Proton conducting Solid Oxide Fuel Cells (SOFCs) with the novel $LaNbO_4$ as the electrolyte

$LaNbO_4$ based oxides are of great interest as new materials for proton conducting SOFCs due to great advantages compared to today's most commonly used materials. Cooperation between NTNU, UiO and the respective TTO's has resulted in a newly established company which will focus on improvements of such fuel cells to make them commercially interesting.

Recent years, SOFCs have been of interest due to the need for more efficient electricity production and exploitation of natural gas resources that can be used to produce electricity. State-of-the-art SOFCs are mostly based on oxygen conducting electrolytes, however, more and more attention is drawn to the proton conducting oxides like cerates (e.g. $SrCeO_3$) and zirconates (e.g. $BaZrO_3$). Even though these materials have quite high proton conductivity, they are not stable in CO_2 and H_2O containing atmospheres. Therefore, we have started focusing on a new class of materials, namely the niobates (e.g. $LaNbO_4$). They have in general lower proton conductivity, but are much more stable and hence interesting materials.

In our proton conducting fuel cells, we are using Sr-doped $LaNbO_4$ as the electrolyte. The anode is a ~1 mm thick cermet of $La(Sr)NbO_4$ and Ni (added as NiO) made by tape casting, and is the loadbearing device. A porosity of 40% is ensured by adding carbon black as pore filler. The electrolyte with a thickness of 20-30 µm is deposited on the anode by spray coating. Then the cathode, a 150-200 µm thick layer of $La_{0.8}Sr_{0.2}MnO_3$, is deposited on the electrolyte by the same method. Here too, a porosity of 40% is ensured by adding carbon black. Finally, the entire fuel cell is co-sintered in air. The cermet will be reduced in-situ during operation. In Figure 1, the cross-section of such a fuel cell is shown. In Figure 2, a complete button cell is shown.

To ensure a good result, it is important to control all parameters during preparation, like particle size, particle size distribution, phase purity, viscosity of slips prior to tape casting, and pore size and pore size distribution in the porous layers. Other important challenges are good interlayer attachment (due to differences in thermal expansion coefficients and different shrinkage during sintering), good mechanical properties of the loadbearing anode and high conductivity of the reduced anode material. All these factors are investigated here.

Cells are tested with H_2 as the fuel on the anode side and air on the cathode side. Water is formed on the cathode side due to reaction of O_2 from air and protons diffusing through the electrolyte. To achieve sufficient output, the main task is to reduce the electrolyte thickness down to approximately 2 – 3 µm. The challenge is to be able to deposit such a thin layer on the anode support that simultaneously is completely dense and free of leakages. Therefore, the anode must be homogenous and with pores down to ~ 100 nm close to the electrolyte. Hence, the pore size distribution must be graded to ensure sufficient gas permeability of the anode, while have small enough pores close to the electrolyte to give the proper surface for depositing a thin layer of the electrolyte material. Attention to the pore filler and the sintering procedure is therefore of great importance to reach the requirements.

Protia AS is established fully owned by UiO and NTNU, and on track to receive VC funding in 2008. The company has licensed technology developed at NTNU and UiO and will continue to support further R&D to commercialise the proton conducting fuel cell (PCFC) technology, a.o. the fuel cells based on the $LaNbO_4$-electrolyte.

The PCFC Project package as of January 2008 consists of 5 complimentary projects with a total financial frame of approximately 40 MNOK:

- nanoPCFC
- STACKPRO
- VERICELL
- N-INNER
- NANIONET

Partners in the projects are NTNU, UiO, SINTEF, Jülich, Chalmers and Risø.

Hilde Lea Lein and Inge Hovd Gangås

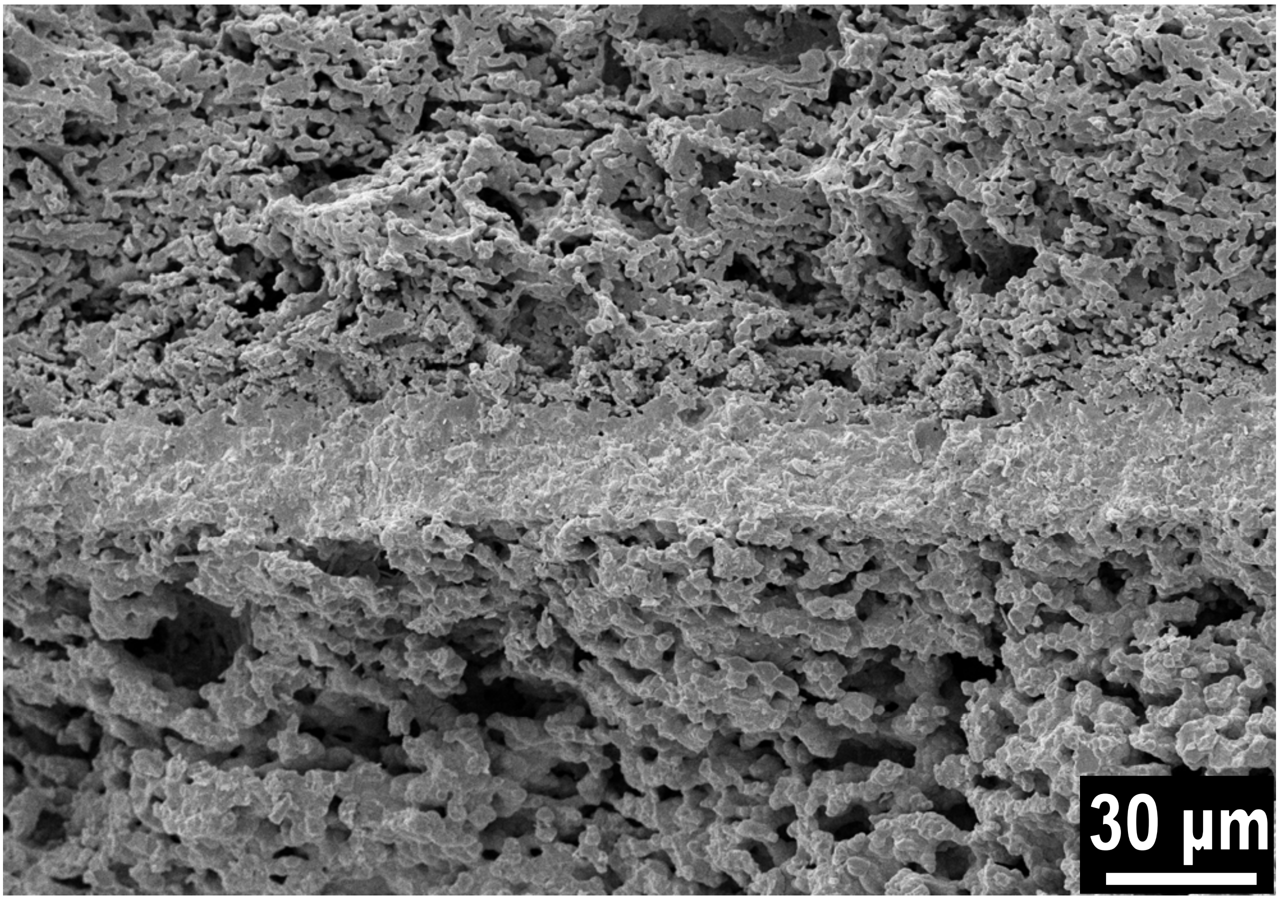

Photo: Hilde Lea Lein

Fig. 1
Cross-section of a fuel cell. Upper layer is the porous cathode, the middle layer is the dense electrolyte and the bottom layer is the porous anode.

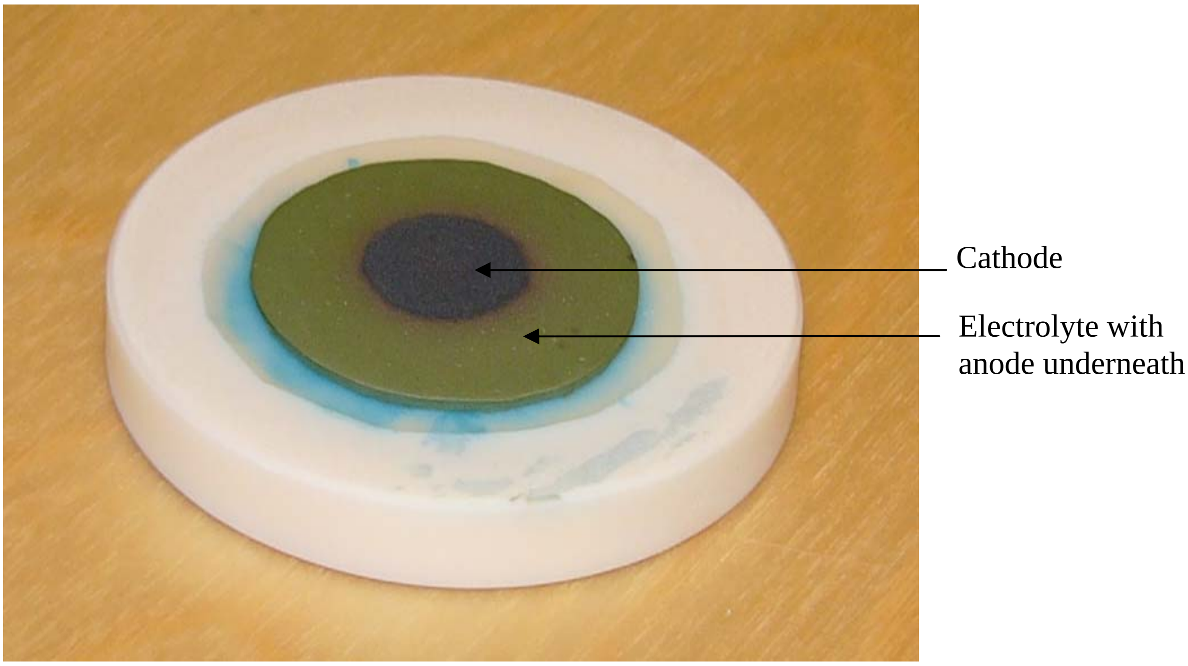

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Fig. 2
A complete button cell.