DLR – German Aerospace Center
Institute of Structures and Design, Stuttgart
Dept. Ceramic Composites and Structures

Marius Kütemeyer
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Participation in the Helmholtz Association

- Success in obtaining program-oriented funding
- Added value from support of the Helmholtz Association
- Helping to shape the organisational development process

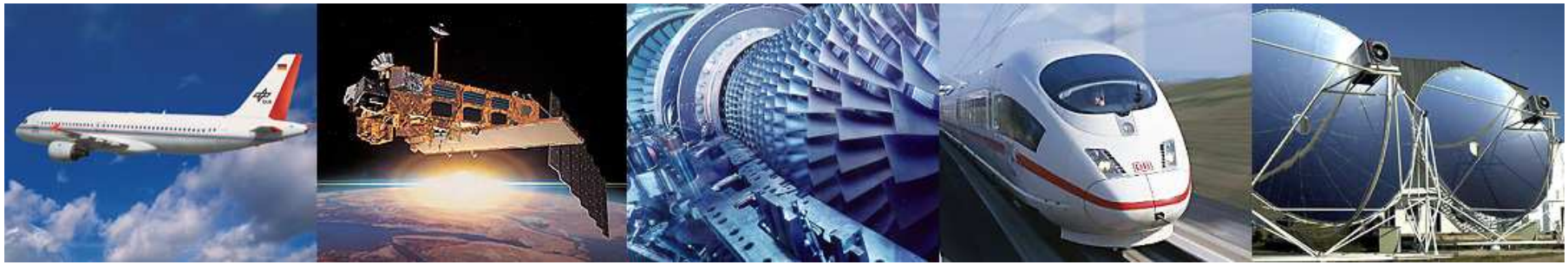
HELMHOLTZ GEMEINSCHAFT

AWI · DESY · dkfz. · DLR · DZNE Deutsches Zentrum für Neurodegenerative Erkrankungen in der Helmholtz-Gemeinschaft · GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel

GSI · GFZ Helmholtz-Zentrum Potsdam · HZB Helmholtz Zentrum Berlin · HZDR Helmholtz Zentrum Dresden Rossendorf · Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung · JÜLICH Forschungszentrum

KIT Karlsruher Institut für Technologie · Helmholtz Zentrum für Infektionsforschung · HelmholtzZentrum münchen · Helmholtz Zentrum für Umweltforschung UFZ · MDC Max-Delbrück-Centrum für Molekulare Medizin Berlin-Buch in der Helmholtz-Gemeinschaft · IPP

DLR
German Aerospace Center

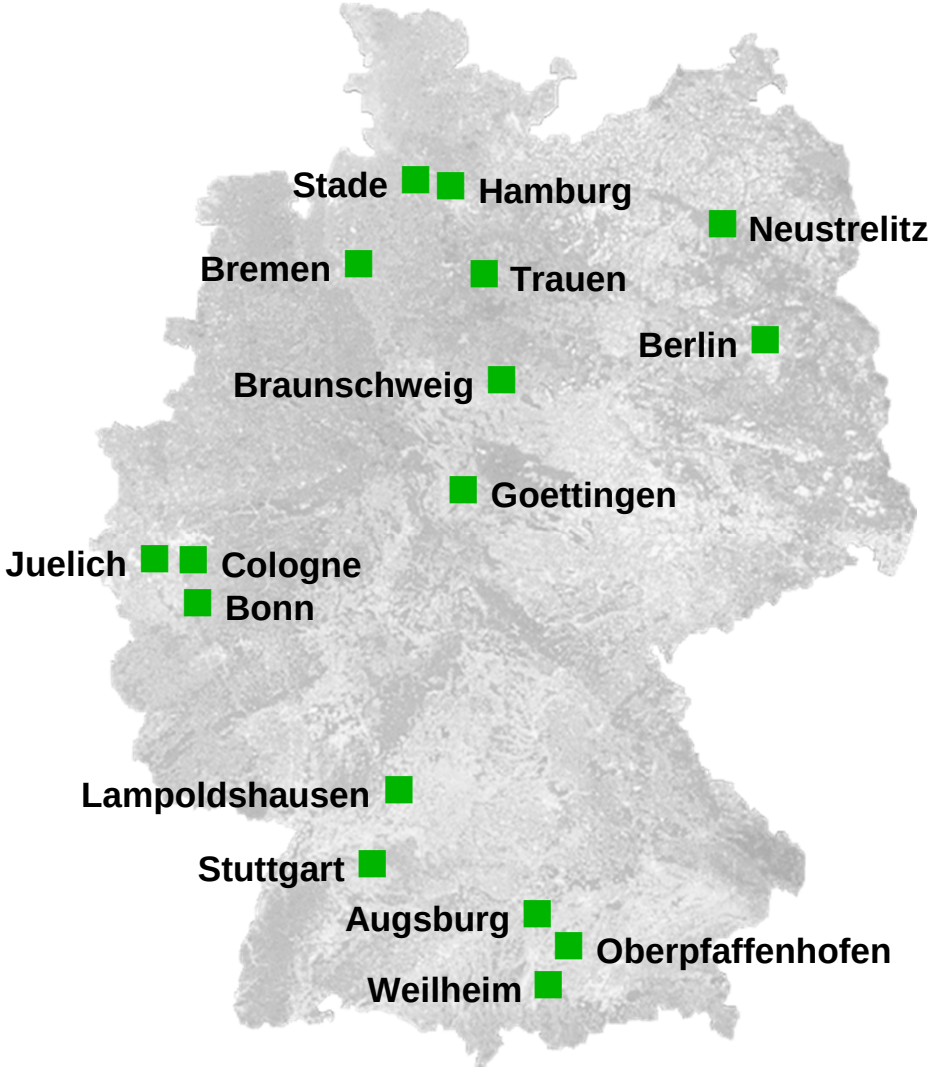


- Research Institution
- Space Agency
- Project Management Agency

Locations and employees

7700 employees across
32 institutes and facilities at
16 sites.

Offices in Brussels, Paris,
Tokyo and Washington.



Research Areas

- Aeronautics
- Space Research and Technology
- Transport
- Energy
- Defence and Security

- Space Administration
- Project Management Agency

Core Goals

	Aeronautics	Space Research and Technology	Transport	Energy	Space Administration	Project Management Agency
Research / Govern-mental Functions / Services	• Continuously enhance DLR's scientific excellence • Strengthen the position of Germany's economy and science in global competition through enhanced support for Europe as an aerospace location • Increase the leverage of the transport and energy business areas • Enhance the utilisation of research results in innovations for the aeronautics, space, transport and energy sectors • Enhance the visibility of governmental functions • Involve Project Management Agency more extensively in Germany and Europe					

Executive Board

Prof. Dr-Ing. Johann-Dietrich Wörner Chairman	■ Overall strategy and development ■ External relations ■ Corporate Communication ■ ESA Council
Klaus Hamacher Vice Chairman	■ Human Resources, Finance, Corporate Organisation ■ Quality Assurance and Infrastructure ■ Technology Marketing ■ Information technology ■ Project Management Agency
Dr. Gerd Gruppe	■ Space Administration ■ National/ESA program
Prof. Dr. Hansjörg Dittus	■ Space Research and Technology: research, programs, projects, technology transfer
Prof. Rolf Henke	■ Aeronautics: research, programs, projects, technology transfer ■ Approved Design Organisation
Prof. Dr-Ing. Ulrich Wagner	■ Transport and Energy: research, programs, projects, technology transfer

Program Management

Institutes and Facilities

Know-how, Research facilities

Program Directorates

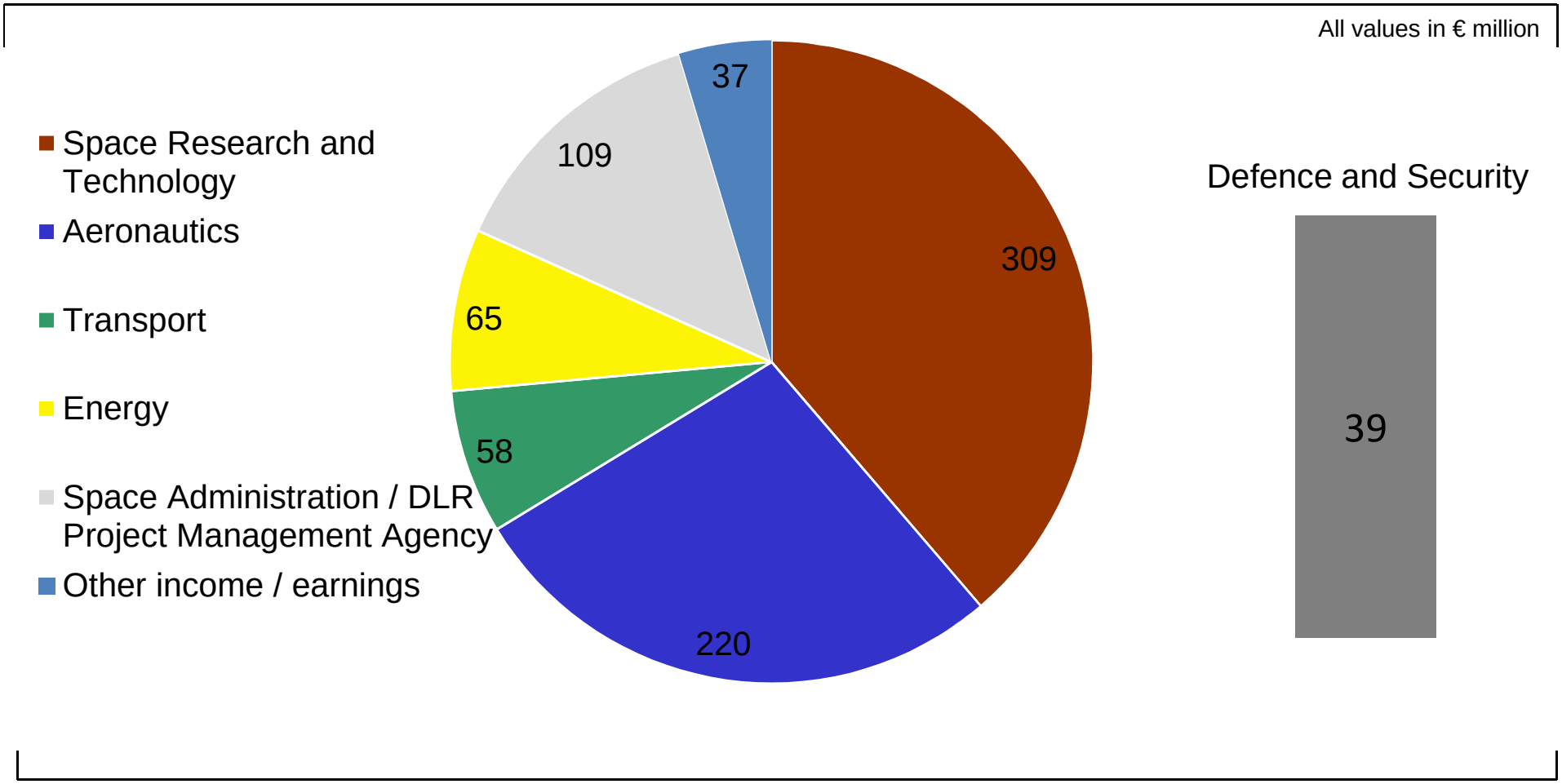
- Aeronautics
- Space Research and Technology
- Energy
- Transport

Resources

Service and resource agreements

Projects
Programs

Total income (actual) 2012 – Research, operations and management tasks: €798 Mio. (excluding trustee funding from the Space Administration / DLR Project Management Agency)



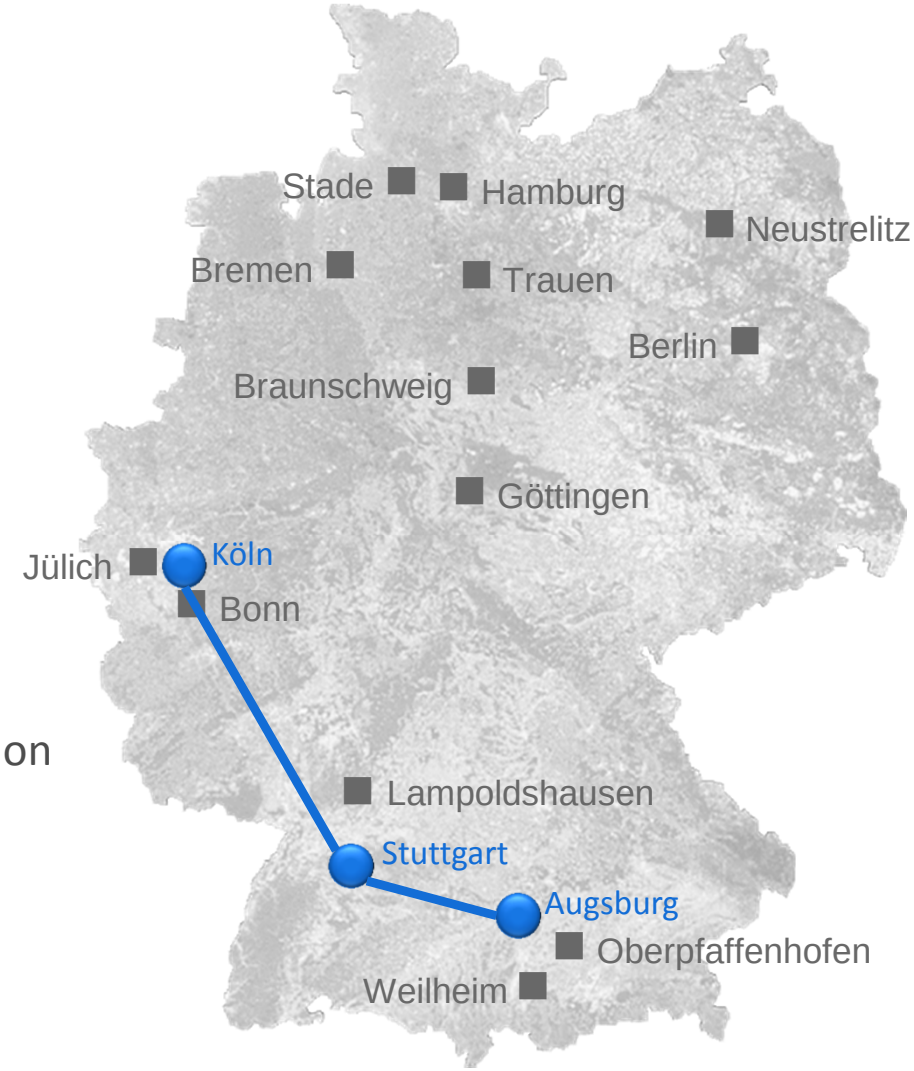
Institutes

Sites

Institute of Material Research
Köln/Porz
Employees: 99

Institute of Structures and Design
Stuttgart
Employees: 84

Center for Lightweight-Production Technology ZLP
ZLP Site Augsburg
Employees: 37



Organisation

INSTITUTE OF STRUCTURES AND DESIGN

Managing Director
Ch. Kindervater

Director
Prof. Dr. H. Voggenreiter

Structural Integrity (Crash – HVI)
Dr. N. Toso

Computer Supported Component Design
Dr. W. Dudenhausen

Ceramic Composites and Structures (CMC)
Dr. D. Koch

Space Structural Components
Dr. H. Hald

Center for Light-Weight Production – Site Augsburg
Prof. Dr. M. Kupke

INSTITUTE OF MATERIALS RESEARCH

Managing Director
Prof. Dr. S. Reh

Metallic Structures & Hybride Material Systems
Prof. Dr. S. Reh

Experimental and Numerical Methods
Prof. Dr. M. Bartsch

Structural and Functional Ceramics
Prof. Dr. S. Reh (acting)

Aerogel Materials
Prof. Dr. Ratke

High Temperature & Functional Coatings
Dr. U. Schulz

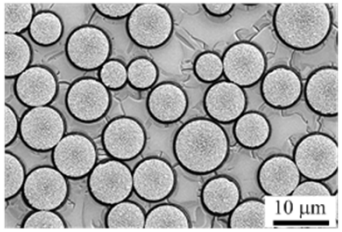
Thermoelectric Material Systems
Prof. Dr. W.-E. Müller

Microstructure Analysis and Metallography
Dr. K. Kelm

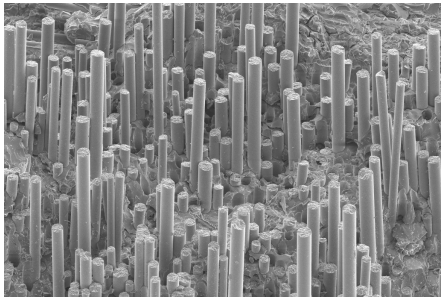
Material Mechanics
J. Wischek

Research Areas

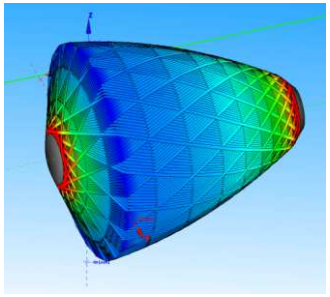
Processing, Material Development, Design



Processing of CMC



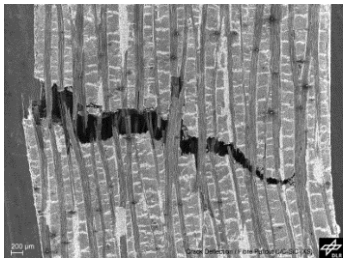
Fiber, Matrix and Interface composition



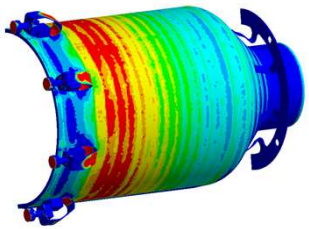
Structures and Design

Prototypes

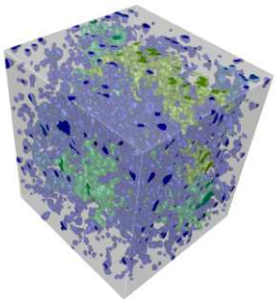
Simulation and Engineering



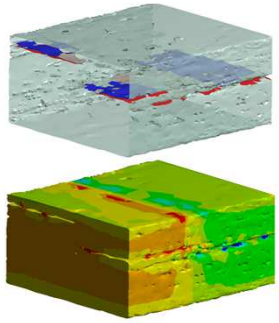
Material Properties



Modeling



NDI

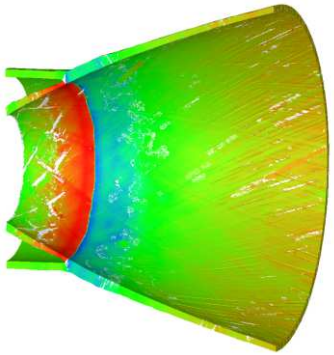


Effects of Defects

Material and Process Development

Processes:

- Reactive Melt Infiltration
  - Liquid Silicon Infiltration LSI
- Polymer Infiltration and Pyrolysis PIP
- Coating via Low Presssure Plasma Spraying
- New fiber placement processes (e.g. winding, braiding)
- Evaluation techniques for NDI, Process evaluation, (preform – reinforced polymer – reinforced ceramic)

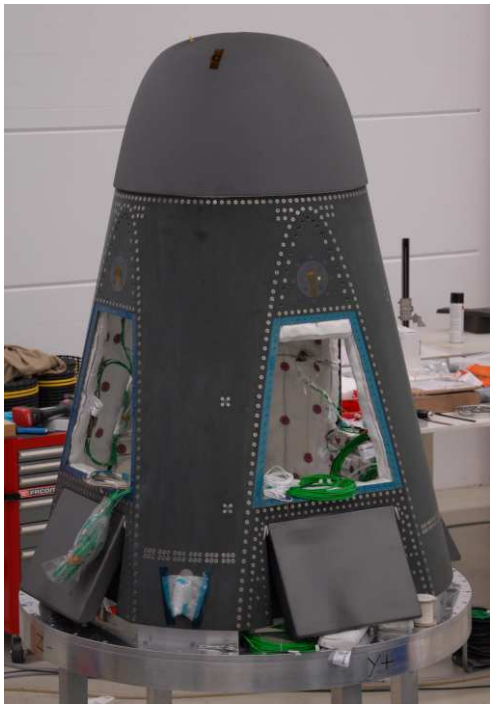


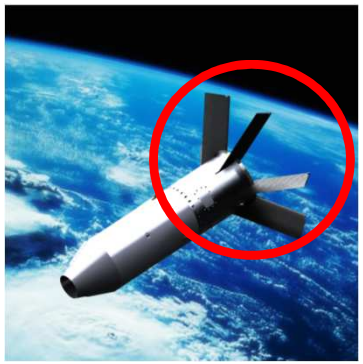
Materials:

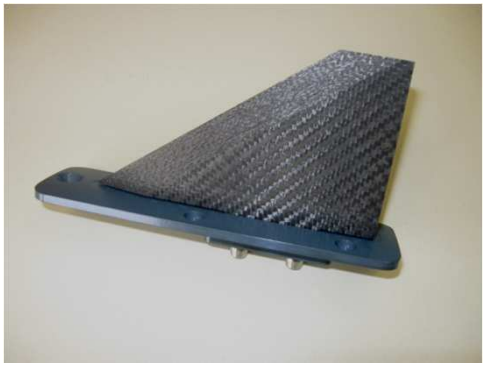
- C/C and C/C-SiC composites
- SiC/SiC composites
- Oxide composites (Oxipol)
- Biogenic ceramics (MiCaSiC®)
- UHTC composites

Returnable Spacecraft Technology – Flight Tests

- CMC Nose Cap System on EXPERT (ESA)
- TPS Experiments on FOTON Missions
- CMC Fin Experiment on HIFIRE 5 and ablative stabilizer leading edge on HIFIRE 3 & 5
- CMC Stabilizer Fins within SCRAMSPACE (UQ/DSTO Australia)
- SHEFEX Flight test program







Responsibility in LIGHT-TPS

- Contribution to Work Packages: WP1 (1PM), WP3 (3PM), WP4(18PM)
- Timeframe: 4M, 19M, 35M

Deliverables:

- D1.2 (list of ceramics to be produced)
- D3.2 (overall TPS design) + D3.3 + D3.4 (set of TPS elements prototypes)
- D4.7 + D4.8 (non-metallic structures for coating) + D4.13 (advanced characterization of coatings)

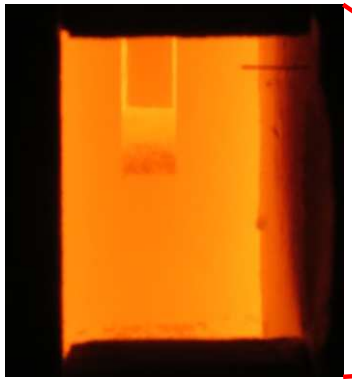
Responsibility in LIGHT-TPS

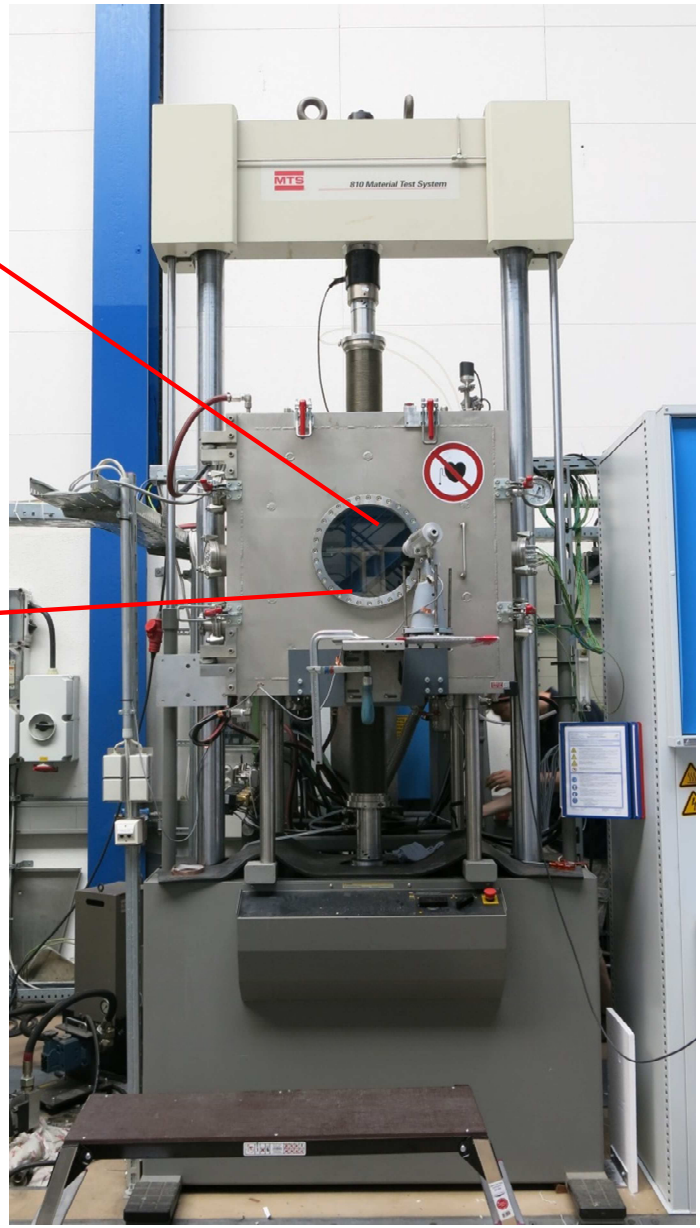
- Contribution to the TPS-Design
  - CMCs
  - Interfaces
  - Sealing
- Manufacturing of CMCs
- Testing of the TPS components and system
  - Oxidation
  - Thermal and mechanical properties
- Analysis of the oxidation behaviour

Thank you for your attention …

Facilities Relevant for the Project

- CMC manufacturing
  - Furnaces
  - Autoclave, RTM, HP





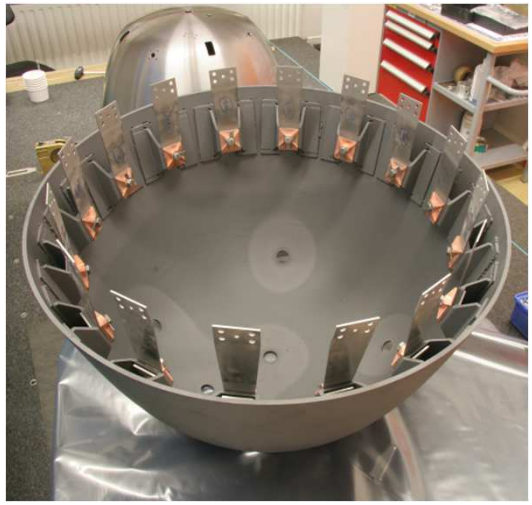
- SEM/EDX
- XRD
- X-Ray CT and Nanotom
- Indutherm (Thermal and mechanical testing and processing)

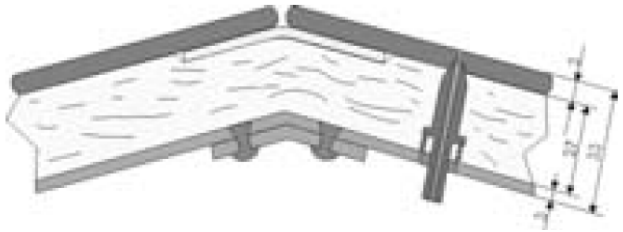
Technical Description

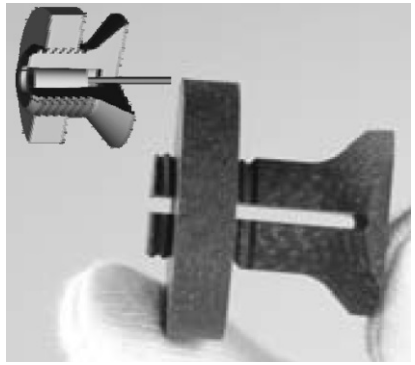
Heating elements	Graphite	C/C-SiC
Max. heating temperature	2000°C	1700°C
El. Power	50 kW	50 kW
Max. sample temperature (depending on sample shape)	Approx. 1700°C	Approx. 1600°C
Atmosphere	Air up to 200 mbar, Nitrogen	Air, Nitrogen
Pressure range	0.1-950 hPa, adjustable between 0.2 to 900 hPa	
Max. mechanical load	250 kN	
Inner chamber dimensions (useable)	750x750x550 mm³	
Data aquisition	digital	

TPS-Design

- CMC
  - Design variation
  - Material variation
- Interfaces
  - Center post
  - Stand-offs
  - Screw rivet
- Sealing





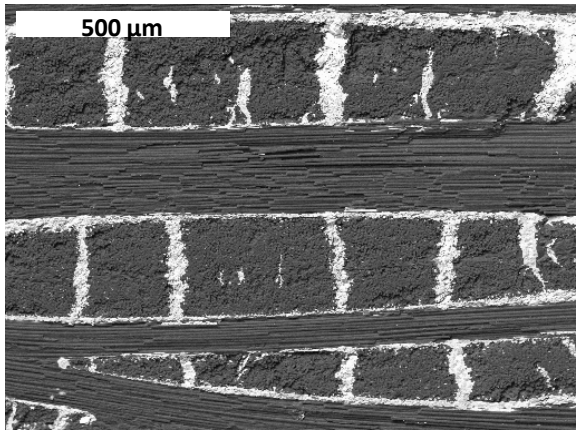


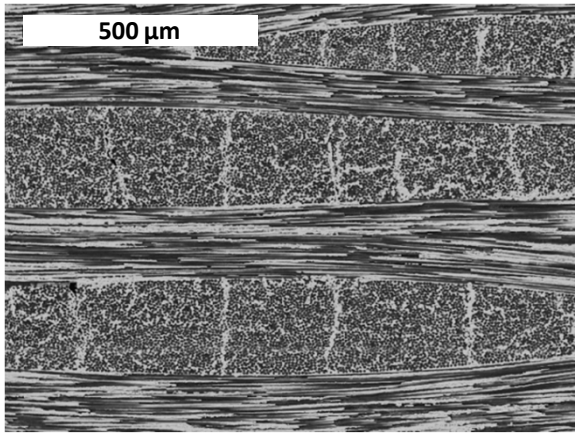
Manufacturing of CMCs

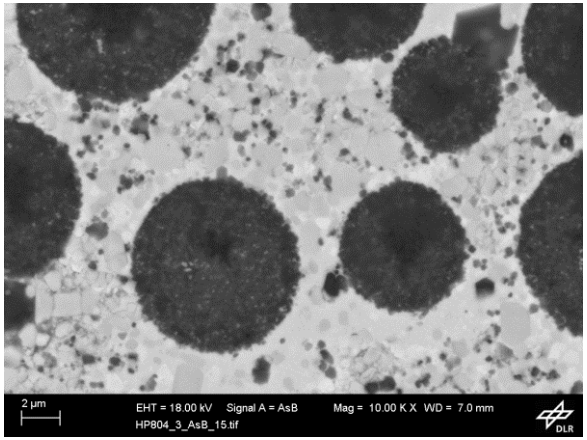
- Adaption of Material Properties

CFRP:
- Variation of reinforcement
- Variation of composition
- Strong or weak F-M-bonding

Composite:
- Strength, stiffness
- Thermal expansion and conductivity
- SiC / Si / C contents
- Oxidation resistance
- UHTCMC ZrB_2 / ZrC



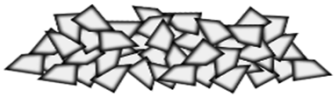




Liquid Silicon Infiltration Process (LSI) for C/C-SiC

Precursor Additives Fibers

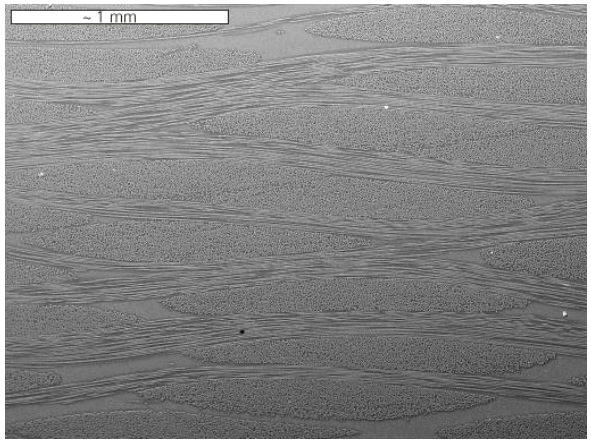
Silicon Granules



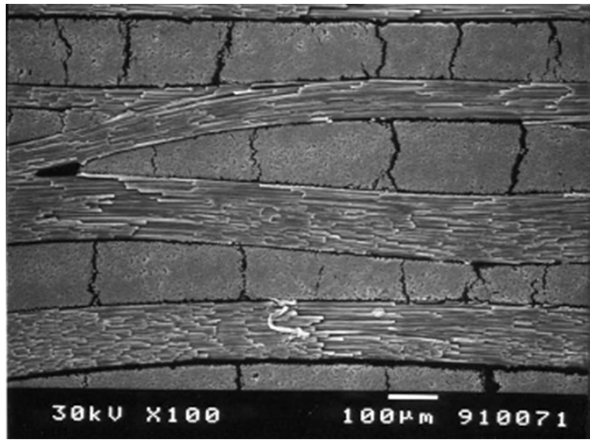
CFRP (Shaping)
RTM, Autoclave, Filament-Winding, Warm Pressing
T < 250 ° C

Pyrolysis
T > 900 ° C
Inert gas
Matrix shrinkage

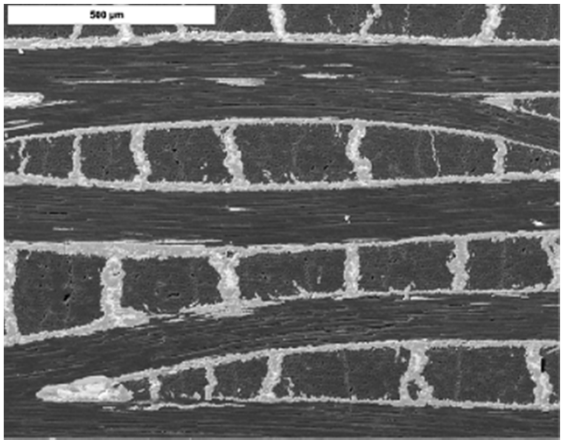
Silification
Si + C → SiC (Matrix)
T > 1500 ° C
Vacuum



CFRP



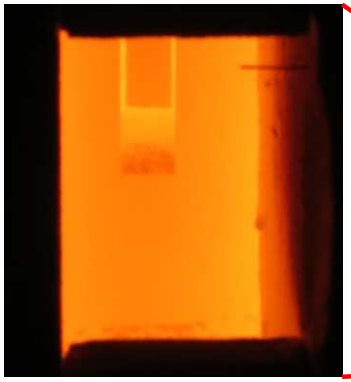
C/C

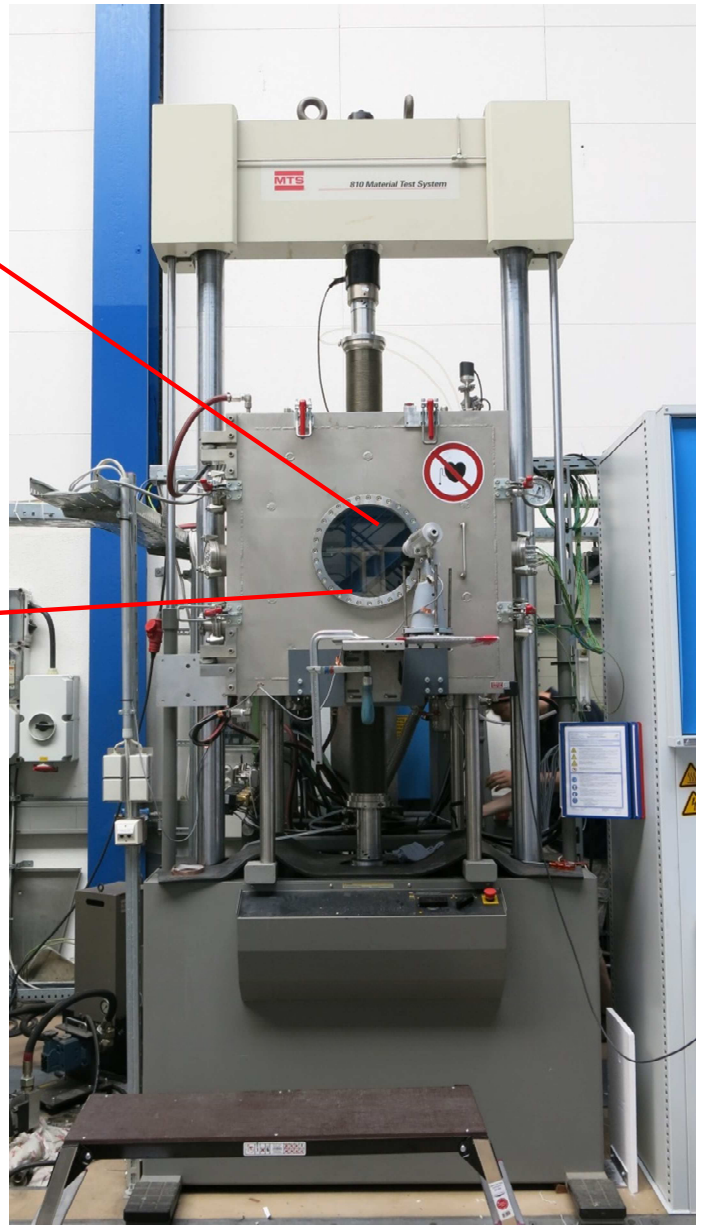


C/C-SiC

Testing

- Induction heating
- Temperature gradient
- Oxidation tests
- Mechanical tests





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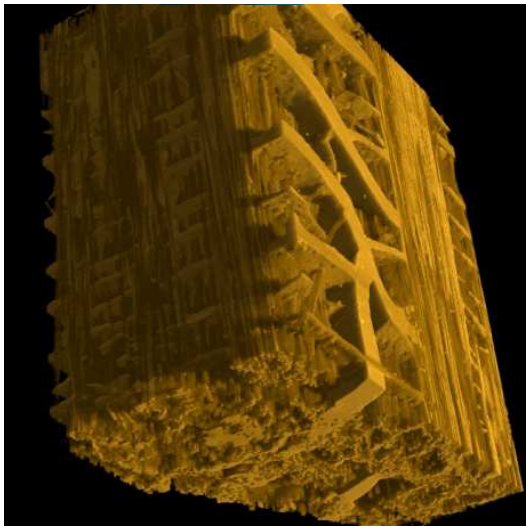
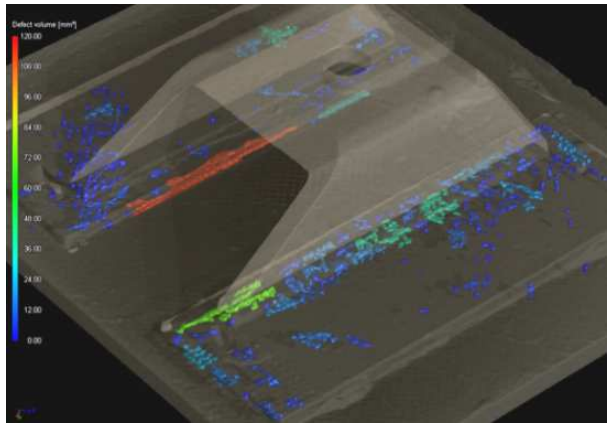
Atmosphere	Air up to 200 mbar, Nitrogen	Air, Nitrogen
Pressure range	0.1-950 hPa, adjustable between 0.2 to 900 hPa	
Max. mechanical load	250 kN	
Inner chamber dimensions (useable)	750x750x550 mm³	
Data aquisition	digital	

Analysis of the oxidation behaviour
NDI, SEM/EDX, XRD

- Detection and classification of defects and definition of tolerances
- Detailed analysis of microstructure and critical volumes in components (e.g. joining area)
- Systematic failure characterization
- Enhanced signal and image analysis
- Calibration of testing methods



3D-Phase analysis for evaluation of resin content and distribution in CMC



Defect analysis inside of components (Computer tomography)