Silver-ceria composites for oxygen separation from air

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Oxygen can be separated from air using a mixed oxygen-ion-electronic conducting membrane. A pressure-driven oxygen separation membrane can be made with a well-mixed composite of an oxygen ion conductor and an electronic conductor. The membrane should be gas tight and the electronic conductor should form a percolating network. Below 600°C rare-earth doped cerias are the best oxygen ion conductors stable over a wide range of partial pressures of oxygen while silver is the best natural electronic conductor known. Additionally, doped cerias can have some electronic conductivity in reducing conditions while silver can provide some oxygen transport.

Rare earth doped ceria nanoparticles were prepared by hydrothermal synthesis and then coated with silver by electroless techniques. The highly dense composites were prepared by careful sintering and then characterized by FEG-SEM, XRD and DC conductivity. The oxygen ion diffusivity was determined by ^{18}O isotopic exchange and depth profiling by TOF-SIMS at 550°C. A 3-D reconstruction was undertaken with FIB-SEM. Oxygen evolution has been followed by MS in a membrane reactor and the results are compared with oxygen diffusivity measurements and literature values.

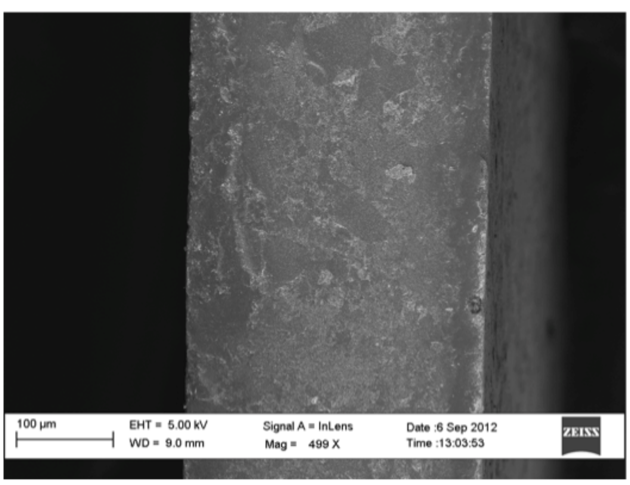

Fig. 1. Silver-samaria-ceria composite.

The doped ceria nanoparticles are highly sinterable and can form a dense (>95%) consolidated body density when coated with silver (Fig 1). FIB-SIM imaging indicates that only a fraction of the silver forms a percolating network. Even at low volume contents (<10%) the composites exhibit metallic conductivity from room temperature (Fig 2).

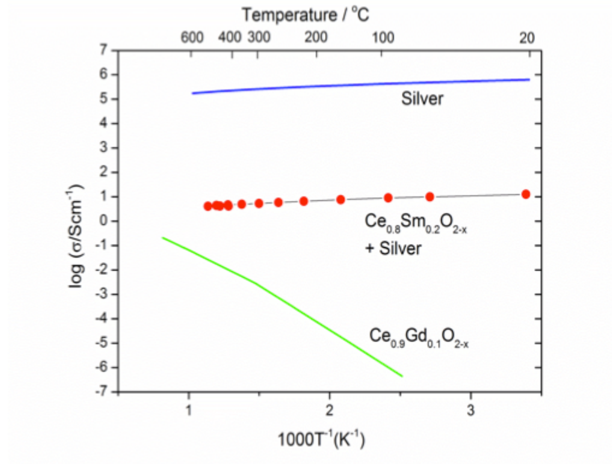

Fig.2. Conductivity of a ceria-samaria composite

We have estimated an oxygen diffusivity of 3 x 10^{-8} cm^2/s with a surface exchange coefficient 7 x 10^{-7} cm^2/s. The diffusivity is virtually the value expected for samaria doped ceria while the surface exchange coefficient has been improved by the presence of silver. Fig 3 shows the m/e signal in a mass spectrometer for N_2 and O_2 permeated at high temperature.

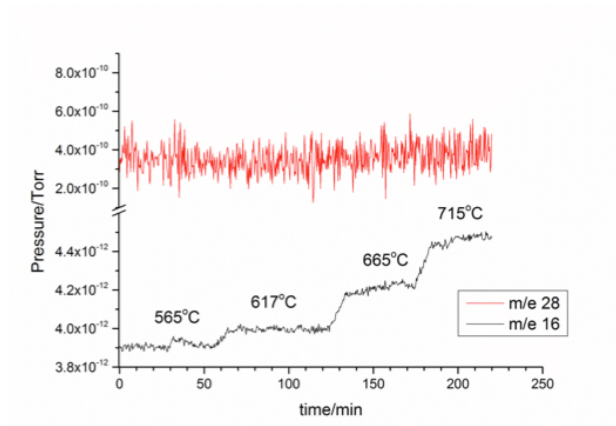

Fig 3. O_2 and N_2 signals at different temperatures.

Conclusions: An easy way of manufacturing silver-ceria composites has been presented. The silver content dominates the conductivity, is percolating even at low concentration and improves the surface exchange coefficient. The CSO provides high oxygen ion conductivity and high sinterability. The composite performs very well at temperatures below 700°C compared with literature values at similar temperatures.

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