I^{2}CNER Webinar

International Institute for Carbon-Neutral Energy Research (I^{2}CNER)
Moonshot for beyond Zero-Emission Society (MOZES)
Kyushu University

Title **Thin Films prepared by PLD: model systems for studies using large facilities techniques**

Speaker Prof. Thomas Lippert

Paul Scherrer Institute (PSI), Switzerland

Time& Date 4:00 PM(JST), Wednesday, January 12th, 2022

Abstract

A number of methods from large scale facilities require the application of well-defined samples, controlling crystallinity, roughness to interface quality, requirements which can be fulfilled by thin films. We apply pulsed laser deposition (PLD) to create these thin films to utilize complementary techniques, ranging from neutron reflectometry (NR) to grazing incidence X-ray absorption spectroscopy (GIXAS), and angle resolved photon emission spectroscopy (ARPES).
The material system which we study are oxynitrides which are applied as photoanodes in photo-electrochemical water splitting. Shortcomings of this material class are a fast decay in activity over the first few electrochemical cycles and a decay on the long term1. While the long-term decay is possibly related to a degradation of the material, i.e., a loss of nitrogen, the fast decay is not really understood, and therefore also no approach can be envisioned how to overcome this problem. We studied the fast decay of the material (and first approaches how to prevent this) by using thin films as model system. For this approach we developed a method on:

• How to deposit oxynitrides with well-defined oxygen content and crystallographic orientation by PLD using NH3 as reactive gas component on conducting substrates.
• Design a cell for in-situ NR and in-situ/operando GIXAS (and modulation excitation, ME-XAS) .
• Measure the thin films before/after photoelectrochemical operation with NR and ARPES and before/after/during operation using GIXAS and ME-XAS.

We could detect a surface modification, i.e., a change in density, by NR in the range of 3 nm, while XAS was utilized to analyze changes in oxidation state (order) for the different elements2. A change of oxidation state of the A cation was detected, while the B cation (here for LaTiOxNy), which is normally assumed to be the active site, undergoes local disordering. This surface modification reduces the overall water splitting activity, but we could identify a co-catalyst, which supresses these modifications. We could also identify critical steps in the water splitting mechanisms, where during surface modifications the formation of NOx competes with the oxygen evolution3. Using ARPES we could finally identify an electron accumulation layer at the surface4 as another mechanism for decreasing the activity.
Now we are working on approaches to mitigate the identified degradation mechanisms.
Without highly defined, high quality PLD films it would have not been possible to utilize the large facilities, and therefore to identify (mitigate) the origins of activity decay of these oxynitrides for water splitting.

About the Speaker

Professor Thomas Lippert received his Diploma (MSc) and PhD in Chemistry from the University of Bayreuth, Germany in 1990, respectively 1993. He joined the Paul Scherrer Institut (PSI) in 1999, after postdoctoral work at NIMC (now AIST) Tsukuba, Japan and Los Alamos National Laboratory, USA, where he was also Technical Staff Member. Since 2002 Lippert is the head of a research group and since 2015 also the deputy laboratory head at PSI and is also since 2013 part of the Laboratory of Inorganic Chemistry at the ETH Zürich.
Lippert's work addresses the fundamentals of thin film growth and the application of thin films for water splitting, multiferroics, Li-ion batteries and other energy related devices. Lippert uses advanced characterization methods, often based on large facilities (neutrons, muons and photons) to study the chemical/electrochemical reactions at the surfaces/interfaces to find new and/or more stable materials and catalysts. He has authored more than 360 papers, delivered more than 160 invited talks, organized several conferences, including the MRS or E-MRS meetings, was president of the E-MRS, and is presently the editor in chief of Applied Physics A: Material Science & Processing.

Registration

Host Prof. Aleksandar Tsekov Staykov

Contact I^{2}CNER・Q-PIT Office of Research Support Services, Research Support and Public Relations
TEL: +81 92 802-6935 Email: iq-kenkyu@jimu.kyushu-u.ac.jp