D2.2 – Report on PVD barrier layer development

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1. Abstract

This deliverable D2.2 reports the development of the PVD process for inter-diffusion barrier layer deposition. The barrier layer in the solid oxide electrolyser cell is required between the electrolyte (Yttria-stabilized Zirconia) and the oxygen electrode (Lanthanum Strontium Cobalt oxide) to prevent chemical reactions inter-diffusion between the two layers. The reaction between the layers creates a high resistance layer thus reduces the performance of the cell. The most commonly used barrier layers are made of Gadolinium doped Cerium (GDC). The barrier layer not only needs to block strontium from migrating towards the electrolyte layer, but it also needs to have low electrical resistance and a thermal expansion coefficient close to the two surrounding layers.

Moreover, the adhesion of the layer must be very strong with the electrolyte and the oxygen electrode. The currently used process for barrier layer (GDC) deposition is either tape casting or screen printing. In both cases there is a need for sintering of the layer at very high temperatures to ensure a good adhesion and right conditions to form dense layer. Such a high temperature heating process is not only energy consuming, but also creates an electrically resistive phase due to the reaction between electrolyte and the barrier layer. Therefore, alternative production methods should be considered. Additionally, the barrier layers made by screen printing and tape casting are in the micrometer thickness range, such thick layers reduce the electrical conductivity of the cell and therefore limit the overall performance.

It is therefore beneficial to have the layer as thin as possible and as dense as possible without creating any secondary phases between the adjacent materials. Since it is possible to deposit thin, dense layers with PVD (physical vapor deposition), more specifically magnetron sputtering, it is of our interest explore the manufacturing of the thin barrier layers with this method.

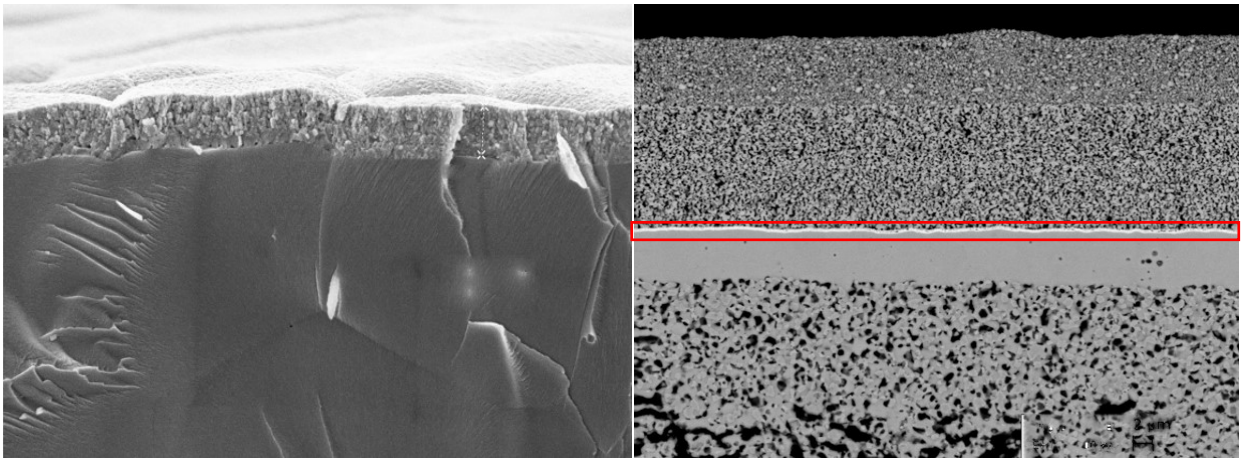

Figure 1 magnetron sputtered GDC layers,Left- as deposited GDC barrier layer on electrolyte, right - barrier layer(highlighted in the red square) within cell structure

By adjusting the deposition parameters such as temperature, argon and oxygen partial pressure, heating during deposition, Naco has deposited thin, dense GDC layers on half cells that do not require sintering. The adhesion of the magnetron sputtered GDC layers is good for the as-deposited layer and also after the remaining layers of the cell are added and the cell is sintered. The magnetron sputtered GDC layers are significantly thinner compared to the screen-printed layers which is beneficial as the reduction of thickness also decreases the electrical resistance of the layer. To fully evaluate the PVD barrier layer, together with partners of Elcogen AS and DTU, several cells will be tested in solid oxide electolyser environment for thousands of hours.