but on the other hand increase the electrical resistance and therefore careful investigations and studies must be conducted. The speed of GD allows checking rapidly the material in different conditions and is therefore an asset for the research.

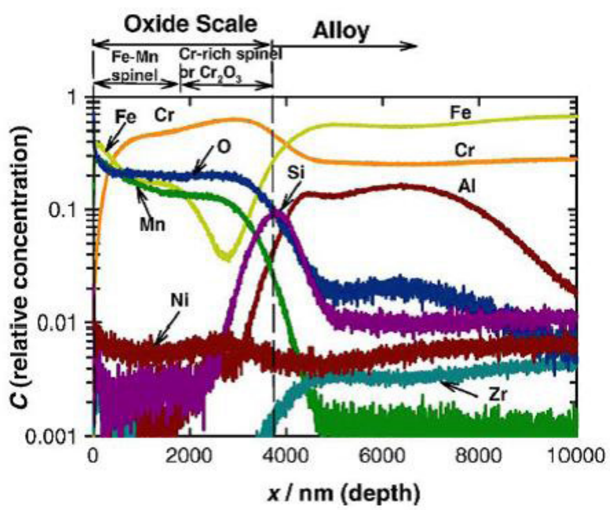

Figure 4: From Ref 1. Elemental distribution at the interface oxide/alloy (oxide was grown at 1073°C for 1100 h)

The second result is from Ref 2. Coatings are electroplated on ferritic stainless steels then exposed to air at 800°C for 3000 h.

Ferritic stainless steels rely on the formation of an outer chromium oxide (Cr_2O_3) scale to protect it against further attack in the highly corrosive SOFC environment but at high temperature with water vapour, chromium can be oxidized to volatile C^{r+6} species that deposit in the cathode where they cause degradation, a phenomenon known as chromium poisoning hence the idea of depositing a top layer (Co or composite Co/CeO_2) on the ferritic steel to prevent the Cr oxide to be exposed.

A dual layered oxide scale formed on all coated samples. The outer layer consisted of Co, Mn, Fe and Cr oxide and the inner layer consisted of Cr oxide as shown in the GD depth profile.

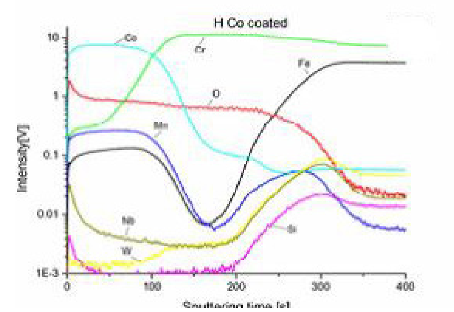

Figure 5: From Ref 2. GDOES depth profile of a Co coated ferritic steel exposed to severe oxidation conditions

The article shows that Cr oxide layer thicknesses and oxidations rates were significantly reduced for the coated samples compared to the uncoated ones.

Conclusion

RF GDOES provides fast elemental depth profile of conductive and non conductive materials and layers. All elements can be measured including O, H etc which makes the technique a useful tool to study the behavior of components in SOFC that are exposed to severe operating conditions

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