Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg



HyFaB – Overall Concept and Generic Stack

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31th testXpo



ZSW at a Glance – Center of Solar Energy and Hydrogen Research

- A non-profit organization ("Stiftung") with 350 employees, 50 m €annual budget and 85 % external funding
- Applied Research & Development on New Energy Technologies:
 - Batteries & Supercapacitors: materials, production technologies, systems, qualification
 - Hydrogen & Fuel Cells: stack-technology, components, systems, production technologies, test center
 - Photovoltaic: materials, thin film technologies (CIGS) & application systems
 - Renewable Fuels: electrolysis, power-to-gas, biomass gasification
 - Energy politics & economics, wind energy





www.zsw-bw.de

ZSW Divisions

// Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg* (ZSW)

Stuttgart Prof. Dr. Frithjof Staiß Stuttgart Prof. Dr. Michael Powalla Ulm Prof. Dr. Markus Hölzle

Studies, Politics Consulting, Wind Energy



Photovoltaics: Materials Research



Batteries







Photovoltaics: Modules Quality & Grid Integration



Hydrogen & Fuel Cells





Hydrogen is a key element in the global energy transition

The Technology Portfolio of ZSW





"To achieve net zero emissions by 2050, global cumulative investments [on hydrogen] must increase to USD 1.2 trillion by 2030 and USD 10 trillion by 2050." (IEA: Global Hydrogen Review 2021))

- ✓ A multi-billion market for hydrogen and hydrogen technologies will emerge worldwide.
- ✓ (South) Germany must shape this market today in order to profit from it later.



ZSW Locations



Stuttgart:

Photovoltaics (with Solab), Energy Consultancy & Carriers, Electrolysis, Hydrogen & eFuels, Finances, IT, HR, Legal; Solar Test Field Widderstall & Wind Test Field Stötten (Swabian Alb)

Ulm:

Electrochemical Energy Technologies Division; Laboratory for Battery Technologies (eLaB)" with Battery Pilot Production Line (FPL) and Battery Test Centre; Hydrogen and Fuel Cell Research Factory (HyFaB)



ZSW in Ulm 2023

Areas of Research: R&D Project funding: Investments:

Number of employees:

// Helmholtzstraße (from 1993)

- R&D fuel-cells and batteries
- Material and components development for Lithium-ion batteries
- Fundamentals & Analytics
- Mechanical / electrical shop



Fuel Cells, Hydrogen and Batteries 15 m Governmental Projects; 17 m € Industry 20 m €; among 7 m € from ZSW

> 220

// eLaB (from 2011)

- Batteries with focus on cellassembly
- Manufacturing pilot line for automotive batteries ("FPL")
- Battery safety



// HyFaB (from 2022)

- Fuel cell assembly model factory for PEMFC
- Largest independent PEMFC test center in Europe
- Hydrogen-laboratory HyLaB







HYDROGEN & FUEL CELL ACTIVITIES



ZSW Fuel Cells: From components to systems to data management





Fuel-Cells: Modelling & Simulation

- Micro-CT: 3D-structures of components and cells, behaviour of Gas Diffusion Layer (GDL), interaction of GDL and bipolar plate (BPP)
- Neutron radiography: Macroscopic visualization of water droplet generation and flow in channels in operando & also applicable to study gas evolution in electrolysis
- Synchrotron tomography: Microscopic visualization of water content in operando and water accumulation
- Computational Fluid Dynamics (CFD) simulations



Fuel cell stack simulation

Neutron radiography





Synchrotron tomography



Fuel Cells: Stack Development and Manufacturing

- CAD construction and FEM / CFD design, components and stacks
- Innovative joining technologies and manufacturing processes
- Robot based stack assembly and testing
- Power range from 50 W up to 100 kW
- Experience with more than 1,300 fuel cell stacks



CAD design - 100 kw generic fuel cell stack



Robot based stack assembly and testing



Component optimization with white light interferometer



Fuel Cell Testing Activities

- Full-size automotive stacks and systems (up to 250 kW_{el})
- Finally 50 fuel cell test stations in 24/7 operation (~ 40 at the moment)
- Accelerated lifetime test & robustness tests
- Wide range of reactant supply lines (H₂/O₂, H₂/Air, Reformate/Air, including forced contaminants)
- 25+ years of test experience









Other Hydrogen Activities at ZSW

- HyLaB: One out of three leading independent Hydrogen quality laboratories world-wide
 - Hydrogen quality analytics down to ppb level
- Mobile test device for certifying Hydrogen refueling stations (HRS)
 - Compliance monitoring for filling protocols (validation of pressure and temperature thresholds and ramps)
 - Hydrogen quantity metering (including balance)
 - Sampling for H₂-quality check (during and after refueling)
- Development of an online monitoring tool for cost effective Hydrogen surveillance at HRS
- 70 MPa Hydrogen Refueling Station for cars on-site













HyFaB - In a nutshell

- Joint project of ZSW, Fraunhofer ISE and VDMA with financial support from various governmental funding (state level as well as federal level)
- Supporting the fuel cell industry in Germany in the transition from handcraft assembly to industrialization
- Main focus: PEM fuel cell stack and its components, assembly, end-of-line testing and commissioning
- Entry platform for newcomers, especially for small and medium-sized enterprises
- Creation and evaluation of quality assurance procedures
- Generation of industry know-how
- Education and training of professionals; information to stakeholders, public
- Provision of a vendor-independent "generic stack" as uniform hardware for partners, co-developers ...

"Don't reinvent the wheel - make it rolling"



Hydrogen at the federal level: 4 + 1 technology and innovation centers - 370 million € by 2024.

- 1. Hydrogen Technology Application Center (WTAZ) in Pfeffenhausen near Landshut
 - Focus on liquid hydrogen; technology transfer & applied R&D;
 - Funding of 70+x million €
- 2. Hydrogen and Mobility Innovation Center (HIC) in Chemnitz
 - Fuel cells for vehicle applications;
 - Funding of 70+x million €
- 3. Technology and Innovation Center Hydrogen Technologies (TIW) in Duisburg, Germany
 - Test/inspection of FC propulsion systems for road, rail, water & air transport, education & training (startup & SMEs);
 - Funding of 70+x million €
- 4. Hydrogen Innovation and Technology Center (ITZ) Northern Germany Bremen/Hamburg/Stade
 - Hydrogen technology for aviation & shipping;
 - Funding of 70+x million €
 - HyFaB in Ulm and Freiburg
 - Industrialization of fuel cell stacks and their components;
 - Funding of 80 million €.







HyFaB-Building Complex (Stage #1 + #2)



Stage #1: 02/2021 - 05/2022



HyFaB: Fuel Cell Test Center, Lise-Meitner-Straße 24

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HyFaB #1 : Fuel Cell Test Center, 23.08.2023

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HyFaB #2, 23rd August 2023

Seminar area and assembly hall (HyFaB-2)

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HYFAB – GENERIC STACK



Generic Stack - Visualization







HyFaB Generic Stack - an Open & Modular Stack Design

State of the art sample parts for the fuel cell industry:

- Preliminary work in FVV project "generic stack" with consensus on high-level specifications
- Flow simulations done and available to 3rd parties
- Active area ~ 280 cm²
- Power density as for automotive application up to 150 kW
- BPP scaled-up into production at EKPO
- BoS Components available from ZSW for academia and industry (on request)
- Bipolar plates in graphitic design to be initiated
- Demonstration Stack with 330 cells assembled
- Fully functinal short stacks assembled
- Performance target achieved (650 mV@ 1,9 A/cm²; > 1,2 W/cm²)





HyFaB Generic Stack - an Open & Modular Stack Design



Explosion view Short Stack (CAD)





CV curve of a 7 cell generic stack



Generic Stack – Metallic BPP CAD Details & Rendering





Generic Stack – Exploded view





Summary

- ZSW in Ulm is one of the leading centers for battery, fuel-cells and Hydrogen R&D in Germany and Europe
- New HyFaB project with new building complex will strongly enhance ZSW's offering to the fuel cell industry
- Joint project of ZSW, Fraunhofer ISE and VDMA with financial support from various governmental funding (state level as well as federal level)
- Supporting the fuel cell industry in Germany in the transition from handcraft assembly to industrialization
- Main focus: PEM fuel cell stack and its components, assembly, end-of-line testing and commissioning.
 - Creation and evaluation of quality assurance procedures
 - Generation of industry know-how
 - Education and training of professionals; information to stakeholders, public
- Provision of a vendor-independent "Generic Stack" as uniform hardware for partners, codevelopers
- "Generic Stack" successfully developed and tested



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MANY THANKS FOR YOUR INTEREST.

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Stuttgart





Ulm eLaB



Ulm HyFaB



Solar test field



Wind test field