IN- AND ACROSS-PLANE CONDUCTIVITIES OF YSZ LAYERS OBTAINED FROM A SINGLE IMPEDANCE MEASUREMENT

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The conductivity of thin YSZ films can be measured perpendicular and lateral to the thin film plane. Both types of measurements are important and reveal information on any potential anisotropy of the conductivity. However, YSZ in- and across-plane conductivities are measured separately and with films on different substrates. In our previous studies [1, 2], it has been experimentally demonstrated that in- and across-plane measurements are possible on a silicon substrate due to the silica interlayer (Fig.1). The dielectric interlayer causes strongly frequency dependent current lines between two electrodes.

In this contribution numerical simulations (COMSOL) of the impedance spectra are demonstrated and the role of the dielectric interlayer is discussed. Simulations of the impedance resulted in an additional high frequency shoulder in the Nyquist plot (Fig. 1 c), which scales with the across-plane resistance of the YSZ layer. The low frequency part of the simulated spectra leads to a highly resistive arc (Fig. 1 c), which scales with the expected in-plane resistance values. Current density lines flip from across-plane current flow at high frequencies to in-plane flow at low frequencies (Fig. 1 a and b). This allows determination of the in- and across-plane conductivities of the YSZ film from a single impedance spectrum. The accessibility of the across-plane part might be improved if the insulating layer had a higher dielectric constant. The effect of different interlayers was demonstrated experimentally and instead of SiO_2 other dielectric interlayers (ZrO_2, Al_2O_3 and Y_2O_3) were used. The expected improvement of the separability of the YSZ across-plane conductivity was not achieved, but a strong effect of the substrate on the YSZ in-plane conductivity was observed. For Al_2O_3 and Y_2O_3 interlayers the in-plane conductivity was three times lower than across-plane, while for ZrO_2 buffer layers in- and across-plane conductivities were almost the same, i.e. an anisotropy of the conductivity was not present.

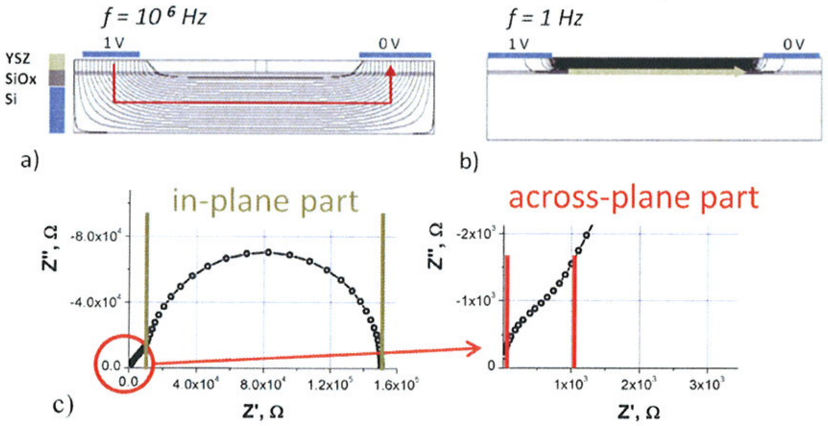

Fig.1. a) and b) Simulated current density lines in a sample at high and low frequencies; c) Simulated impedance spectrum

References:

[1] E. Navickas, M. Gerstl, G. Friedbacher, F. Kubel, J. Fleig. Solid State Ionics, 211, 58 (2012).

[2] E. Navickas, M. Gerstl, G. Friedbacher, F. Kubel, J. Fleig. Journal of the Electrochemistry Society, 159, B411 (2012).