

## Innovative Production Technologies for new car concepts

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# Agenda

- Fraunhofer Allianz Automobilproduction & Fraunhofer IFAM at a glance
- Casting Technology
- Component Development
- Our Offer

# Fraunhofer AutoMOBILE Production Alliance

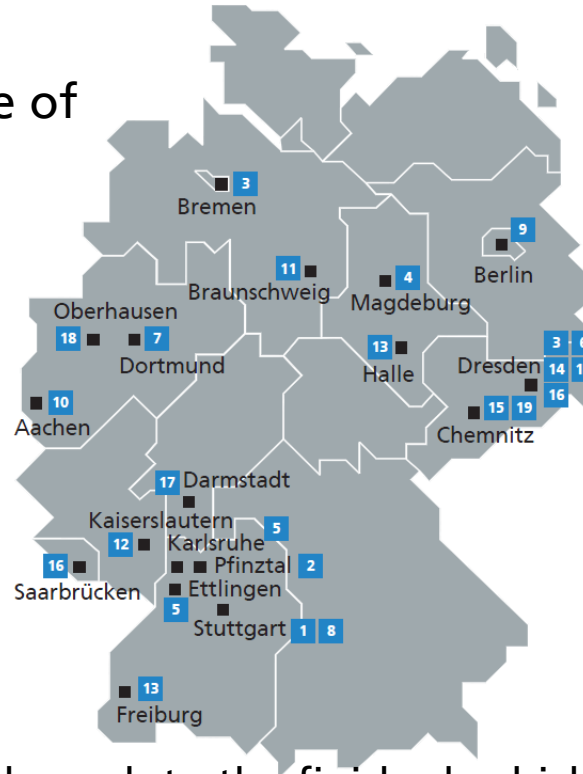
## » Members «

### COMPETENCE BY NETWORKING

The Fraunhofer Alliance pools the expertise of **19 Fraunhofer-Institutes**, who collectively provide the automotive industry with a competent single-source partner for its research and development needs.

Due to the complementary topics of research focus of the individual institutes, innovations can be implemented in a **rapid, integrated and sustainable way along the entire process chain of automobile manufacturing** – from the planning stage right through to the finished vehicle.

The head office of the Fraunhofer autoMOBILEproduction Alliance is situated at the Fraunhofer Institute for Machine Tools and Forming Technology IWU in Chemnitz, Germany. The spokesman **Prof. Dr.-Ing. Welf-Guntram Drossel** is the leader of the alliance.



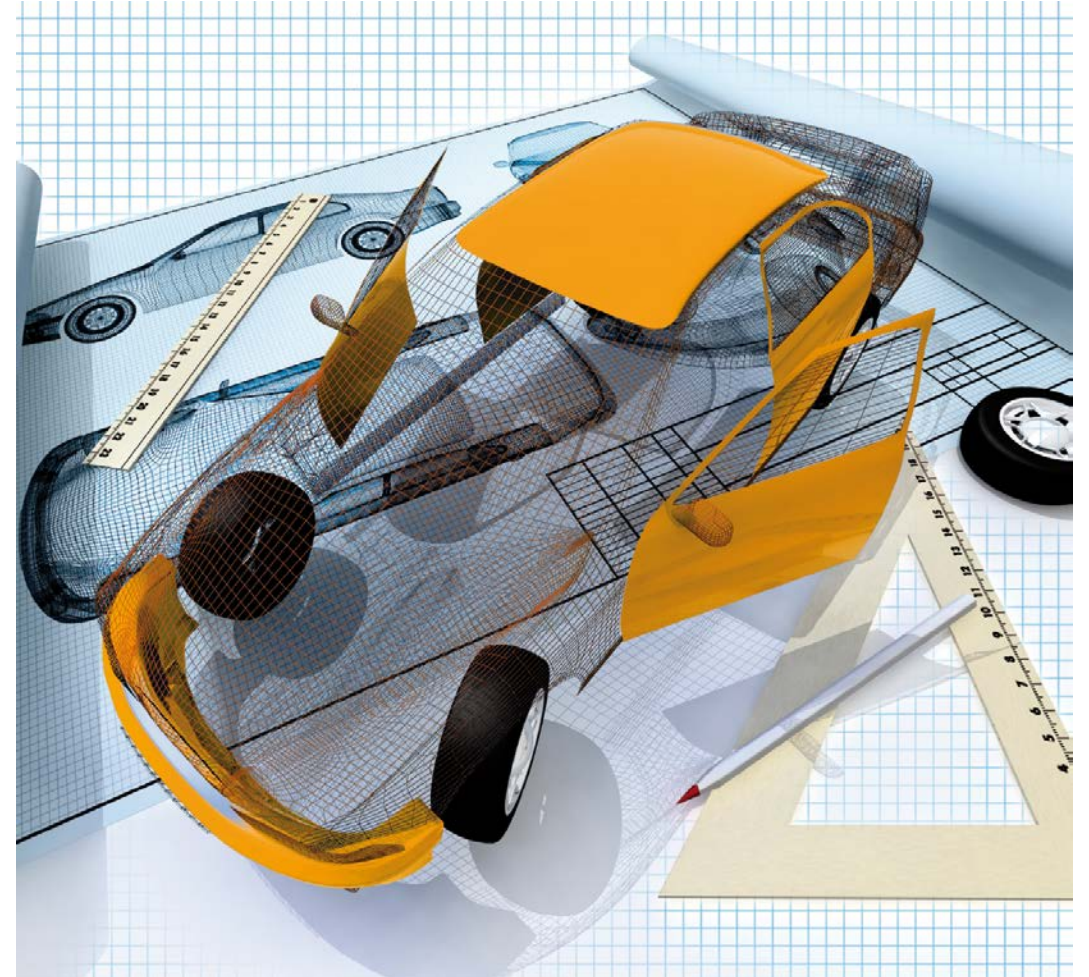
Fraunhofer Institute for

- 1 Industrial Engineering **IAO**
- 2 Chemical Technology **ICT**
- 3 Manufacturing Technology and Advanced Materials **IFAM**
- 4 Factory Operation and Automation **IFF**
- 5 Optronics, System Technologies and Image Exploitation **IOSB**
- 6 Ceramic Technologies and Systems **IKTS**
- 7 Material Flow and Logistics **IML**
- 8 Manufacturing Engineering and Automation **IPA**
- 9 Production Systems and Design Technology **IPK**
- 10 Production Technology **IPT**
- 11 Surface Engineering and Thin Films **IST**
- 12 Industrial Mathematics **ITWM**
- 13 Mechanics of Materials **IWM**
- 14 Material and Beam Technology **IWS**
- 15 Machine Tools and Forming Technology **IWU**
- 16 Non-Destructive Testing **IZFP**
- 17 Structural Durability and System Reliability **LBF**
- 18 Environmental, Safety and Energy Technology **UMSICHT**
- 19 Electronic Nano Systems **ENAS**

# Fraunhofer AutoMOBILE Production Alliance

## » Primary Goals «

- Sustainable **increase of efficiency** and conserving resources
- **Development of technologies** and methods ready for series production in the automotive industry
- Creating **production networks**
- Developing optimal utilization concepts
- ➔ Alliance offers **competence** along the **entire process chain** and is the ideal **partner** for single topics up to **integrative and comprehensive tasks**



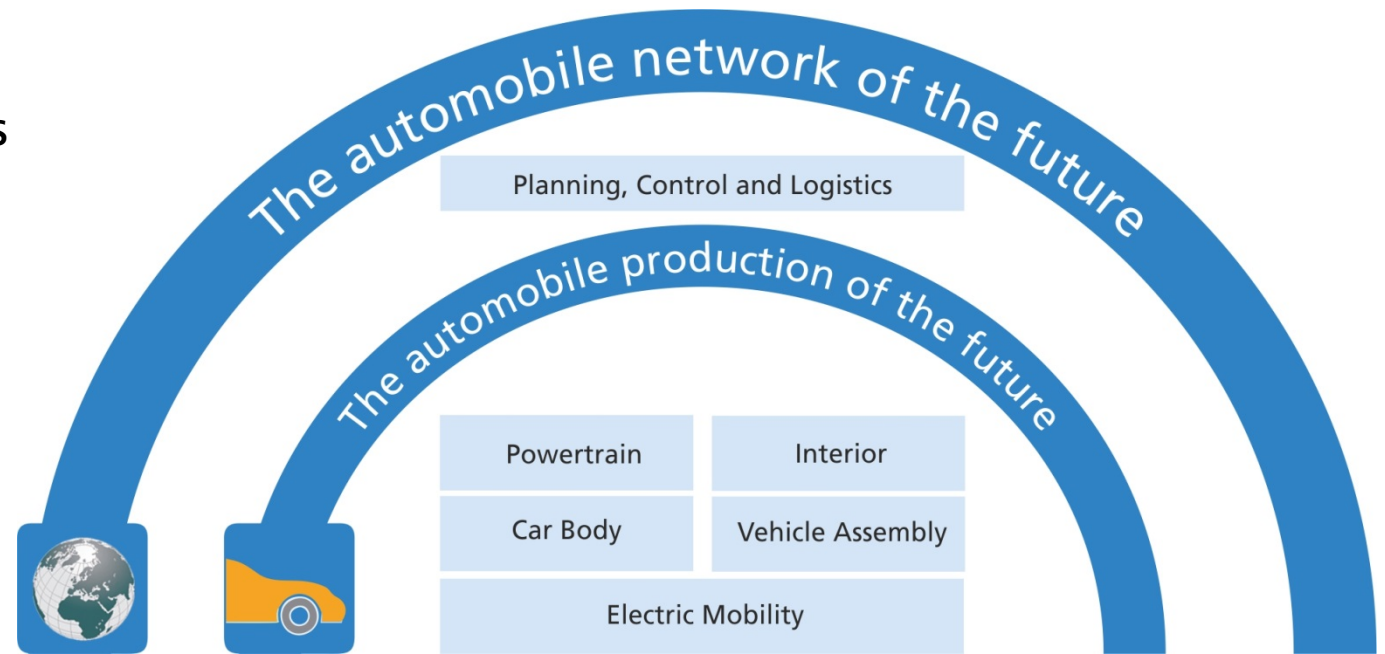


# Fraunhofer AutoMOBILE Production Alliance

## » Business Portfolio «

Members of the alliance work together in following business units:

- Planning, Control and Logistics
- Powertrain
- Interior
- Car Body
- Vehicle Assembly
- Production Research for Electric Mobility



# Fraunhofer AutoMOBILE Production Alliance

» Typical Services in all fields of action «

- Conceptions
- Process chain planning
- Simulations
- Prototyps
- Feasibility studies
- Detailed research and development
- Realization of series production
- Light weight concepts
- Resource efficiency

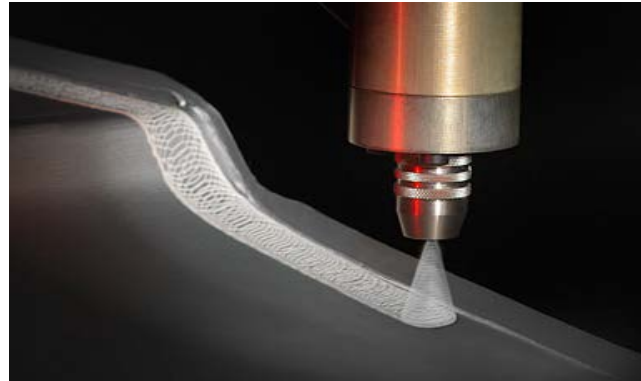


# Fraunhofer IFAM – Core Competencies

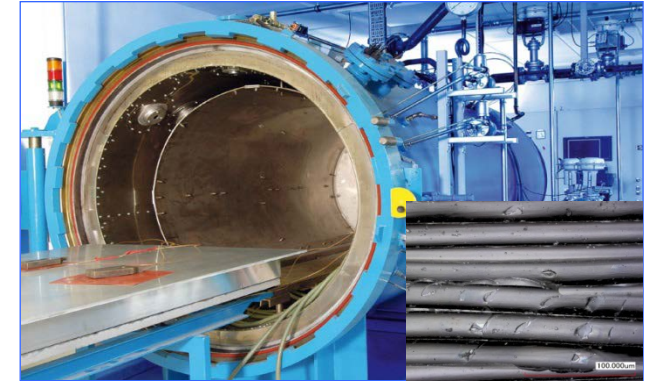
SURFACE TECHNOLOGY



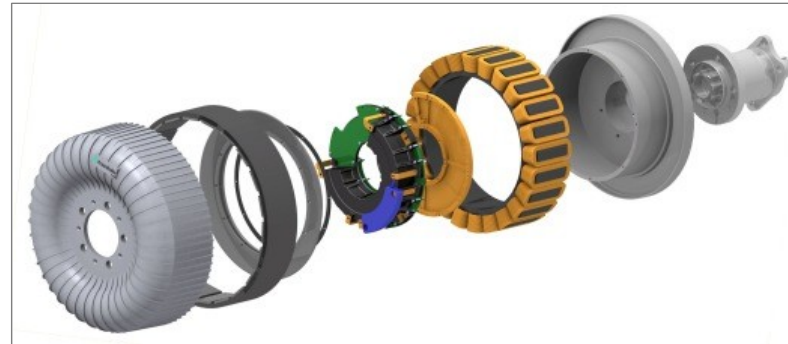
ADHESIVE BONDING



FIBER REINFORCED MATERIALS



CASTING TECHNOLOGY



ELECTRICAL COMPONENTS AND SYSTEMS



POWDER TECHNOLOGY SINTERING PROCESSES

# The department of Casting Technology and Component Development

## casting technology

- castings with complex geometries
- function integrated castings  
(*Embedded sensors / RFID transponder*)
- material and process development  
(*especially for die casting, lost foam-technology, investment casting*)
- numerical simulation, component analytics

## component development

- full electric drive train / wheel hub motors
- development of ECUs / power electronics
- functional safety
- productions technologies for electrical machines, casting production of coils and housings using
- vehicle concepts, especially for electric mobility





# Agenda

- Fraunhofer Allinz Automobilproduction & Fraunhofer IFAM at a glance
- **Casting Technology**
- Component Development
- Our Offer

# Department Casting Technology & Component Development

## Focus areas / topics of research

### Castings with complex geometries

- Diecasting
- Lost Foam Technology
- Investment casting
- Lost cores (Non-permanent cores)

### Casting Technology development

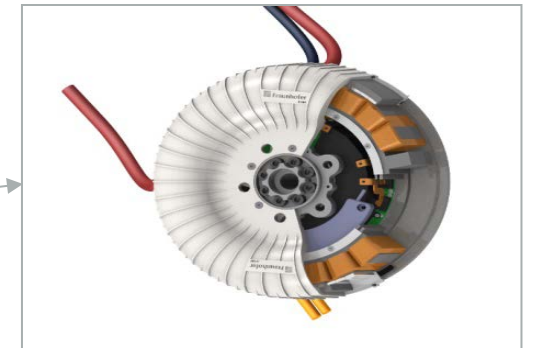
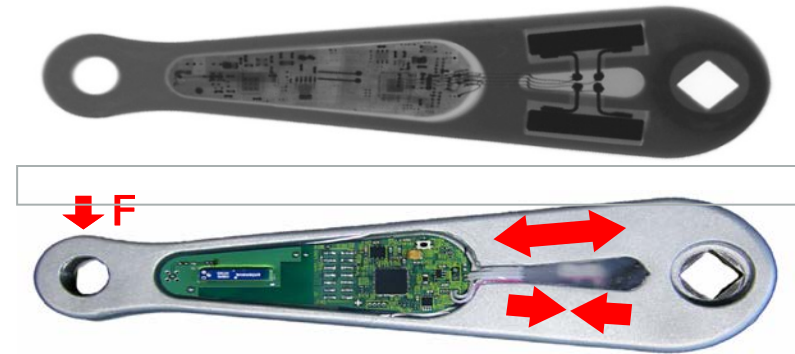
- Material- und process development
- Numerical Simulation
- Component analysis

### Function-integrated Castings

- Sensors and Aktuators
- RFID-Component marking

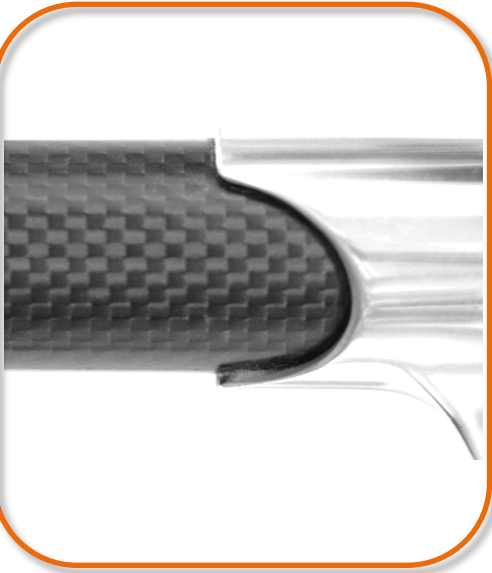
### Electricmobility

- Vehicle concepts
- Wheel hub motor
- Component development



# Current research subjects in casting technologies

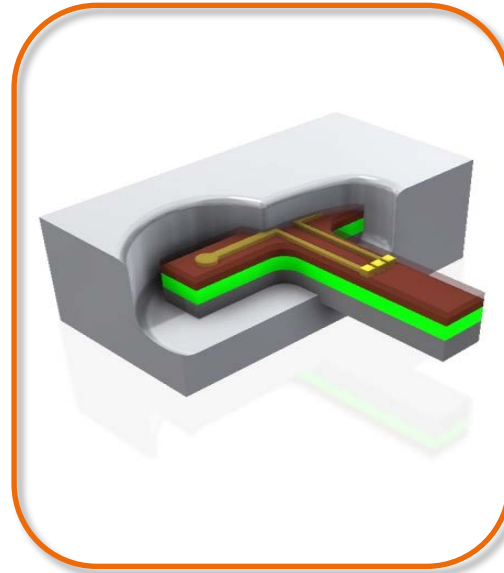
CFRP-aluminium  
hybrid casting



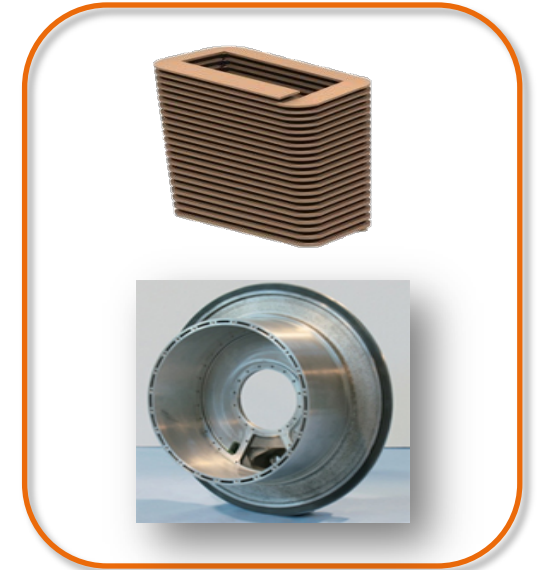
embedding of RFID  
transponder for  
part identification



embedding of sensors  
for condition monitoring



new cast parts  
for electric mobility  
applications



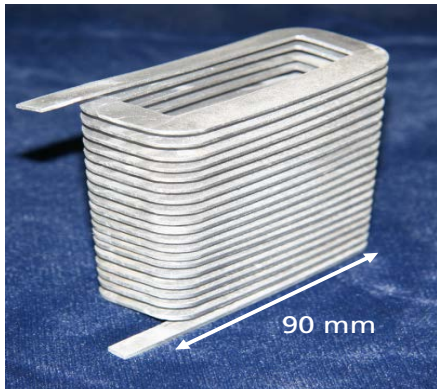
# Department Casting Technology & Component Development

## Examples for the topic „complex cast parts“

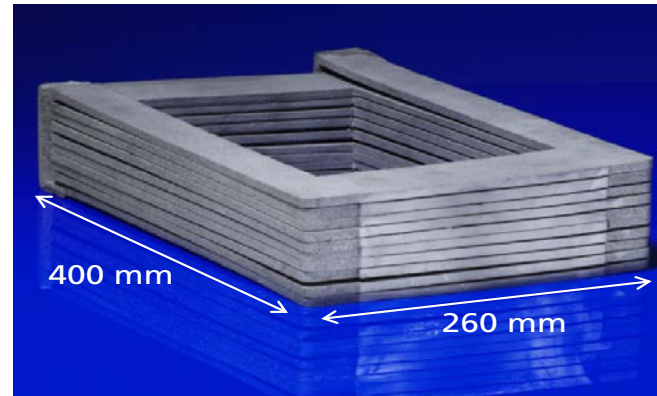


**Lost Foam cast part with cooling channel:**  
Stator for wheel hub motor

**Pressure die casting part:**  
passenger car center stack, joint for control units



**Investment casting part:**  
Coil for electric motors produced by casting



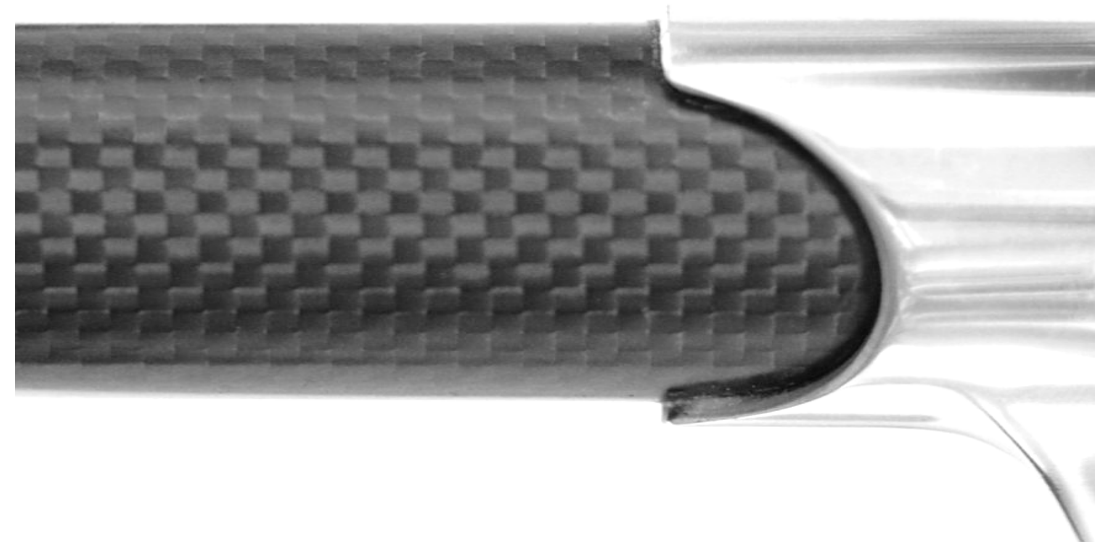
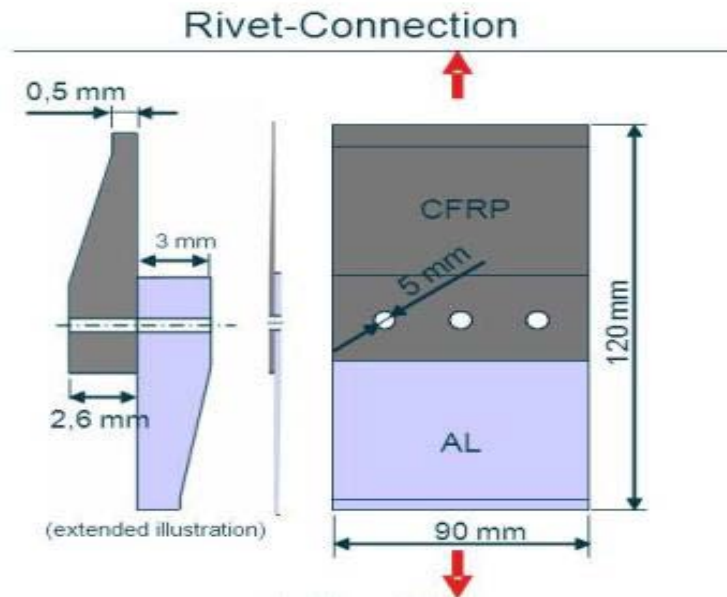
**Lost Foam part:**  
coil for large electric machines  
procuded by Lost Foam



# CFRP-aluminium hybrid casting

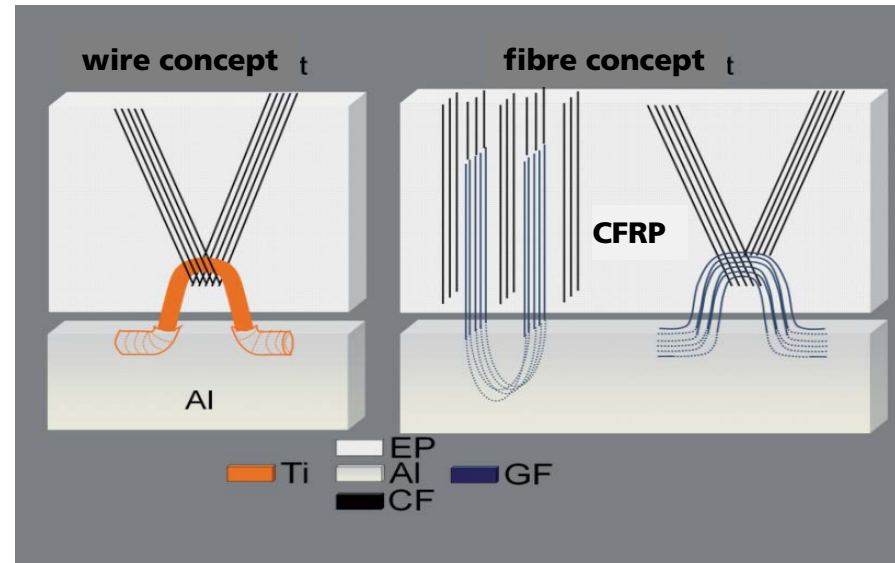
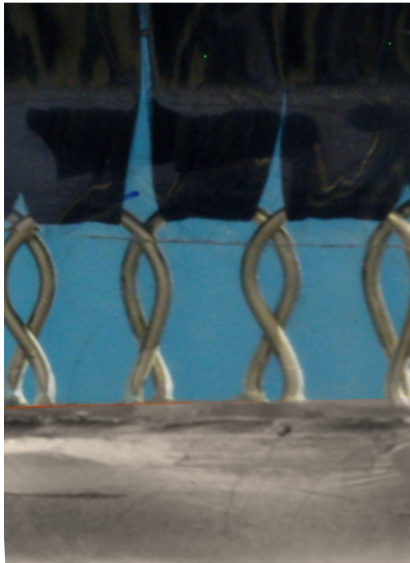
## ■ motivation and objectives

- trend in modern lightweight materials is increasingly towards multi-material design
- realization of lean, heavy duty and reliable transition structures for CFRP-Al-mixed connections in integral design (e.g. cast nodes)



# CFRP-aluminium hybrid casting

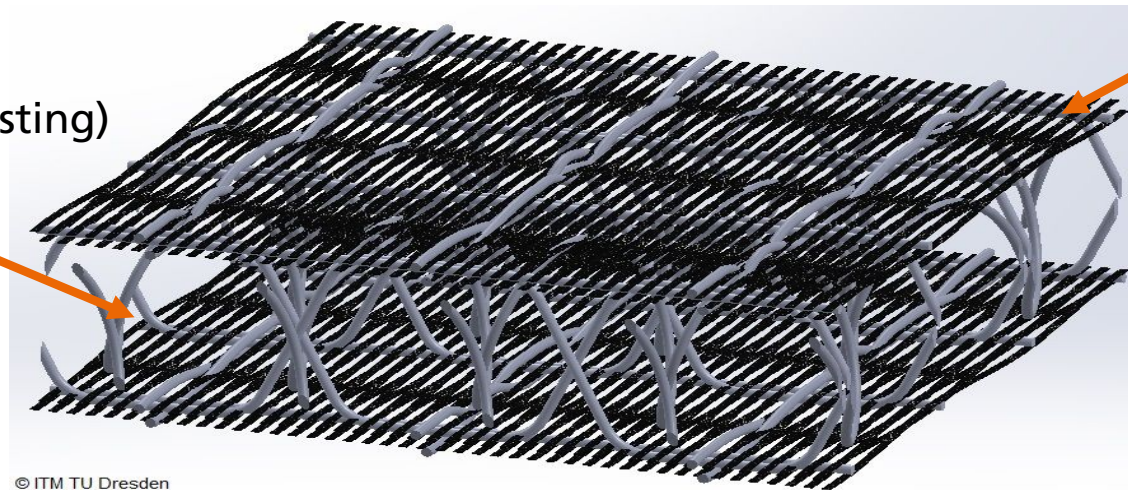
- advantages
  - lightweight construction / small space design
  - corrosion-resistant join patch
  - fibre adjusted design



# Next Step - „CarGuss“

- **Idea:** **local** carbon-fibre reinforced aluminium high and low pressure die casting parts
- **Solution:** **3D carbonfibre-wire hybrid textile to stabilize the carbon fibres during casting process**
- **Advantages:**
  - economic, series-production
  - high **increase of stiffness** und strength
  - combination of research perceptions > 10 years (transfer of knowlegde)

Wire:  
(stabilization for the casting)



C-Faser:  
(stiffness of the cast)

Innovation  
3D Wire-Textile

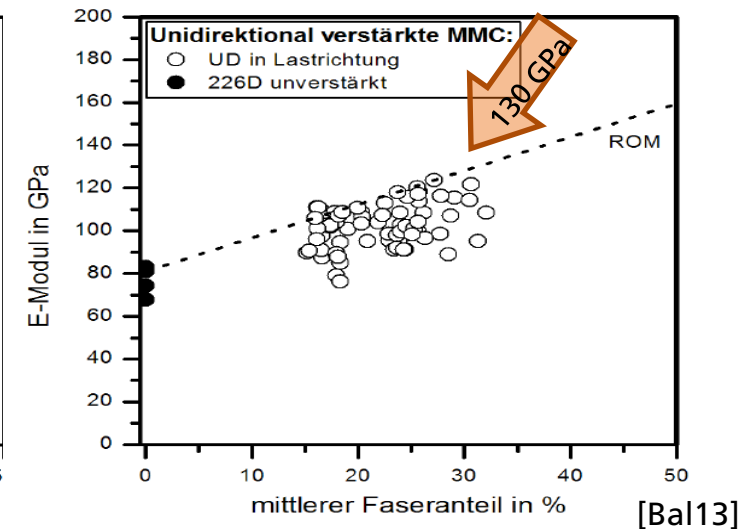
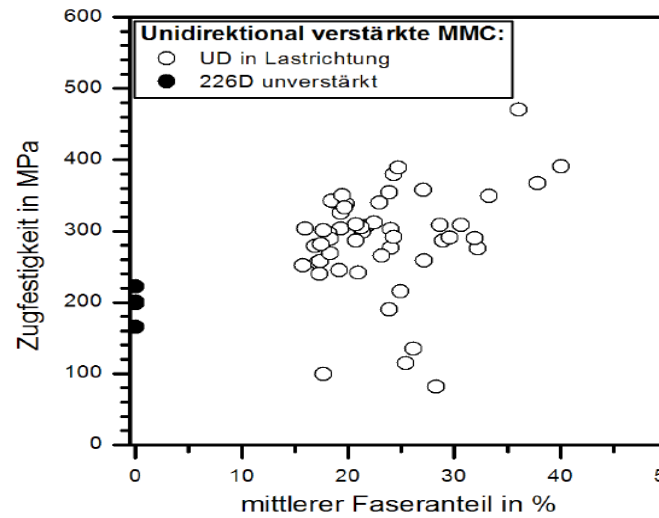
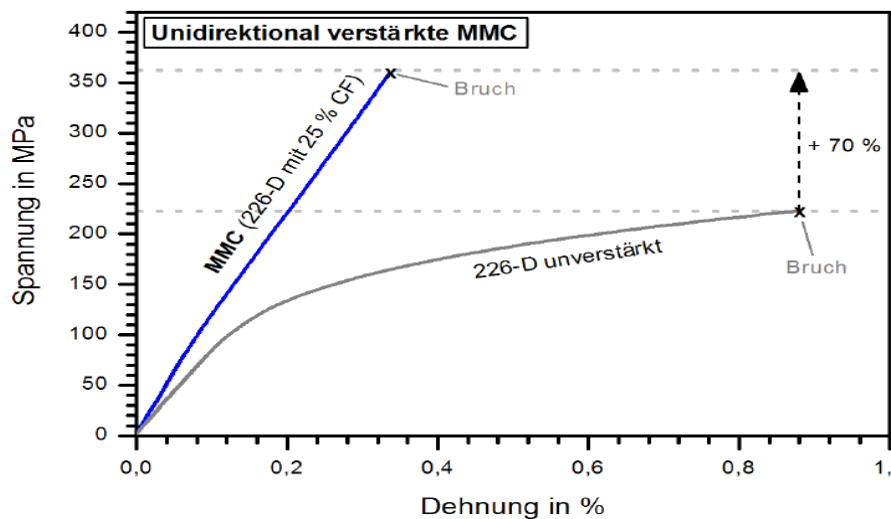
In cooperation with



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# material characteristics - objective

Material characteristics	AlSi9Cu3	Al-CF-comboud (25 % fibre volume)
Tensile strength [MPa]	240	increase ca. 70 %
Stiffness [GPa]	75	increase ca. 50 – 100 %
Strain to rupture [%]	> 1	< 1
Density [g/cm <sup>3</sup> ]	2,76	ca. 2,7



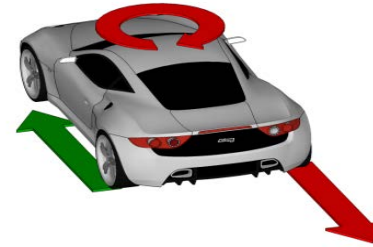
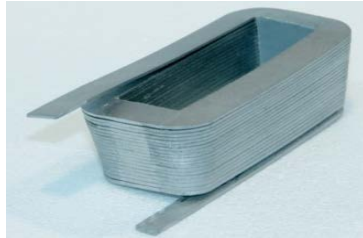
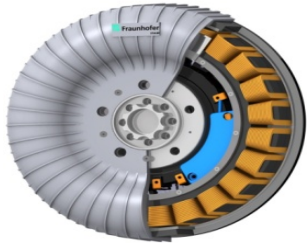


# Agenda

- Fraunhofer-Gesellschaft & Fraunhofer IFAM at a glance
- Casting Technology
- **Component Development**
- Our Offer

# Department Component Development

## FROM THE DEVELOPMENT TO THE SAVE APPLICATION IN VEHICLE



### DEVELOPMENT

- electromagnetic design / simulation of electric machines
- vehicle control, inverter, software development, controller
- construction of electric drive
- recent vehicle concepts of electro mobility

### PRODUCTION

- casting production of coils
- manufacturing of complex components for electric machines using casting technology
- assembly of prototypical electric drive
- component manufacturing drive chain / chassis

### TESTING

- functional safety of control units
- performance test of electric machines
- fault tolerance of electric drive
- testing of complete vehicle

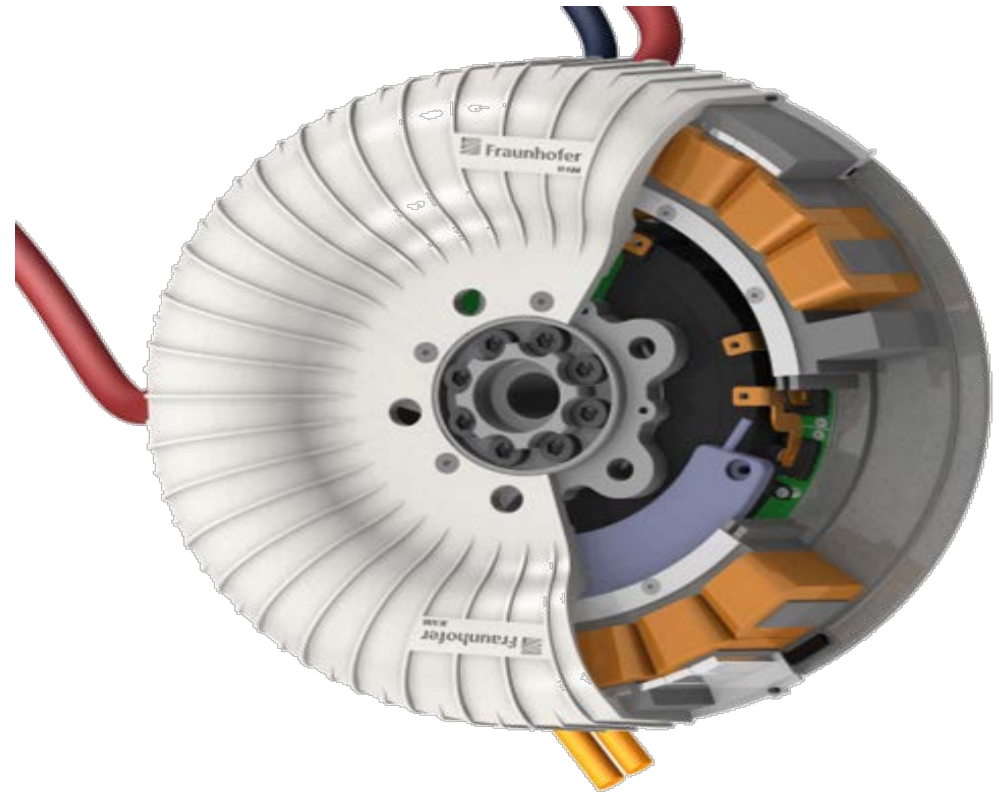
### APPLICATION

- vehicle integration of components
- configuration of test bench and demonstrator vehicle
- Major structuring of further education electro mobility

# DEVELOPMENT

## Fraunhofer Wheel Hub Drive - Drive Concept

- permanent magnet synchronous machine with outer rotor
- power electronics (IGBTs) with dc-link capacitor and control unit placed inside the stator case
- case integrated fluid cooling for stator windings and power electronics
- increased fault tolerance by changes in the converter-drive topology
- CAN-Bus connection to vehicle control unit



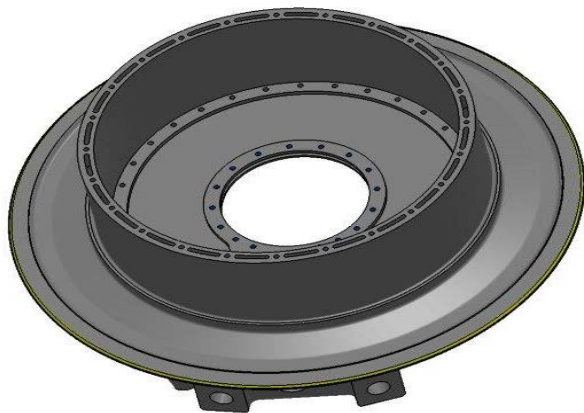
**Fig.:** sectional view of the wheel hub motor

# PRODUCTION

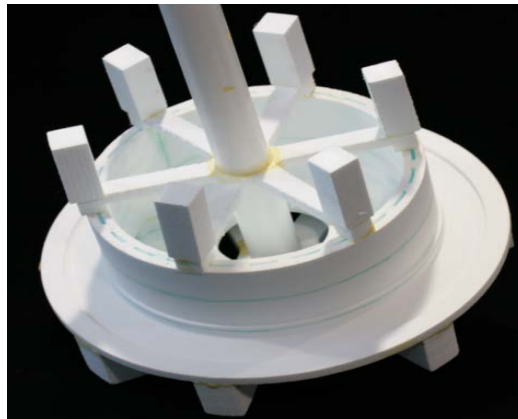
## Design and construction of complex casting parts

- Production of complex casting parts for electrical machines using Lost Foam casting (e.g. integrated fluid cooling system)
- Great freedom of design (e.g. undercuts, wide range of variants)
- Cost-efficient production of models due to low tool wear
- Milling of EPS-models for rapid production of functioning prototypes
- Inherent flexibility due to segmentation of the model

**CAD-model**



**EPS-model**



**Raw part**



**Machined part**

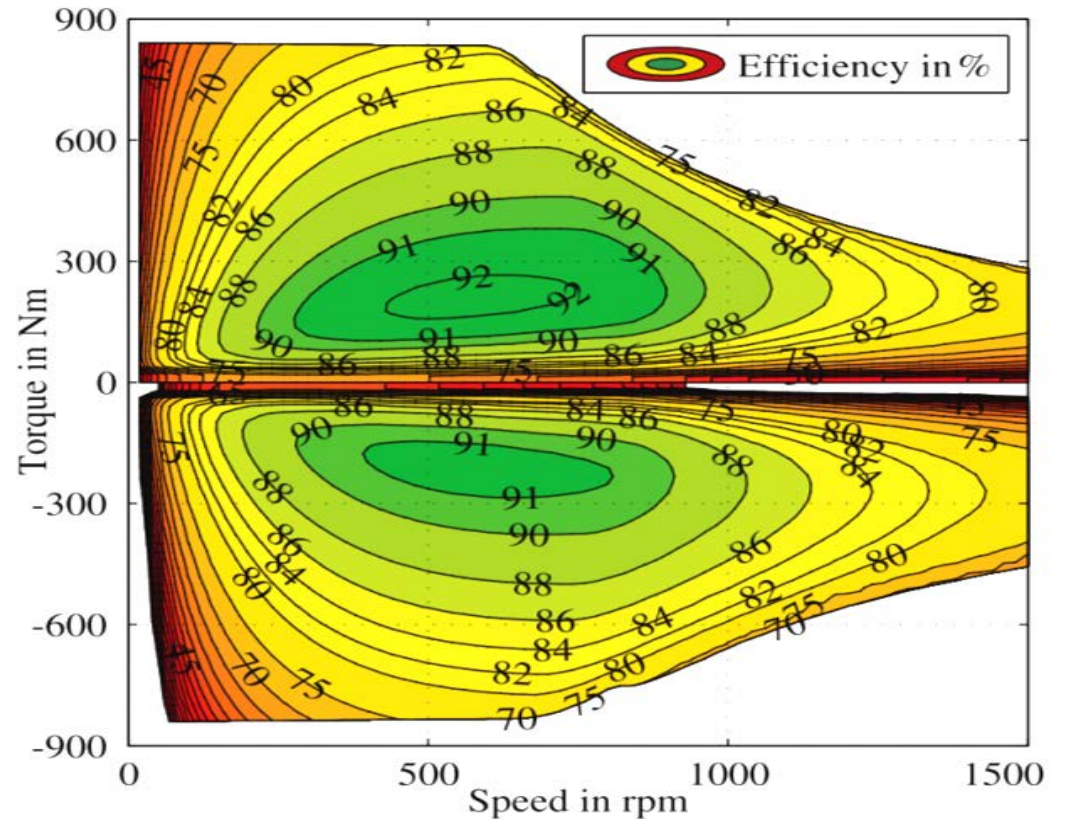




# TESTING

## Fraunhofer Wheel Hub Drive – Specifications and Efficiency Map

Description	Value
Rated Power	<b>50 kW</b>
Peak Power	<b>72 kW</b>
Rated Torque	<b>700 Nm</b>
Peak Torque	<b>900 Nm</b>
Max. Speed	<b>1500 rpm</b>
Rated DC-Voltage	<b>400 V</b>
Max. Efficiency	<b>93.4 %</b>
Mass (incl. Bearings)	<b>42 kg</b>
Outer diameter	<b>364 mm</b>
Length	<b>105 mm</b>

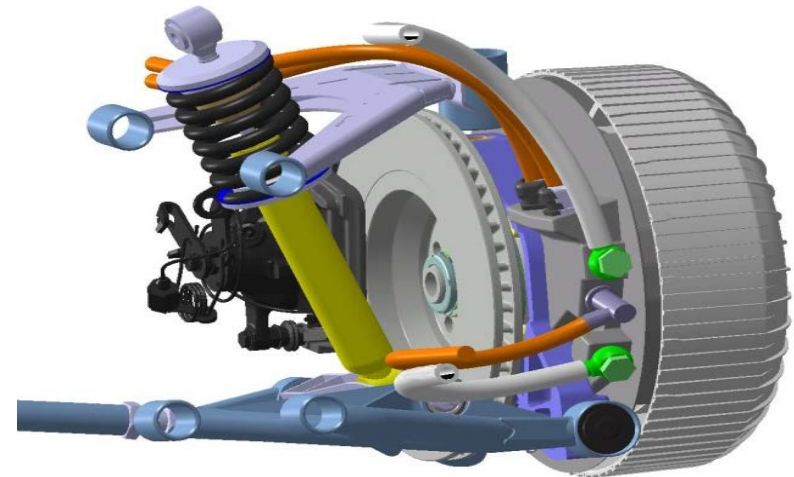


**Measured efficiency map**

# APPLICATION

## Vehicle integration and testing - Demonstrator vehicle

- Integration of two wheel hub drives at the rear axle of an electric concept car
- 400 V Lithium-ion battery system with 37.6 kWh
- Complete control over vehicle control unit, independent adjustment of torque distribution possible
- Retention of the original disc brake system at the inner side of wheel carrier
- Reconstructed suspension system



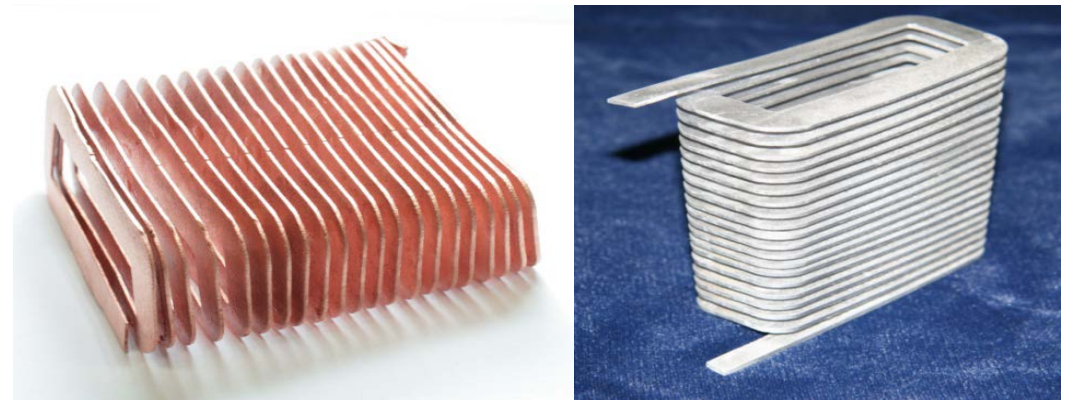
**Top:** Concept car »Frecc0 2.0« with wheel hub drives

**Bot.:** Wheel carrier with inner-side disc brake and mounted wheel hub drive

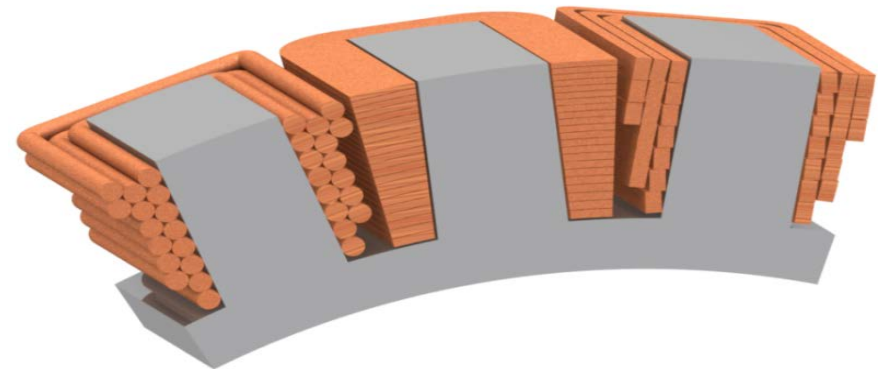
# PRODUCTION

## Casting of coils for electric machines

- Idea: Coils are produced using a casting process
  - Exact reproduction of design geometry
  - Possibility to vary the cross-sectional geometry along the entire length of the conductor
- Flat conductor alignment with variable width and height
- Slot filling factor up to 90%
- Minimised skin effect
- Positive model of the coil is stretched to allow the casting process and insulation
- Compression of the coil after the casting process



**Casted coils (copper / aluminium)**



**Sectional view of different conductor types: circular (left), rectangular (right) and casted (middle)**

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# Contact



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