Development of hydrogen barrier coatings for fuel cell applications

INDUSTRIAL PILOT PROJECT

THE INDUSTRIAL CHALLENGE

Sandvik Materials Technology (SMT) provides coated steel strip products for fuel cell applications; Sandvik Sanergy® LT for low temperature fuel cells (PEMFC) and Sandvik Sanergy® HT 441 for high temperature (SOFC) applications. For the next generation of coatings for SOFC applications we investigate hydrogen (H) barrier coatings. The effect of hydrogen is well known as it severely deteriorates the corrosion protection of the interconnect material. However, the exact mechanism is not understood

WHY USING A LARGE SCALE FACILITY

Neutron reflectivity (NR) measurements have the potential to unravel the presence of H deep inside a metal matrix, in a direct and fully non-invasive manner. This is not possible with any other technique. Of specific concern is the application of NR for studies of the effect of a dual atmosphere (i.e. H_2 gas on one side of the sample, and air on the other side) on samples of FeCr alloy. In an operating SOFC, the dual atmosphere is known to damage the corrosion resistant oxide layer formed on the so-called interconnect - the question is why.

HOW THE WORK WAS DONE

SMT and Chalmers have been collaborating for many years in the field of SOFC materials, but the collaboration with their NR expertise was new. A series of samples were exposed to typical SOFC operating conditions at Chalmers and subjected to NR measurements at the Super ADAM instrument at the Institut Laue-Langevin (ILL) in Grenoble, France.

THE RESULTS AND EXPECTED IMPACT

A somewhat unexpected finding from this very first NR experiment was the observation of a large surface roughness, which we believe originate from the thermal growth of the protective oxide layer. To measure on samples with a lower surface roughness, which is normally needed for a high-quality NR pattern, special attention has been directed towards the preparation of more flat samples, which is further described in the following. Figure 1 shows the NR data as measured on the sample exposed to SOFC condition (green) as well as on an unexposed sample (black).

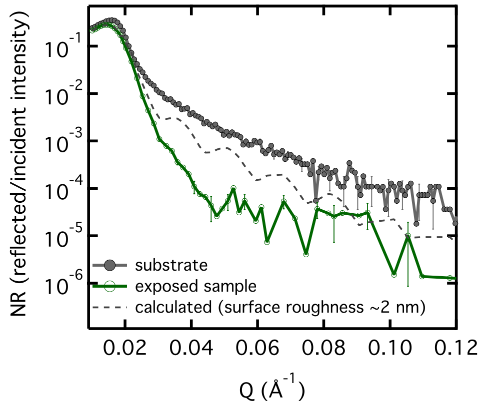

Figure 1. NR curves as measured on a unexposed sample (substrate, black) and an exposed sample (green). A calculated curve for the case of a sample with low roughness (gray, dashed) is also shown.

The NR data suggests that the exposure leads to an increase of the surface roughness from ~1 nm (on the surface of the substrate) to ~5 nm. Furthermore, the analysis indicates that the ~5 nm roughness is mainly at the oxide/air interface, meaning that the low roughness at the substrate/oxide interface is virtually unaltered under exposure. This is an important new result in itself that provides insight into the oxidation mechanism of the material and that encourages further NR studies, such as on a systematic series of films varying in exposure time.

Nonetheless, it should be noted that the increase in surface roughness causes a damping of the oscillations of the NR pattern, see *e.g.* the calculated NR curve in Fig. 1. This effect makes the extraction of the chemical composition and quantification of H in the film very difficult. This encourages the use of alternative sample preparation techniques, such as sputtering, to prepare atomically flat samples. With a view towards the future, we recognize the unique potential of further NR experiments on these samples and, for this reason, both SMT and Chalmers are committed to continue this track outside the scope of this project.

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