Separation of mixed, grain and grain boundary conductivity in Gd-doped Ceria thin films and their response to sulfur poisoning

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The in-plane conductivity of polycrystalline thin films depends on bulk and grain boundary conductivities. While both contributions may differ from bulk samples, it is difficult to separate them by impedance spectroscopic methods with typically used sample geometries. The difficulty is linked to the small cross-sectional area of a thin film, compared to a macroscopic sample. This can be partly overcome by lithographic patterning of the electrodes as long, thin interdigital fingers, in order to maximize the cross-sectional area, and minimize the electrode separation.

With such an optimized geometry, we succeeded in the otherwise impossible separation of grain and grain boundary conductivity. We can show that analogously to the case of Yttria stabilized Zirconia thin films, the bulk conductivity in the Gd-doped Ceria (GDC) thin film matches the value known from polycrystals. The grain boundary conductivity limits the overall in-plane conductivity and it is also more prone to degradation by redox cycling and sulphur poisoning, than in the case of macroscopic samples.

Moreover, it is often difficult to differentiate between ionic and electronic contributions to the total conductivity of mixed conductors. The interdigital fingers geometry employed here can be used for separation of electronic and ionic conductivities, and measurement of the chemical diffusion coefficient, by comparing conductivities in the high frequency regime, where total conductivity is measured, and the purely electronic DC conductivity, due to the virtually ion blocking metal electrodes.