

Effect of Doping on Surface Reactivity and Conduction Mechanism in Samarium-Doped Ceria Thin Films

Nan Yang¹, Alex Belianinov², Evgheni Strelcov², Antonello Tebano¹, Vittorio Foglietti¹, Daniele Di Castro¹, Christoph Schlueter³, Tien-Lin Lee³, Arthur P. Baddorf², Nina Balke², Stephen Jesse², Sergei V. Kalinin², Giuseppe Balestrino¹, and Carmela Aruta¹

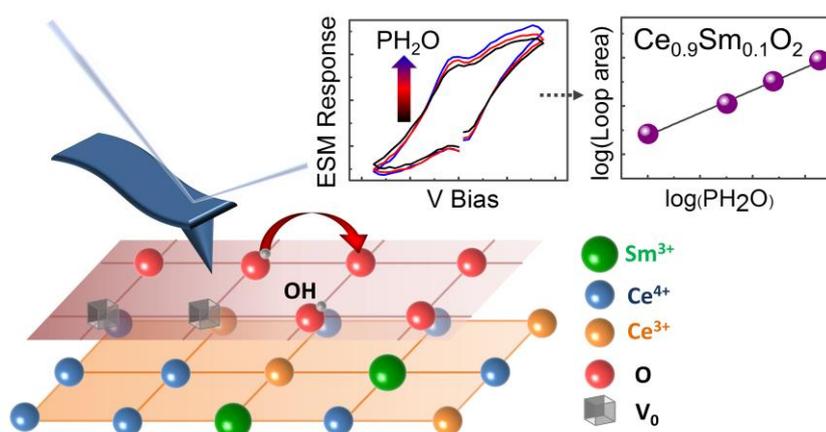
¹CNR-SPIN and DICII, University of Rome "Tor Vergata", Rome I-00133, Italy

²CNMS, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, United States

³Diamond Light Source Ltd., Didcot OX11 0DE, United Kingdom

ACS Nano 8, 12494–12501 (2014)

Pure and doped Ceria based materials attracted great attention in last two decades due to their wide range of applications, e.g. catalysts, gas sensors, memristors and micro solid oxide fuel cells. It is well known that doping and granularity influence the type of conduction, if electronic, protonic or oxygen ionic. With a systematic study on epitaxial thin films by electrochemical strain microscopy and hard x-ray photoemission, we answer to the open question on how doping affects the conduction mechanism and the related surface activity, such as water adsorption and dissociation with subsequent proton transport in the lattice. We find that at lower Sm concentration, thanks to presence of Ce^{3+} , the proton conduction is prevalent, featured by lower activation energy and higher conductivity, which is interpreted in terms of different energy landscapes involving hydroxyl group and oxygen ions in the crystal lattice. Our work demonstrates that trivalent doping element concentration must be considered as an important factor for the design of ceria-based systems, helping in improving the performance of energy storage devices.



Hysteresis loop behavior (top-left) and area (top-right) of the electrochemical strain microscopy measurements at different relative humidity, showing the effect of proton conduction in $\text{Ce}_{0.9}\text{Sm}_{0.1}\text{O}_2$ thin films, together with the schematic representation of the proton conduction mechanism (bottom).

References

- S. Doria et al. Appl. Phys. Lett. 103, 171605 (2013)
Nan Yang et al. Nanotechnology 25, 075701 (2014)