

Conference Report

Operando VII

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The 7th international congress on *operando* spectroscopy (Operando VII, May 7–11, 2023) took place in Switzerland, in the middle of the grandiose arena of the Bernese Alps. The Grindelwald municipal hall (Fig. 1) and the Grindelwald Sunstar Hotel offered the right settings for inspiring discussions on the state-of-the-art of *operando* methodologies. After moving the congress for two years in a row due to the coronavirus pandemic situation, **Operando VII** was finally held fully in person. Aligned with the spirit of the Operando congress series, all participants were housed in a single hotel and the congress was organized in one single main scientific session allowing for maximum interaction among all participants.



Fig. 1. The entrance of the municipal hall of Grindelwald.

The main objective of the Operando congress series is to bring together academic and industrial staff, researchers and students to discuss state-of-the-art, recent discoveries and the progress of *operando* methodologies, *i.e.* characterization of functional materials in their working state, and their possible implementation in R&D and industrial processes. In *operando* studies, physico-chemical methods probe the structure of functional materials such as catalysts, battery materials, electrocatalysts and photocatalysts, under operating conditions while their performance (activity, selectivity) is measured simultaneously, to obtain so-called structure-activity/selectivity relationships. These relationships are essential for the rational design of novel functional materials or the further optimization of catalytic processes. Examples include automotive catalysts and catalysts for fine chemical synthesis, sensors, electrocatalysts as well as batteries. The structure of the functional material is determined using a range of spectroscopy/diffraction techniques including especially state-of-the-art *operando* tools available at large scale research facilities such as the Swiss Light Source.

We received more than 180 abstracts of which 34 were selected as scientific talks and 6 as keynote lectures. All other abstracts were presented as posters displayed in a single poster session on Monday and Tuesday (Fig. 2). The invited plenary and keynote speakers represented the *operando* community in various aspects, *e.g.* spectroscopy, microscopy, heterogeneous and electro-catalysis, bringing academic experiments to industry and introducing machine learning tools. Operando VII hosted 170 participants including industry delegates (active participants and sponsors) from Europe, USA, Asia, Africa and South America (Fig. 3).

Two parallel discussion panels organized on Tuesday evening discussed the state-of-the-art in *operando* cell design (chairs: M. Daturi and D. Ferri) and *quo Vadis operando* at the newest generation synchrotron facilities (chairs: A. Hoffman and M. Nachtegaal). To set the stage and encourage participants to think big, **Franz Renz** (Leibniz Universität Hannover, Germany;



Fig. 2. The lively poster session.



Fig. 3. Group photo.

Fig. 4) opened the congress on Sunday evening with a lecture on spectroscopy in unusual conditions, highlighting his development of analytical tools for several extraterrestrial missions to the planet Mars. He showed the strength of their hand sized Mössbauer spectrometer for on-site analysis of surface rocks, which led to the identification of Jarosite, revealing the past presence of vast amounts of water on Mars.



Fig. 4. Franz Renz.

In the plenary lecture on Monday, **Jan-Dierk Grunwaldt** (KIT, Germany; Fig. 5) showed the need for synchrotron-based *operando* studies to address the temporal and spatial (along the catalyst bed) dynamics in relevant processes such as gas after treatment and CO₂ hydrogenation catalysis. In the plenary lecture on Wednesday, **Erich Stach** (University of Pennsylvania, USA; Fig. 6), who is a pioneer in the development of advanced *in situ* and *operando* electron imaging, diffraction and spectroscopy techniques, shared recent advances in electron microscopy studies under environmental conditions and its combination with complimentary X-ray-based techniques at the synchrotron and thus coupling molecular level information and morphology under reaction conditions.

Operando VII ended with a congress dinner at the Grindelwald Sunstar Hotel. A welcome reception and a Swiss dinner with original Swiss music further delighted the attendees on the previous days. On Tuesday afternoon, the social program included a tour to the glacier canyon of the river Lütschine or a cable

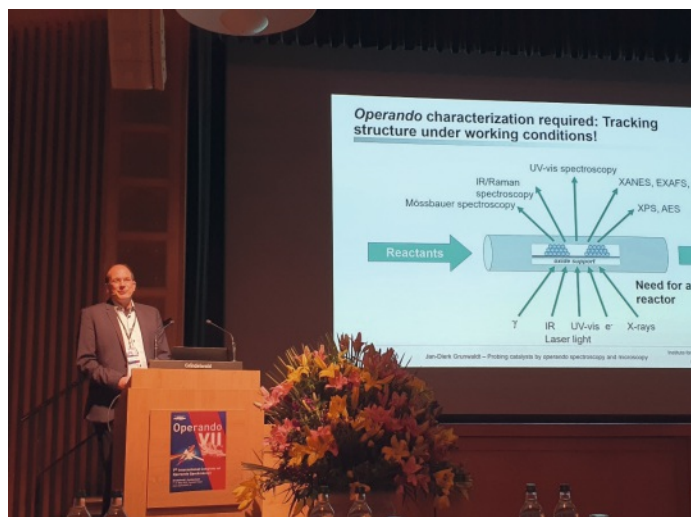


Fig. 5. Jan-Dierk Grunwaldt.



Fig. 6. Erich Stach.

car ride up to the First station to admire the spectacular landscape around Grindelwald.

Operando VII would not have been possible without the generous support of numerous sponsors (Casale S.A., The Swiss Chemical Society, Shell plc, Bruker GmbH, Bronkhorst Schweiz AG, IRsweep AG, VSparticle B.V., Reacnostics GmbH, The Royal Society of Chemistry, ExxonMobil, Hiden Analytics and GMP). Sponsorship especially enabled the support for thirty PhD students with travel grants. The Paul Scherrer Institute further supported the event with infrastructure (webpage, poster boards, badges). The main outcomes of this congress will get communicated in a dedicated issue of the peer-reviewed journal *Catalysis Today*, while *operando* spectroscopy activities in Switzerland will receive attention in the May 2024 issue of *Chimia*.

As a satellite event of Operando VII, the Operando school was launched for the first time with the aim to increase exchange and to actively involve the next generation of *operando* scientists. On May 11th, participants of the school (close to 40 registrations) were transferred to the Paul Scherrer Institute where they attended tutorials from renowned experts in the field, *i.e.*, **Bert Weckhuysen** (Utrecht University, The Netherlands), **Marco Daturi** (ENSICAEN, France), **Miguel Bañares** (Spain) and **Adam Hoffman** (Stanford University, USA). These tutorials included various topics ranging from cell design/selection to vibrational and x-ray absorption spectroscopies, visits of PSI's *operando* facilities including the Swiss Light Source. Also in this case, we are grateful for the financial contribution by Casale S.A., Bruker GmbH and the Royal Society of Chemistry, which allowed the hosting of the speakers and to organize social events.

This first occasion of the Operando congress series in Switzerland was a great opportunity to highlight *operando* research in Switzerland and improve networks in the international research community.

Acknowledgments

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