Investigation of solid solubility in $Ce_{1-x}La_xNbO_4$; a proposed material for SOFC and gas permeable membranes

In recent years large resources have been invested in research for development of more efficient power generation systems. One of the technologies that have received much interest is the solid oxide fuel cell (SOFC), which has a wide variety of applications. These systems are of particular interest to the oil and gas industry where they can be combined with gas turbines for electricity production based on natural gas. Several of the component materials for SOFC can be used for separation of gases, which is also a technology of great interest.

Existing SOFC systems and gas permeable membranes, however, have some performance limitations due to insufficient electronic and ionic conductivity and low CO_2 tolerance of the material constituents. It is therefore of great importance to develop new materials with improved properties. In previous years large efforts have been invested in improving oxygen conducting materials. However, it has recently been found that hydrogen conductors may have a brighter future due to more efficient fuel utilization, which has caused current and future research to focus mainly on hydrogen conducting materials.

Two materials that have been investigated by the inorganic materials and ceramics research group, are $LaNbO_4$ (patent application pending) and $CeNbO_4$. $LaNbO_4$ is known to be a relatively good proton conductor, while $CeNbO_4$ is found to possess considerable mixed ionic and electronic conductivity. Their conductive properties as pure materials are still not sufficient for commercial purposes. However, there is a great possibility that a mixture of the two may possess enhanced conductive properties.

$LaNbO_4$ and $CeNbO_4$ are isostructural and when mixed, are therefore very likely to form solid solutions for a wide range of compositions. X-ray diffraction analysis has confirmed that $Ce_{1-x}La_xNbO_4$ form a solid solution containing only one phase for all values of x. In the X-ray diffractogram (Fig. 1) it can bee seen that the peaks shift to lower 2θ values with increasing La-content, which indicates that the unit cell parameters change with composition due to La(III) being larger than Ce(III).

Work has started on synthesis and characterization of thin film membranes, and ceramic processing techniques have been developed where dense 10-15 µm thick membranes are produced by spray coating a porous support, using a mixture of ceramic powder and ethanol. The porous support, which is made of the same material as the membrane, is permeable to H_2 and O_2 and serves to improve mechanical strength of the membrane. Fig. 2 shows a scanning electron micrograph of the cross section of one membrane, where the boundary between the porous support and the ~15µm thick membrane is clearly seen. Work is ongoing to decrease the thickness of the film in order to achieve improved permeability rates.

Fride Vullum

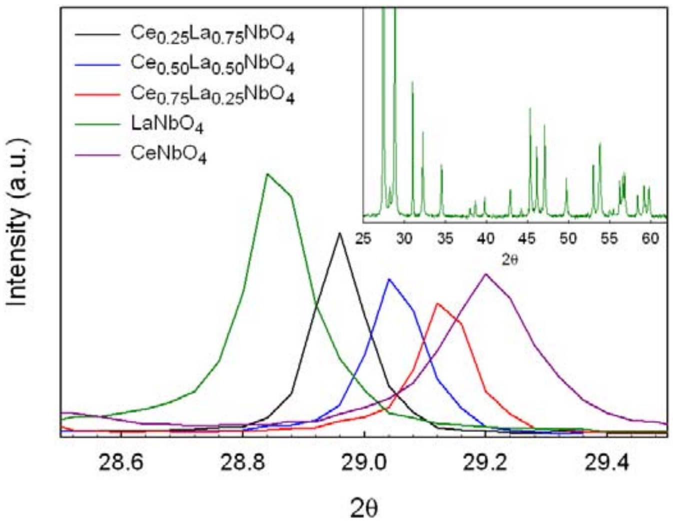

Photo: Magnus Rotan

Fig. 1:
X-ray diffractograms of $Ce_{1-x}La_xNbO_4$ focusing on one peak to show the shift in 2θ, with the inset showing the entire 2θ range.

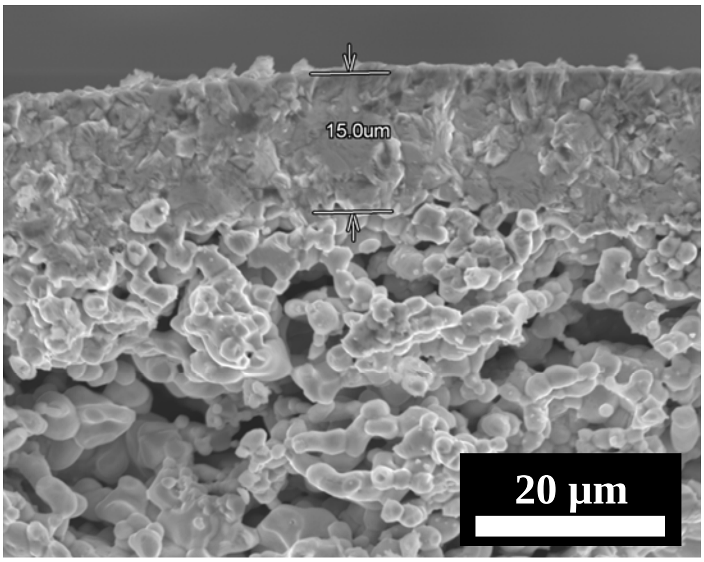

Photo: Magnus Rotan

Fig. 2:
SEM image of a dense15 µm thick membrane on a porous support.