COMSOL Multiphysics® Simulation of Energy Conversion and Storage Concepts Based on Oxide Crystals

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Abstract

Recent development on global warming and in particular a change in energy policy in Germany have renewed interest on green power based energy and material conversion, and solutions for efficient storage in respect to short and long term power generation applications. Unused power sources exist on various forms such as vibrations, flowing water, as well as wind and waste heat energy. Whereas the use of the latter form can increase the efficiency of the corresponding processes such as charge and discharge of batteries, the conversion of waste heat energy into chemical or electrical energy can be realized by using the pyroelectric effect, for instance.

Two kinds of concepts based on oxide materials are presented: The first concept describes a system converting waste heat energy into chemical energy by pyrocatalytic water splitting, which in turn can be used for electricity generation from fuel cells. The second concept aims to use oxygen defects migration inside a crystal as electromotive force to store and release electrical energy. Another application based on oxygen migration uses a temperature gradient, which can result in material properties similar to the first concept described.

However, the physical and electrochemical governing processes inside these conversion and storage devices are often complex. A mathematical modeling based on a finite element method was utilized using the COMSOL Multiphysics® software in order to investigate underlying processes under various conditions up to device design.

In this work, different energy conversion and storage concepts are described. COMSOL Multiphysics® simulations of corresponding devices, which include important physical and electrochemical characteristics, are presented, describing the basic functionality of these devices.

Keywords: Energy, Conversion, storage systems, simulation, comsol Multiphysics