H$_2$-H$_2$O-Ni-YSZ electrode performance
and segregation to the interface.

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Interfaces in solid oxide fuel cells play a large role in determining the performance of the cells. Ni-YSZ cermets are designed for the maximisation of the three phase boundary (TPB) between nickel, YSZ and hydrogen, as it is the general assumption that the electrochemical reactions are taking place at or in the vicinity of this. This means that the nature of the TPB and also of the Ni-YSZ interface is essential for the performance of Ni-YSZ electrodes. The influence of impurities on the electrochemical behaviour of the Ni-YSZ interface has been examined by using two different types of Ni: 99.995% Ni (pure) and 99.8% Ni (impure).

The Ni point electrodes on a YSZ electrolyte have been examined by impedance spectroscopy at OCV and during anodic and cathodic polarisation at 1000°C in 97 %H$_2$ and 3% H$_2$O. The trend of the polarisation resistance with time was dependent on the purity of the Ni (1).

The open circuit voltage (OCV) polarisation resistance data for the pure and impure nickel electrodes were plotted in a log(1/LSR) vs. 1000/T graph, where LSR is the three phase boundary length specific polarisation resistance. It was found that the best pure electrodes were up to 2 orders of magnitude better than the best impure electrodes (fig. 1.)

A comparison of the polarisation resistance data with different kinds of Ni-YSZ electrodes from the literature suggested a clear separation of the most pure Ni-YSZ electrodes from both the impure electrodes and the majority of electrodes from the literature.

The segregation of impurities to the Ni-YSZ interface was examined with SEM/EDS, AFM, XPS and TOFSIMS (2) (3) and it was found that both the interface between 99.8% nickel and YSZ as well as the interface between 99.995% Ni and YSZ contained several different impurity elements.

Impurities were found to segregate both from the Ni and from the YSZ to the interface. The impurities were found both as a more or less continuous film (2), as impurity particles in the interface, as a ridge of impurities along the TPB (3), and as a film on the YSZ surface (4). The impurity phase was described as an alkali silicate glassy phase.

In the literature several suggestions of the scenario in the vicinity of the three phase boundary is presented. Not until recently have the impurities been considered as an obstacle for the electrochemical reactions in solid oxide fuel cells (5).

The ridge along the TPB is an obstacle for processes taking place at or close to (within 1-3 μm) from the three phase boundary. The partly blocking interface restricts reactions at the Ni-YSZ interface and the impurity layer on the YSZ surface may impede the water formation reaction.

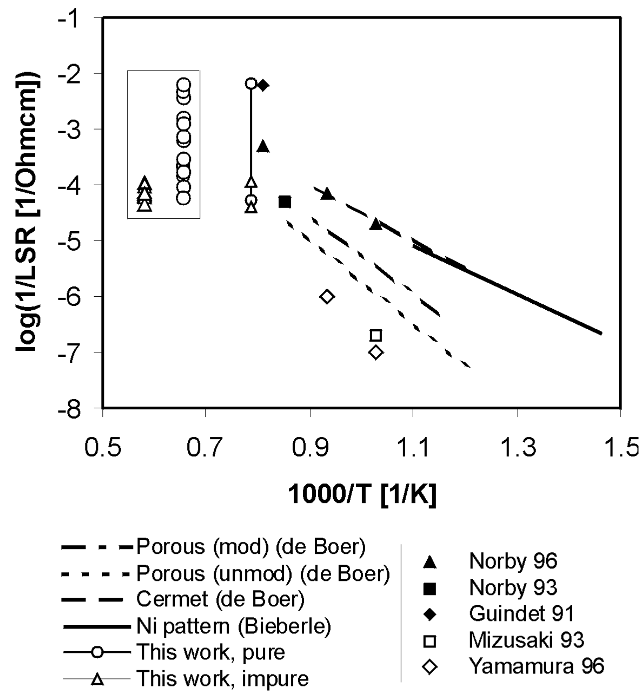

Fig. 1. OCV data for the pure and impure electrodes (O, Δ.) at 1000°C. The inset shows the distribution of the specific values. The other points and lines show values from the literature. Both point, porous, cermet and pattern electrodes are represented. Clearly, the literature data are more consistent with the impure electrodes with the exception of the data from Guindet.

References

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