EVALUATION OF MECHANOCHEMICALLY SYNTHESIZED NiO/SDC COMPOSITE NANOPOWDERS FOR THE DEVELOPMENT OF NANOSTRUCTURED CERMET ANODES

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The development of intermediate temperature solid oxide fuel cells (IT-SOFC) demands a higher performance from the electrolyte and electrodes. To achieve this strategies such as employing thin, highly conductive electrolytes such as samarium-doped ceria (SDC)(1) or designing electrodes featuring highly dispersed electrocatalysts(2) are becoming increasingly popular. Evident here is a common requirement for an ultra-fine or nano-scale grain structure. To achieve this nano-sized ceramic precursor materials are necessary.

Mechanochemical processing is emerging as a commercially viable method for the large scale production of highly dispersed nanoparticles such as ZnO, ZrO_2 and CeO_2(3). We have shown previously that CeO_2 can be doped with Sm(4) yielding nanoparticulate SDC, ideal for the fabrication of nanostructured electrodes and electrolytes. We now extend this research with the synthesis of NiO/SDC composites nanopowders and investigate its suitability for the formation of anode cermets for IT-SOFC.

Composite powders containing 35%NiO, 50% and 65%NiO/SDC were synthesized mechanochemically. Energy filtered TEM elemental mapping, BET and XRD. These materials exist as 10-20nm crystallites of NiO and SDC highly dispersed in 30-50nm agglomerates, shown and hence can truly be termed nanostructured. Figure 1 shows a 75nm agglomerate consisting of NiO and SDC crystallites.

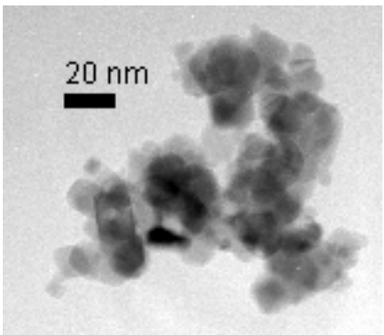

Figure 1. Mechanochemically synthesized 50%NiO/SDC

Sintering was performed on compacted nanocomposite powders at temperatures below 1200°C, yielding ceramic composites having intermediate densities whilst maintaining crystallite sizes below 50nm. SEM shows a microstructure consisting of a sub-micron distribution of NiO and SDC domains which upon closer inspection have a sub-structure with 20-70nm features, shown in Figure 2.

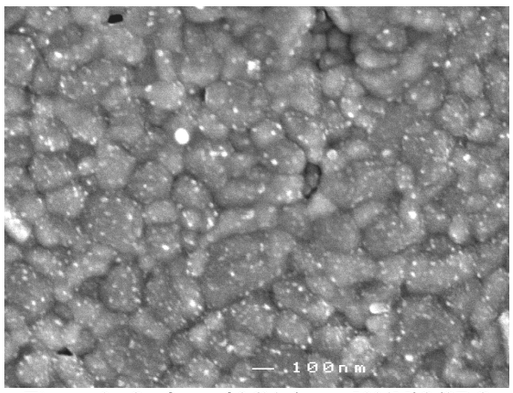

Figure 2. Surface of 86% dense 50%NiO/SDC composite sintered 3hrs at 1200°C

The sintered composites were converted into cermets by reduction with H_2 at 400°C. The reactions were monitored by recording the increase in conductivity, the 60vol%Ni cermet had a conductivity of 2.5 S/cm which was the highest measured. The optimum Ni content for cermets fabricated from NiO/SDC nanocomposites was between 50 and 60% Ni by volume, shown in Figure 3.

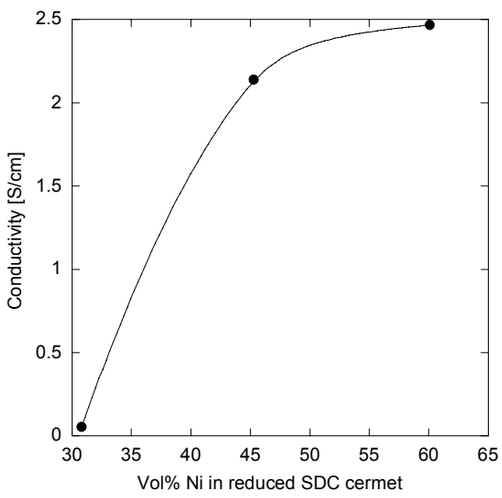

Figure 3. Conductivity of Ni/SDC cermets at 400°C

The substantial conductivities of the cermets suggests that they would make ideal anode support structures for an IT-SOFC. Mechanochemically synthesized NiO/SDC nanocomposite powders show great utility for the fabrication of nanostructured anode cermet supports.

References:

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