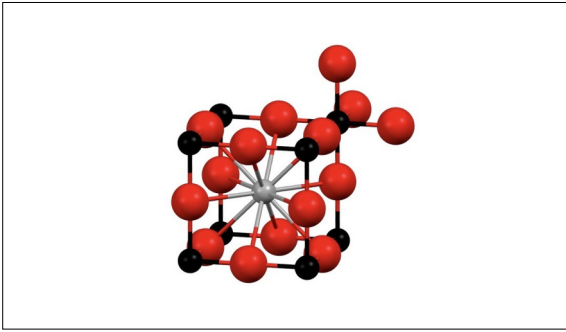




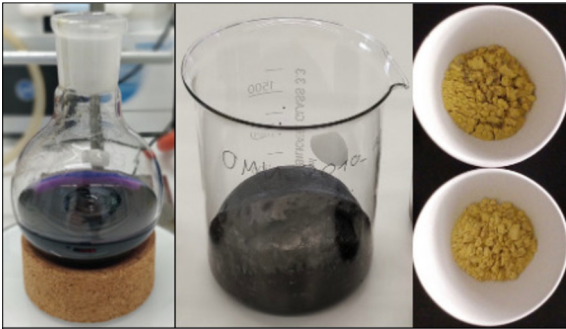
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Subject Area	General energy technology

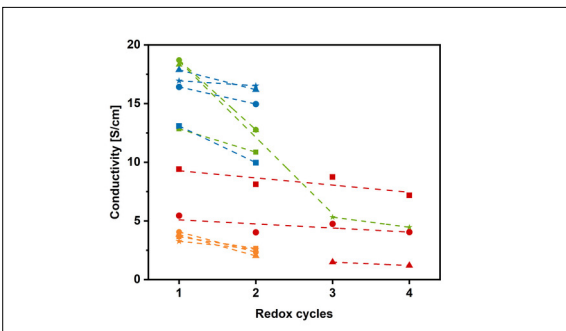
Synthesis and characterization of redox-stable materials for SOEC



Unit cell of strontium titanate: Sr (grey) and Ti cations (black) and O anions (red)
Own presentation



Sol-gel process: solution of metals cations, dried gel, and calcined perovskite powder
Own presentation



Measured conductivities: LST green, LSTC red, LSTCG orange, CLSTC blue, substitution concentration: ■ < ● < ▲ < □
Own presentation

Definition of Task: In the nickel based cermet cathode and current collector of solid oxide electrolyzer cells (SOEC), the electric conductivity arises from the metallic nickel. During operation nickel suffers from structural degradation, lowering the performance of the cell. Thus, Nickel shall be replaced by a ceramic current collector material in order to maintain a high electronic conductivity, but keep chemical compatibility.

Strontium titanate based perovskites can exhibit electronic conductivity in reducing atmosphere. Besides, it is stable in oxidizing and reducing conditions at high temperatures.

The goal of this study was to synthesize and characterize titanate-based materials with high conductivity, redox-stability, and chemical compatibility with other cell components for the application as a current collector. While the crystal lattice of titanate perovskite easily allows the substitution of cations, properties of the material can be designed.

Approach: La as a substitute for Sr in lanthanum strontium titanate (LST) gives the material n-type semiconducting behaviour. However, conductivity often degrades with redox cycling. Cr as a substitute for Ti (LSTC) enhances structural stability and therefore stabilizes the conductivity with the drawback of overall lower conductivities. On the basis of LSTC additional substitutions by Mo (LSTCM), Ga (LSTCG), as well as Ca on the A-site (CLSTC), which are promising for enhancing the conductivity were examined with the aim of a redox stable, but high conductivity.

Series of A-site deficient LST with substitutions in various concentrations were synthesized with the EDTA-citrate sol-gel method. Materials were examined by XRD in terms of crystal structure and phase purity. The chemical compatibility with the cathode (CGO) and the electrolyte material (ScSZ) was examined. For the conductivity measurement, powders were pressed and sintered to dense ceramic samples. The electronic conductivity was examined upon alternating atmospheres at the operating temperature of 850°C.

Result: For LSTCM no phase purity was reached at the applied synthesis temperatures. Since further heat treatments in reducing and oxidizing conditions did not lead to an improvement, LSTCM was not further pursued. LST, LSTC, LSTCG, and CLSTC exhibited a phase pure perovskite structure. Chemical compatibility of all co-substituted LST materials with anode and electrolyte materials is given.

LST showed the highest conductivity of up to 18.7 S/cm, accompanied by the highest decrease of up to 30% after one redox cycle. Cr in LSTC lead to better redox stability with a decrease of 8% per redox cycle but at lower conductivity levels. The combined Cr/Ga substitutes in LSTCG lowered the conductivity further with no improvement of the stability. With Ca besides Cr in CLSTC conductivity was regained up to the level of LST with the advantage of better redox stability.

By optimizing the stoichiometry of the perovskite and the powder treatment, performance of CLSTC can be further enhanced.