Uncovering the origin of local electrochemical response in $Ce_{1.9}Gd_{0.1}O_2$

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Cerium oxide (CeO) has a wide range of different applications such as gas sensing, water splitting and others. CeO is an attractive alternative to yttria-stabilized zirconia as an electrolyte for low-temperature fuel cells because of its high ionic conductivity, low reactivity and good chemical compatibility with many mixed conducting cathode materials [1].

Recently, the giant electromechanical response (EM) was demonstrated in CeO associated with specific electrostriction mechanism coupled with off-center shift Ce^{4+} ions in the cubic oxygen environment from oxygen vacancies [3]. Understanding of the processes driving this electrostriction mechanism at the nanoscale is a way to improve performance of the material through the modification of the sample preparation pathway and various doping strategies, especially at high frequencies. On the other hand, the authors performed nanoscale studies were confused to give a single opinion about EM response at the nanoscale [2, 4]. The EM signal in CeO was usually discussed as Vegard strain due to voltage induced motion either oxygen vacancies [2] or polarons [4].

Here we combined laser interferometry [5] and scanning probe microscopy (SPM) to study origin of EM response in CeO. An effective electrostriction coefficient $Q_{33} = 7{,}2\cdot 10^{-23}$ m^2/V^2 for the frequency range from 2 kHz to 20 kHz was determined in macroscopic measurements, while SPM EM signal we attributed not to Vegard strain but to coupled electrostriction and electrostatic phenomena. The ratio between electrostatic and electrostrictive contributions for the different SPM tips used in the measurements was estimated using COMSOL computer modelling. We showed the possibility of separation the electrostriction during local EM measurements with stiff enough cantilevers and quantitative estimation of the electrostriction coefficients distribution within thin film microstructure.

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