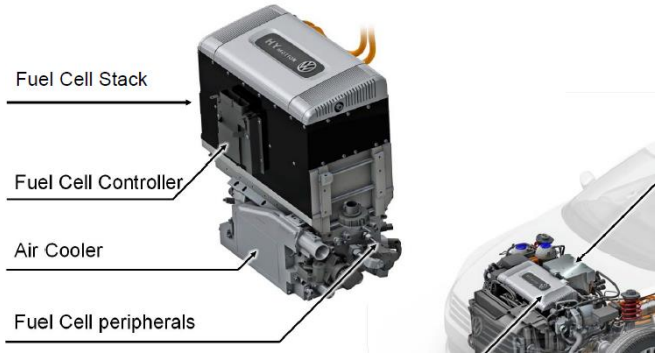
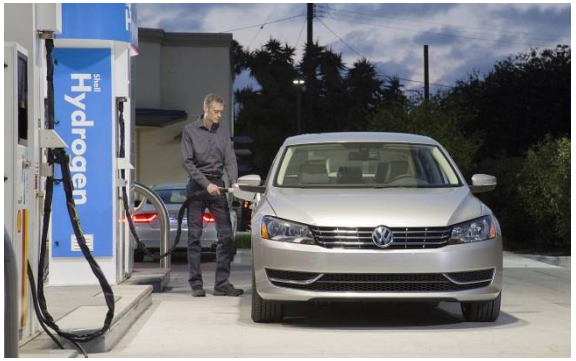
A Brief Introduction

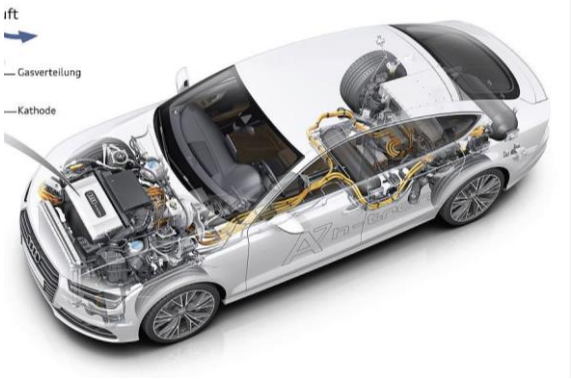
ALF Alternative Fahrzeugantriebe

Martin Biák

Department of Advanced Powertrains







Sources: Volkswagen, Audi, Hyundai

Institute for Automotive Research

- 2 departments
- 29 staff members

Prof. Dr.-Ing.
Thomas von Unwerth (Director)
Department of Advanced Powertrains

Prof. Dr.-Ing.
Ralph Mayer
Dep. of Automotive Systems Engineering

Department of Advanced Powertrains

17 academic & research staff members
3 research assistants
3 technical staff members

6 external PhD students

Hydrogen / Chemistry Lab

Powertrain / Component Test Facility

Industry

VOLKSWAGEN AKTIENGESELLSCHAFT

automotive iav

DAIMLER

ThyssenKrupp

SCHAEFFLER

LuK INA FAG

SCHERDEL

MAN

Continental

Audi

Webasto

thermo

BMW

PM PROTON MOTOR Fuel Cells · Power Systems

Public

Bundesministerium für Bildung und Forschung

MERGE Cluster of Excellence

AIF ALLIANZ INDUSTRIE FORSCHUNG

AdAntE

ZIM Zentrales Innovationsprogramm Mittelstand

ESF Europäischer Sozialfonds für Deutschland

BAYERN – SACHSEN ELEKTROMOBILITÄT VERBINDET

Technische Universität Braunschweig

CiTE

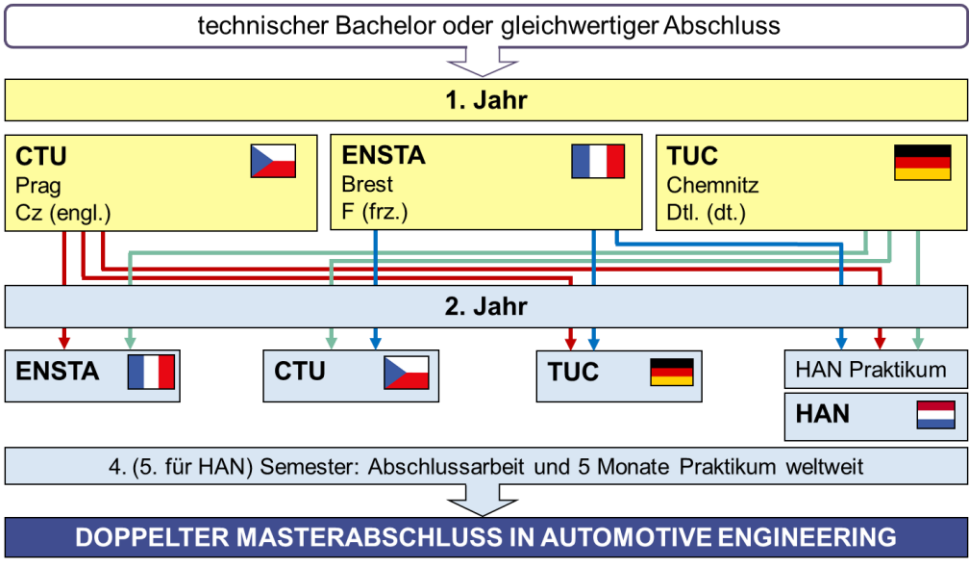
Université franco-allemande Deutsch-Französische Hochschule

ZBT Zentrum für BrennstoffzellenTechnik

FCH FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

International double-degree programme "Automotive Engineering"

- 2 diplomas from 2 (of four) international universities in 2 years
- In-depth technical knowledge at the highest level and inter-cultural competences
- Unique in Europe
- Study in two different European languages
- Huge advantage for an international career
- Access to the networks of partners of the participating universities



Application for the double degree programme:

- via e-mail to diana.lohse@mb.tu-chemnitz.de (preferred)
- via post: Technische Universität Chemnitz
  Professur Alternative Fahrzeugantriebe, Diana Lohse
  09107 Chemnitz, Germany
- application deadline: 1 June

Further information : e-mail: diana.lohse@mb.tu-chemnitz.de, phone: +49 371 531 33794, web: www.emae.eu

H2AC4schools – Závody saských a českých škol PrOJETÍ světa elektromobility s vodíkem

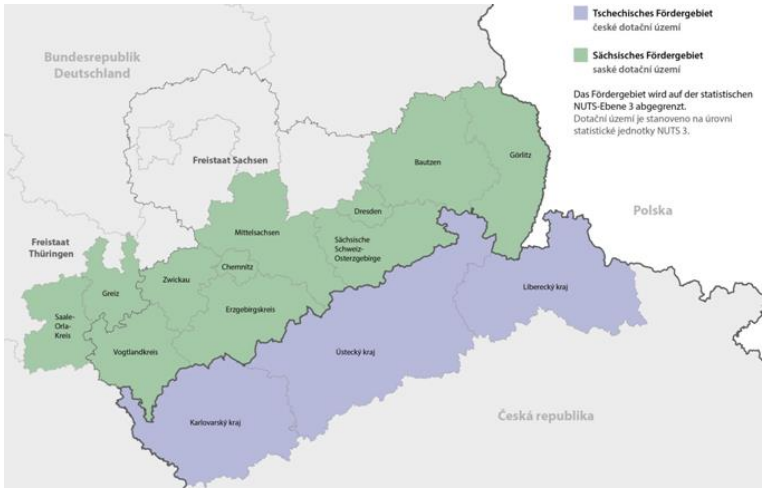
Partners:

TECHNISCHE UNIVERSITÄT CHEMNITZ

ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

VYSOKÁ ŠKOLA CHEMICKO-TECHNOLOGICKÁ V PRAZE

Horizon Educational



Financing:

Europäische Union. Europäischer Fonds für regionale Entwicklung. Evropská unie. Evropský fond pro regionální rozvoj.

SN CZ
Ahoj sousede. Hallo Nachbar.
Interreg V A / 2014 – 2020

Scope:

- Renewable energy
- Practical learning
- Engineering
- Fuel cell powered racing cars
- Team work

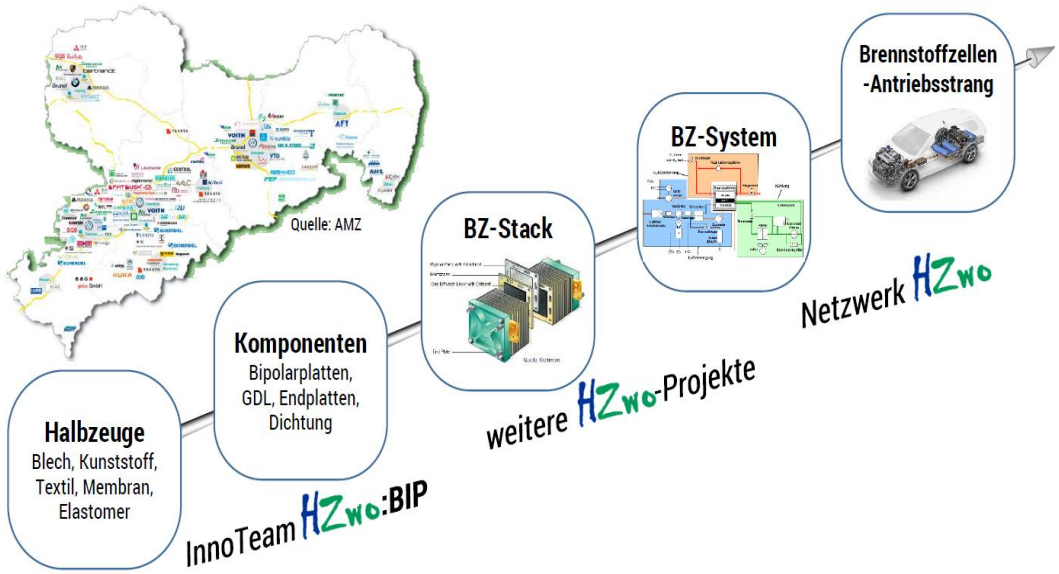
Further information : e-mail: diana.lohse@mb.tu-chemnitz.de, phone: +49 371 531 33794, www.sn-cz2020.eu

Network HZwo: Antrieb für Sachsen

HZwo – the network

- Future Powertrain
- Fields of Development
- R&D Projects

Settlement of new value chain for leading future powertrain technology in „Autoland“ Saxony



- **R&D for mobile PEM-fuel cell applications,** powertrain components, manufacturing and production processes, series ready components and drivetrain development
- **Project family** hand in hand with saxonian SMEs and research institutes
- **Public funding** from Saxony
- **Installation of single, compound and lighthouse projects**
- **Start in 2016 with first ESF-funded innovation team** for series-ready bipolar plates
- **Cluster for production issues** applied for funding

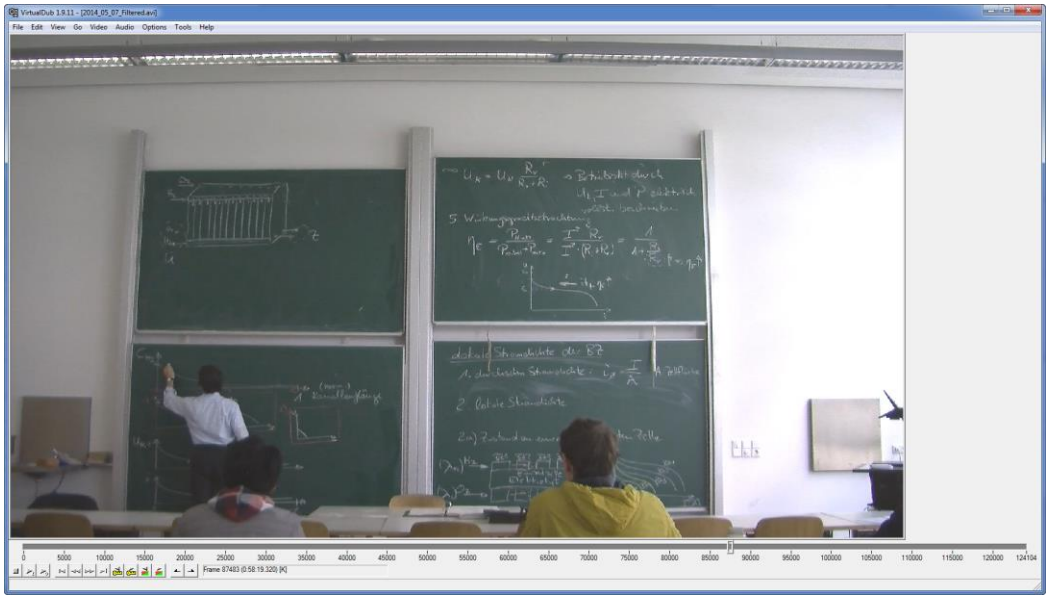
TECHNISCHE UNIVERSITÄT CHEMNITZ

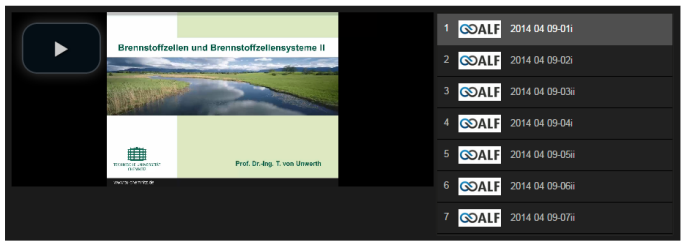
Fraunhofer IWU

Fuel cell and fuel cell systems II in the framework of Schaufenster Mobilität

schaufenster elektromobilität
Eine Initiative der Bundesregierung

- **Motivation:** reduce the workload of the professor and give students the opportunity to revise the subject
- NOT only video → slides, blackboard shots and info graphics embedded in video
- Videos accessible on the ALF webpage (password-protected)





Further information : e-mail: jiri.hrdlicka@mb.tu-chemnitz.de, phone: +49 371 531 34843

ALF
Alternative Fahrzeugantriebe

Thank You for Your Attention

Backup slides

Laboratories

Hydrogen lab

- Designed for fuel cell systems
- Ventilation designed to cope with the stored hydrogen (7 kg H_2 5.0)

Chemistry lab

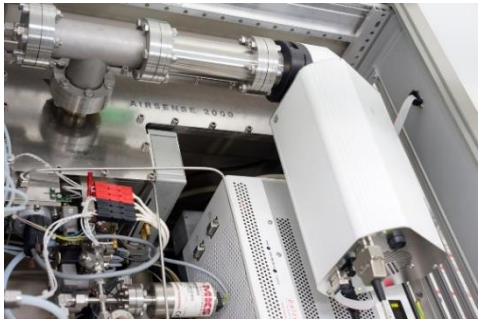
- Characterization of components and single cells
- Testing of short stacks

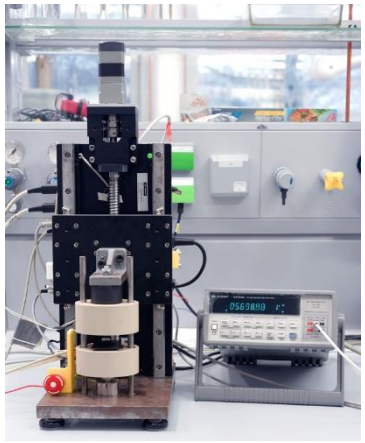


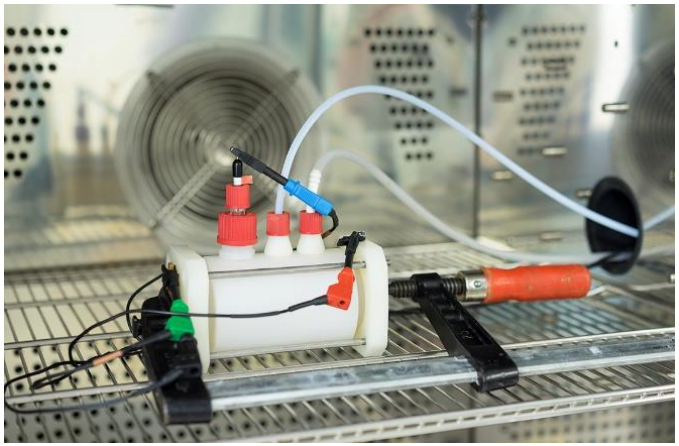

Characterization of components

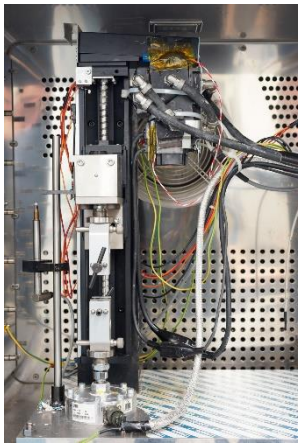
BiPolar Plates, Gas-Diffusion Layer, Membrane-Electrode Assembly, anode loop, etc.

- Resistivity measurements (through-plane: bulk/contact)
- Corrosion measurements (potentiostatic/-dynamic)
- Mechanical tests (tensile/flexural/torsion)
- Permeation tests (being built right now)









Testing of single-cells and short stacks

Single-cell and short-stack tests

- Single cells up-to 100 A (depends on config of power loads)
- Short stacks, big cells up-to 600 A (depends on config of power loads)

Testing of full-sized stacks

Greenlight Innovation G700

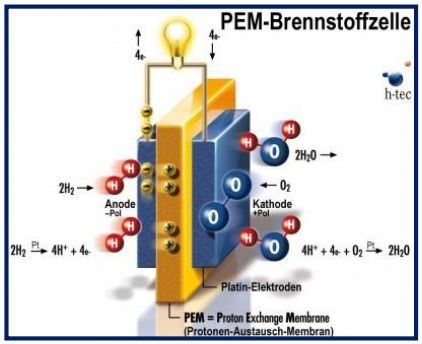
- Characterization and testing of FC **stacks**, **FC systems** and **FC system components**
- Automotive-, train-, airborne- and maritime- systems
- Systems up-to 150 kW_e – power loads are available
- hydrogen supply ~2.7 tons of H_2 5.0 (planned), oil-free air supply 160 g/s at up-to 13 bar, cooling up-to 300 kW
- Tests run under simulated real-world conditions (T, p, φ, a)

→ TU Chemnitz is the first European university and research organization in Germany with the capacity to operate at such power level – **Unique in Europe**

Continental AG procured the test stand, provided some of the necessary equipment (e.g. compressor, hydrogen storage) and financed the incurred construction measures (up to a reasonable limit)

Drive systems I – Powertrain

Introduction to vehicle propulsion technology, Power demand of a vehicle
Characteristic diagrams, diagram conversion
Gear ratio,
Types and concepts of propulsion
Energy stores, energy converters
Gearboxes, Output, differential,
Impact on fuel consumption

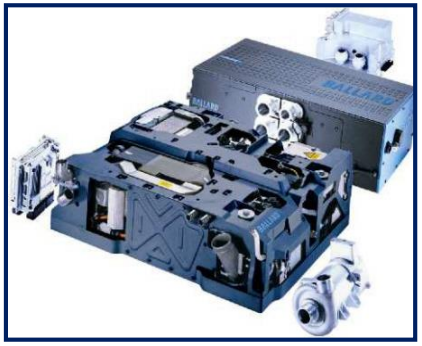


Fuel cells and fuel cell systems I

Introduction to fuel cell and hydrogen technology,
Physical chemical basics,
Structure of a fuel cell system (air subsystem, hydrogen subsystem, cooling subsystem, control subsystem, fuel cell subsystem),
Subsystem components,
Influence of the components on the overall efficiency

Drive Systems II – Engines

Historical development
Procedures, cycles
Real motor
Ignition and combustion, carburation
Forced induction
Established motors
Engine dynamics
Engine components
Cylinder, cylinder head, valve train
Overall structure of engines

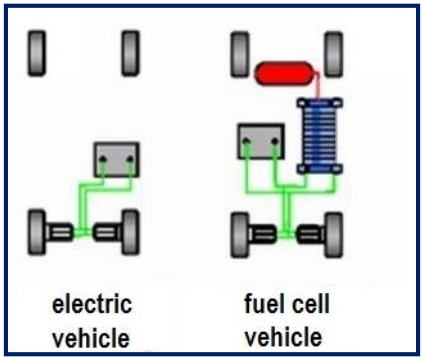


Fuel Cells and Fuel Cell Systems II

Fuel cell drive systems
Structure, components, efficiencies
Fuel cell vehicles (package concepts, platforms)
Hybridisation of fuel cell vehicles
Control and regulation of fuel cell drives
Mobile hydrogen storage
Hydrogen generation, transport and fuelling (infrastructure)

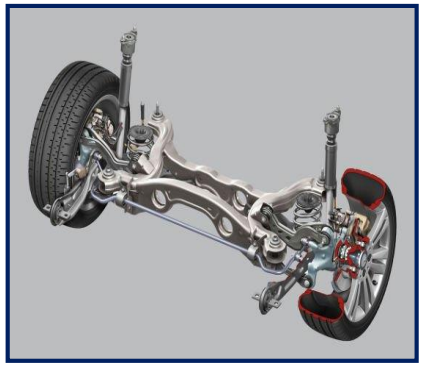
Drive Systems III – Gearboxes

Structure of car transmissions: manual, automated manual, automatic, dual-clutch, gear boxes for hybrid and electric vehicles
Functioning, Design and calculation of gearbox components,
Starting clutch, torque converter, synchronisations, planetary gearing



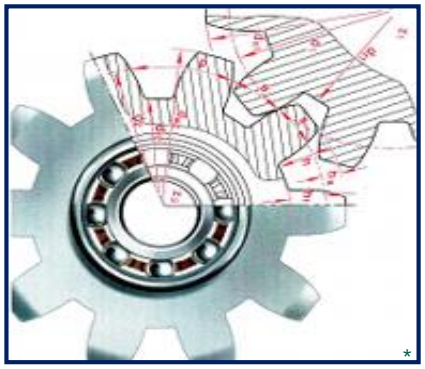
Drive Systems IV – Vehicle Energy Technology

Modelling and balancing of drive systems with regard to energy
Energy storage systems
Energy flows in drive systems
Energy management of hybrid drive systems
Battery technologies
Control and regulation of drive systems



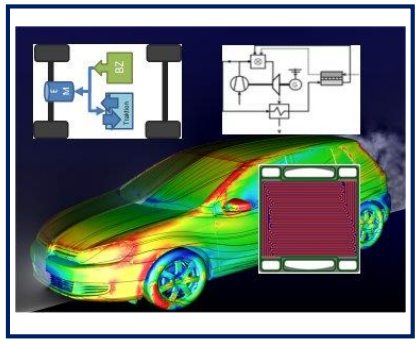
Basics of running gear technology

Chassis (wheel/tyre, wheel suspension, steering, brakes, suspension/damping) ,
Driving dynamics (steady, dynamic driving behaviour, electronic stability control systems ABS/ESP)
Assistance systems, Electrics/electronics,
Motorcycle technology,
Utility vehicle technology,
Testing (component testing, driving tests)



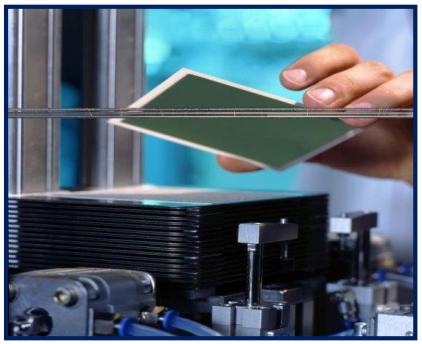
Engineering design/machine elements

Technical drawing
Basics in strength calculation
Shaft calculation
Calculation of shaft-hub connections
Calculation of couplings
Design and recalculation of springs
Calculation of screws
Calculation of bearings
Gearing design



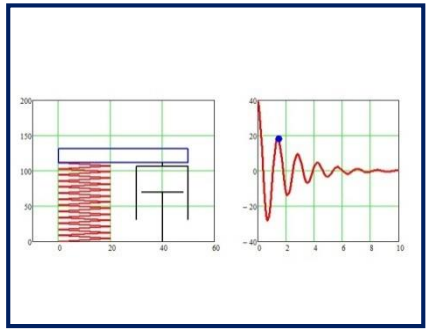
Modelling and simulation of fuel cell drive systems

Modelling of fuel cell systems
Simulation tools for fuel cell drives
HIL/SIL environments
Simulation of fuel cell components (CFD/FEM) Simulation of a fuel cell drive system (Matlab/Simulink)



Lab course advanced powertrains (currently being developed)

Energy analysis of a fuel cell
Energy analysis of a hydrogen-powered combustion engine
Energy analysis of a fuel cell system
Control of a fuel cell system



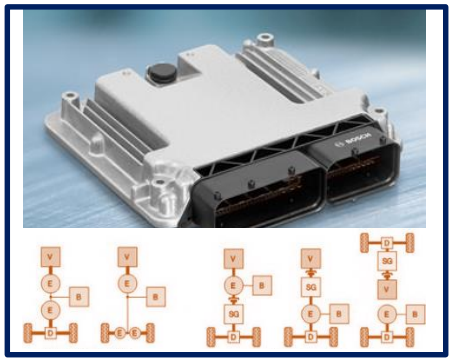
Dynamic simulation of drive systems

Solving of differential equations
Numerical methods for determining zeros
Solving of linear and non-linear systems of equations
Optimisation, Fourier analysis
Combustion simulation
Simulation of plain bearings
Structural dynamic analysis

part of the following study courses:

- Mechanical Engineering (BA/MA, field of study Automotive Engineering)
- Automotive Production and Engineering (BA/MA)
- Automotive Engineering (MA, Europ. Double degree, since winter term 2014/15)
- Electric Mobility (MA)
- Sustainable Energy Supply Technology (MA)

About Us – Main Fields of Research

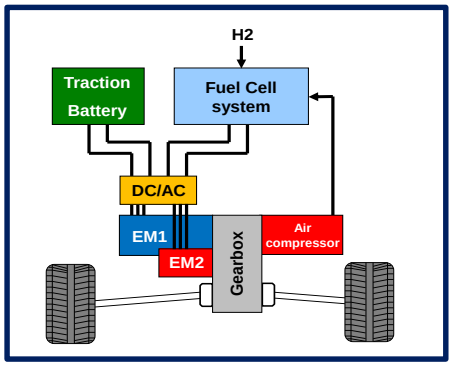


Operational strategies/ energy management

- Fuel cell systems
- Battery management systems
- Thermal management
- Hybrid concepts

Characterization / system optimization

- Durability
- Performance/dynamics
- Energy density
- Safety

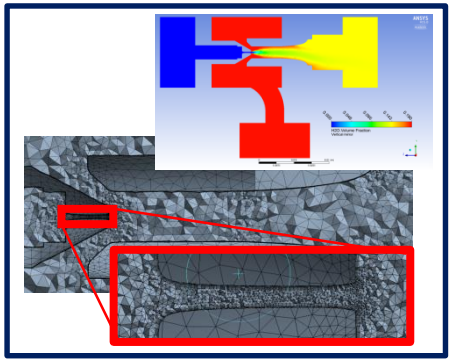


Powertrain development

- Hybrid transmission
- Coupling of auxiliary units
- Efficient power distribution
- Innovative concepts

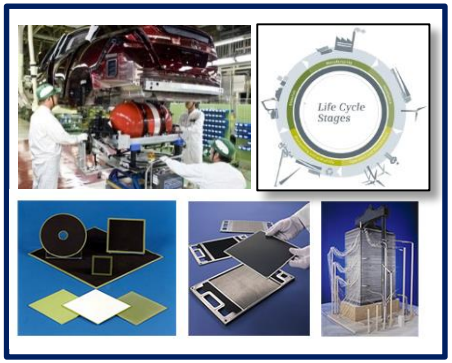
Measuring of Fuel Cells

- Measuring of MEAs
- Characterization of bipolar plates
- Stationary and transient tests for single cells



Modelling and simulation

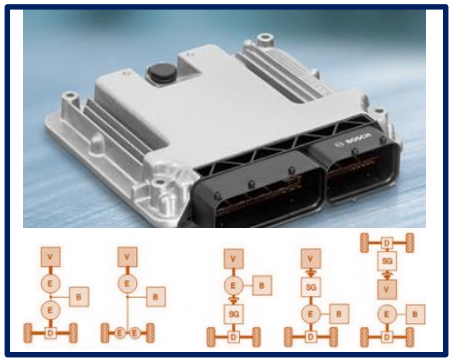
- Transport processes
- Flow processes
- Vehicle dynamics
- Efficiency
- System dynamics



Manufacturing processes for components

- Fuel cell components
- Fuel cell stacks
- Vehicle integration
- Sustainability, Life cycle assessments

About Us – Main Fields of Research



Operational strategies/ energy management

- Fuel cell systems
- Battery management systems
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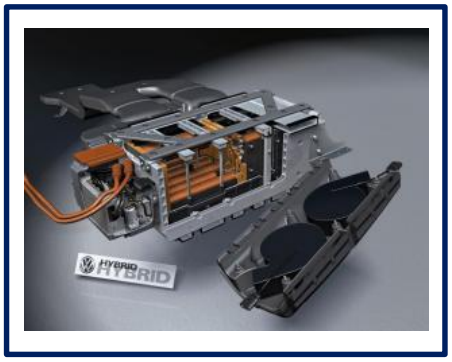
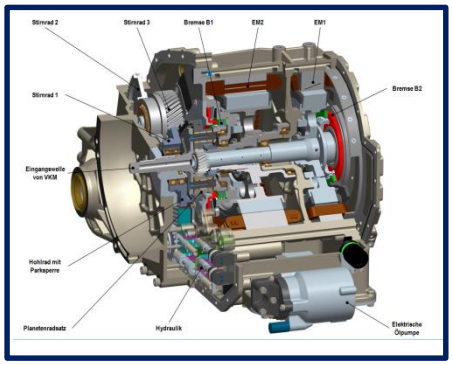
- Hybrid concepts



Characterisation of components of advanced powertrains

- Durability
- Performance/dynamics
- Energy density
- Safety

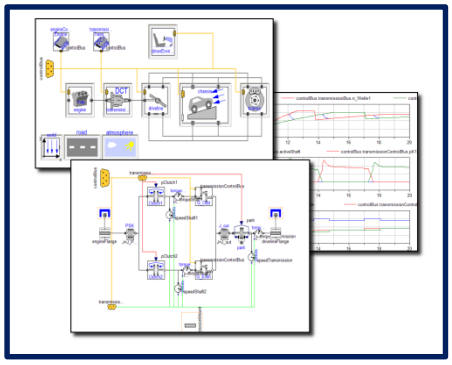


Powertrain development

- Hybrid transmission
- Coupling of ancillary units
- Efficient power distribution

Ecological/economic analysis

- Diffusion of new technologies on the basis of life cycle costs
- Efficiency of energy storage technologies
- Well-to-wheel analyses



Modelling and simulation

- Transport processes
- Flow processes
- Vehicle dynamics
- Efficiency
- System dynamics

Production processes for components

- Fuel cell components
- Fuel cell stacks
- Battery systems
- Vehicle integration

Fit for Automatic Manufacturing and Assembly

Duration: 36 months
Start date: 1 March 2017
EC Funding: 2.9 M€

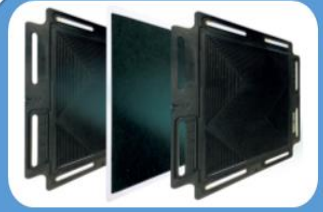
Partners: TUC - ALF (DE)
USK (DE)
Uniresearch (NL)
UPS (BE)
Proton Motor (DE)
EWII (DK)
Fraunhofer IWU (DE)

FIT-4-AMANDA

Identification of critical components and bottleneck processes in stack and stack component production lines

Integration of established automotive industry best practices on production and quality to the manufacturing of PEM FC stacks and stack components

Current designs of stacks and stack components



Current (manual) manufacturing practises

Current specs of purchase parts

Current (inline) test methods for quality assurance of products and processes

Redesign of current stack and stack components design to optimize manufacturability

Definition of a roadmap for step-wise development and automation of manufacturing technologies for PEMFC stack components and stacks

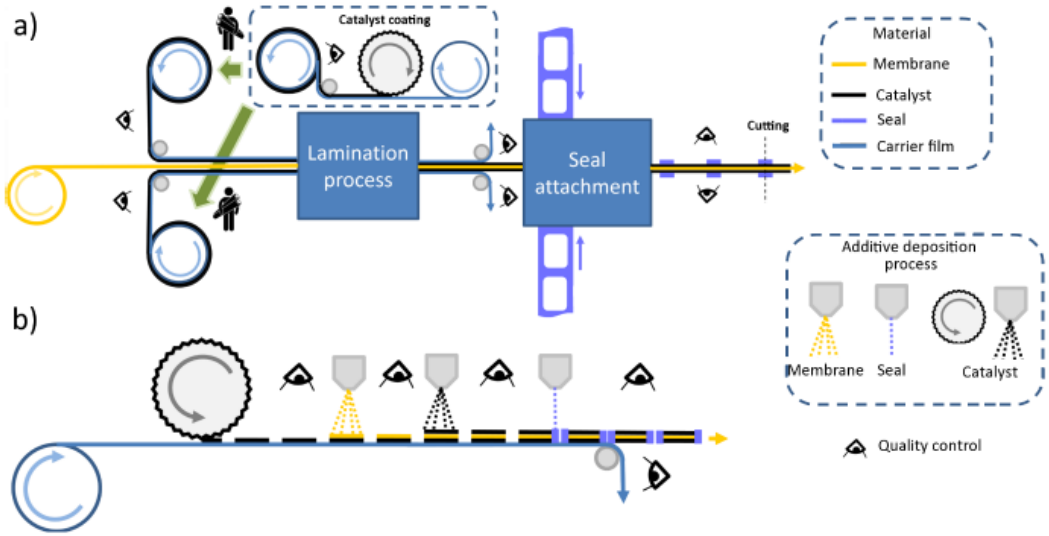
For more info: www.fit-4-amanda.eu

Mass Manufacturing of MEAs Using High Speed Deposition Processes

Duration: 36 months
Start date: 1 Jan 2018
EC Funding: 3.3 M€

Partners: TUC – ALF, DPI (DE)
Fraunhofer ENAS (DE)
Universita Modena (IT)
System SPA (IT)
JMFC (UK)
INEA (SI)
Nedstack (NL)

Process flow for current CCM manufacturing process



Additive layer manufacturing process for CCM in MAMA-MEA project

Modular roll-to-roll laboratory system for additive material deposition techniques at TUC

microFLEX – Modular roll-to-roll deposition production line for industrial applications

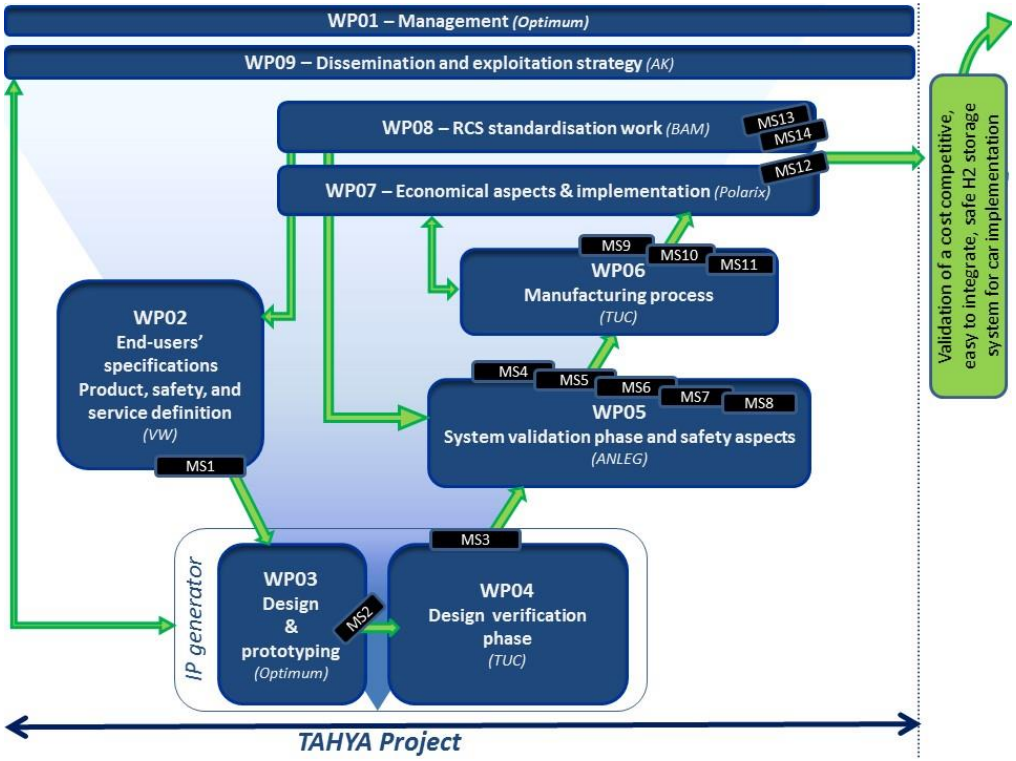
For more info: www.mama-mea.eu

Tank Hydrogen Automotive application

Duration: 36 months
Start date: 1 Jan 2018
EC Funding: 4 M€

Partners: Optimum CPV (BE)
RAIGI (FR)
Volkswagen (DE)
BAM (DE)
Anleg GmbH (DE)
TUC – ALF, SLK (DE)
AbsisKey (FR)
PolarixPartner (DE)

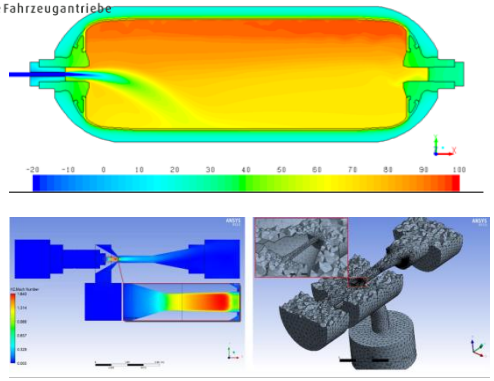
TAHYA TANK HYDROGEN AUTOMOTIVE



TUC tasks

Winding technology

ALF Alternative Fahrzeugantriebe Simulation



Goal: cost competitive, easy to integrate, safe H2 storage system for high volume automotive application

For more info: www.tahya.eu

Fuel Cell Stack