NICKEL/CERAMIC COMPOSITES FOR CURRENT COLLECTION TERMINALS

Xingguo Wei and Alan Atkinson
Imperial College
Department of Materials, London SW7 2BP, UK.

SOFCs built as thick film structures on porous supports often require conducting elements to collect current from one set of cells and transfer it to the next set of cells in the stack. We have therefore investigated electro-deposition to produce electrically conducting regions within a porous ceramic support. The metal chosen was Ni because it is already a common constituent of SOFC anode structures and is readily formed by electro-deposition. The ceramic in this study was chosen to be spinel ($MgAl_2O_4$) because it is relatively inert, insulating and readily available.

EXPERIMENTAL

Porous spinel support plates (25 x 25 x 1 mm) were produced by sintering spinel powder for 1 hour at 1500°C. Spherical organic pore-formers of 50-micron diameter were added. The volume fraction of porosity measured on 15 specimens was 39.5 ± 0.9 %. A thin silver electrode was applied to one face and nickel was then electro-deposited onto this electrode through the porous ceramic from a nickel sulphamate electroplating solution to form a composite. Thermal expansion and 4 point DC electrical conductivity of the composite were measured between room temperature and 1000 °C in a reducing atmosphere (1% hydrogen in nitrogen).

RESULTS AND DISCUSSION

The microstructure of a polished cross section of the composite is shown in Figure 1. The white areas are nickel and the ceramic appears darker. The darkest phase is porosity. The nickel in the composite clearly forms a continuous three-dimensional network. The volume fraction of Ni in the composite varied from 16 to 20 %, so that the electro-deposited Ni had filled approximately half of the pore volume of the spinel matrix. A simple pressure test showed that the composite was impermeable to direct gas transport.
The coefficient of thermal expansion of the composite is close to that of the spinel as expected from the higher volume fraction and elastic modulus of the ceramic phase. The electrical conductivity of the composite (Figure 2) is repeatable when thermally cycled and has the same temperature dependence as pure nickel although 1000 times lower than pure nickel in magnitude. The long term stability of the electrical conductivity of the composite at 900°C is shown in Figure 3. The early decay in conductivity is probably due to redistribution of the Ni in the pores of the spinel driven by surface and interfacial energies. However, the structure rapidly stabilises and reaches an almost constant value.

CONCLUSIONS

Electro-deposition is a low cost, flexible method to produce an inter-penetrating network conducting composite. Using a porous spinel matrix with approximately 40 volume % porosity, electro-deposition of Ni gave a composite with approximately 18 volume % Ni that is impermeable to gases.
The thermal expansion coefficient of the composite is close to that of the ceramic. The electrical conductivity of the composite has the same temperature dependence as Ni and is stable on thermal cycling, but shows a slow reduction with time at 900°C which soon stabilises.

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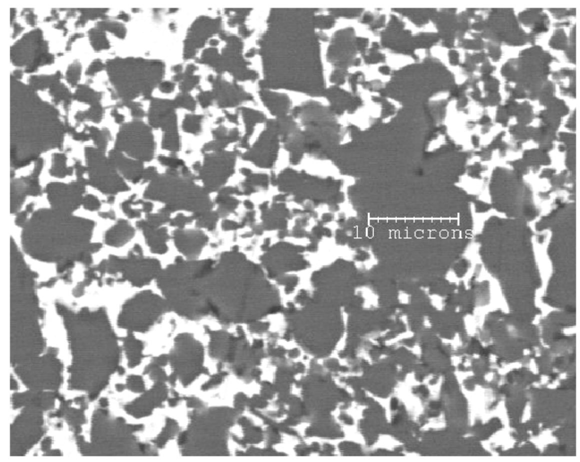

Figure 1 BSE micrograph of cross section through the composite

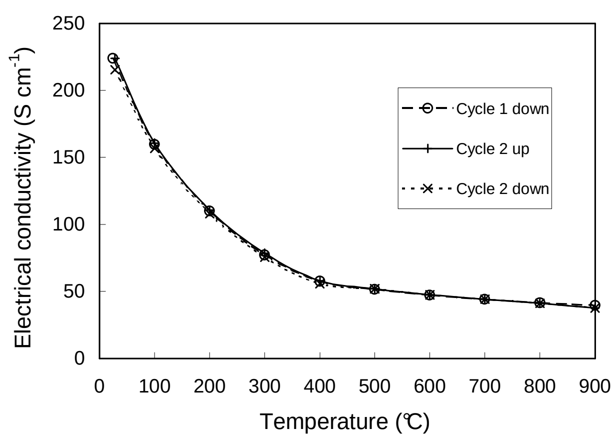

Figure 2 Effect of thermal cycling on electrical conductivity of composite

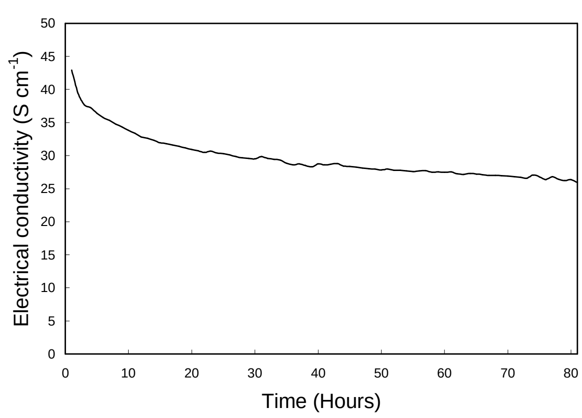

Figure 3 Electrical conductivity as a function of time at 900°C.