SUCCESS STORY

CEST
Center for electrochemical Surface Technology

Programme: COMET – Competence Centers for Excellent Technologies

Programme line: COMET-Centre

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ATTACK OF THE ACIDIC GASES: FUEL CELLS FOR A SUSTAINABLE ENERGY SUPPLY

WITH A NOVEL MEASUREMENT TECHNIQUE CLARIFY HOW ACIDIC GASES DIMINISH THE REACTIVITY OF ELECTRODE SURFACES IN SOLID OXIDE FUEL CELLS.

Solid oxide fuel cells are a promising technology that can be used to convert sustainable fuels such as hydrogen into electrical energy with a high degree of efficiency. As they require high temperatures during operation (700-900 °C), they are particularly suitable for stationary operation and as small power sources. Although the development of these fuel cells has made great progress in recent years, a limiting factor is still the reaction at the air electrode, where oxygen is incorporated into the fuel cell, which is then transported through the fuel cell where it reacts with hydrogen to form water. To date, it has been difficult to find a material with good reactivity for this oxygen incorporation that is also stable against degradation processes that occur during operation. In this project, researchers from CEST were able to elucidate the mechanism of one of these degradation processes for the first time using a newly developed measuring method, thereby making an important contribution to the development of reactive and stable materials.

Investigations on truly pristine materials

A critical aspect for research of degradation processes is the question of how to investigate the reactivity of a truly clean surface. It is usually difficult to ensure that a sample is not exposed to environmental influences between manufacturing and measurement that may significantly affect its performance. In this project, it was possible to measure the reactivity of a surface in the first moments after sample production. The samples are produced using pulsed laser deposition (PLD), in which a very thin layer of a material grows on a heated substrate. Using a new measurement setup, it was now possible with this production method to contact the sample electrically directly in the vacuum chamber in which it is coated and to measure its reactivity for oxygen incorporation (in-situ PLD or i-PLD).

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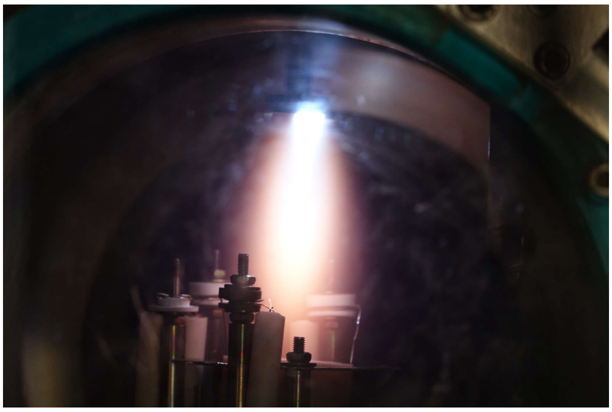
A key result of these experiments was that truly clean, freshly produced surfaces are many times more reactive than all samples previously described in literature. Using modern surface analytics, it was then uncovered that as soon as such surfaces are removed from the PLD chamber and examined in a conventional measuring atmosphere, minute traces of acidic gases adhere to the surface (e.g. sulphurous gases or CO_2), which substantially impair oxygen incorporation. Even extremely small quantities of these gases are sufficient, which are practically unavoidable in conventional measuring stands. Therefore, it was not possible to actually examine clean surfaces until the i-PLD experiments that were carried out here. Subsequently, it was also possible to clarify the mechanism of the degradation that is induced by these gases, which cause a charge redistribution between the surface and the gas molecules, thus deactivating the surface for a further reaction with oxygen.

The path to the optimal electrode material

This discovery immediately raises the question of how such degradation processes can possibly be avoided. In the course of the investigations at TU Wien and CEST, it turned out that it is actually the outermost surface that determines how susceptible the material is to contamination with acidic gases, and that not all materials are equally sensitive to this contamination. In follow-up experiments, which also used the i-PLD method, the researchers further found that the modification of such surfaces with other materials (e.g. ultra-thin oxide layers in the sub-nanometer range) also has a significant effect on oxygen incorporation and can even significantly accelerate it.

One strategy to create highly reactive surfaces that are simultaneously stable against degradation processes could therefore be to find the ideal surface modification that offers the perfect compromise between reactivity and stability. If such a material can be developed, this would be a major step forward for sustainable energy conversion systems and would greatly facilitate local power generation from hydrogen.



Copyright Matthäus Siebenhofer, Photo of a PLD laser pulse that removes material from a target, which then grows on the sample surface. The sample is mounted in a new type of measuring device (bottom part), which allows the sample to be contacted electrically during the PLD process.

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