# Phase distribution visualization in Solid Oxide Fuel Cells by monochromatic neutron Bragg-edge tomography

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**Summary:** Neutron tomography study of half-cell Solid Oxide Cell reveals the detailed phase distribution depending on the redox conditions.

## 1. INTRODUCTION

Solid Oxide Cells (SOCs) efficiently convert chemical energy (e.g. hydrogen) into electrical energy in fuel cells (SOFC) or convert electrical energy into chemical energy in electrolysis cell (SOEC). Usually a SOC is constructed from three layers: a porous fuel electrode, a solid electrolyte and a porous air electrode. A major obstacle in the commercialization of SOC is their durability, which is mainly affected by the fuel electrode degradation [1, 2]. A prevalent material used for the electrodes is nickel-yttria stabilized zirconia (Ni-YSZ) cermet. During the initial operation the NiO particles are reduced into Ni. Throughout this process the microstructure of the fuel electrode and its support is established. The microstructure is responsible for the mechanical and electrochemical properties, which further determine the performance and durability of SOC.
It has been demonstrated that there is a strong correlation between reduction / oxidation rates and the mechanical properties of the Ni-YSZ cermet [3]. This material, despite of the fact that it is a brittle ceramic, can experience large plastic deformations, when exposed to stress and reducing or oxidizing conditions at the same time.

## 2. EXPERIMENTAL METHOD

An efficient way to image phases is by monochromatic neutron imaging [4]. We present the results of high-resolution monochromatic neutron tomography experiment on a Solid Oxide half-cell (only the fuel electrode and an electrolyte), performed at Antares, FRM-II in Germany. This allows for 3D imaging of the Ni and NiO phases.

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## 3. RESULTS

We have measured samples (300 µm thick layers, see Figure 1), which were previously imaged under stress in-situ at two different temperatures (at J-PARC in Japan). This study provides a detailed overview of the 3D phase distribution in the final state of the samples. The phase distribution is expected to differ close to the electrolyte interface and close to the free fuel electrode surface, and therefore also the stress distribution will differ. Using an MCP detector at pulsed neutron sources, as it was done in the experiment at J-PARC, gives a unique possibility to measure in-situ changes of Bragg edge pattern. However, phase distribution on such a small scale (300 µm) could not be observed in detail using this setup due to not sufficient resolution and field of view smaller than sample length (60 mm). This can be achieved by monochromatic imaging at continuous neutron sources, which offer high neutron flux, such as FRM II, and using high-resolution detector setup available e.g. at Antares beamline.

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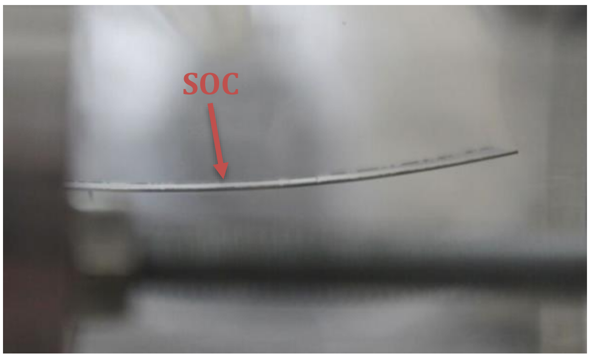


Figure 1. The sample used in the experiment

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