Controlling strain and micro-structure of yttria stabilized zirconia thin films

Yttria stabilized zirconia (YSZ) is a good oxygen ion conductor and therefore commonly used as electrolyte material for solid oxide fuel cells (SOFC). Conventional SOFCs have to be operated at temperatures >800°C in order to enhance the oxygen conduction inside the electrolyte. The recent approach to facilitate lower temperatures and a scaling down for portable devices is to make the electrolyte thinner or to increase its conductivity through modifications. Although the development of oxygen conducting thin film based SOFCs preceded rather quickly, a large number of fundamental questions concerning the physical and chemical mechanisms remained.

YSZ thin films were grown by pulsed laser deposition to obtain different strain states and microstructures. Depositions at room temperature yield amorphous films, which crystallize during a subsequent annealing step. Large grains with diameters >100 nm are formed in comparison to a polycrystalline columnar structure with feature sizes ~20 nm that is obtained at higher deposition temperatures (>200 °C). The strain state of such a columnar structure may be easily influence by using different laser fluences as shown by X-ray diffraction measurements. A decrease of the activation energy for oxygen ion migration with decreasing in-plane strain was determined by electric conductivity measurements while the total ionic conductivity did not change significantly. Another approach to change the microstructure was the application of an angle between the plasma plume and the substrate normal during deposition. In this case, tilted columnar microstructures were obtained. The mechanical properties of these thin films were analyzed by nanoindentation. In comparison to the conventional thin films lower hardness and elastic modulus values were measured which could prove to be beneficial for the application as a free-standing membrane in a μ-SOFC.