



LIGHTer
International
Conference
GOTHENBURG 20-21 NOV

10

Resistance welding of high-performance reinforced thermoplastics in fuselage applications

Simon Bauer

M.Sc., German Aerospace Center (DLR)

Three important questions regarding welding

Why? Where? How?



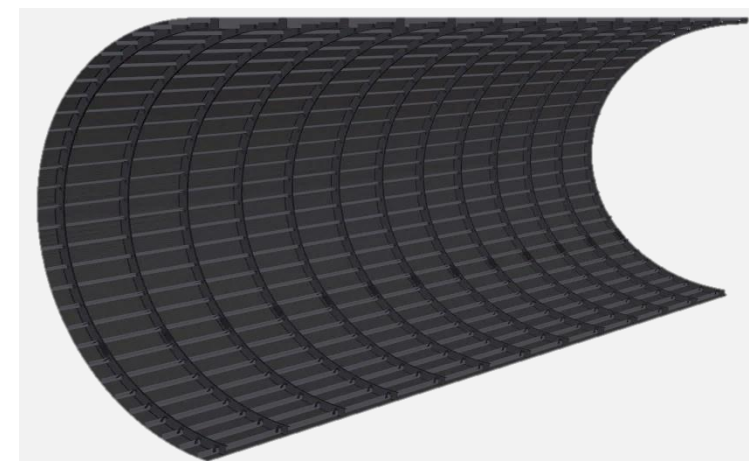
Why Welding?



[1]



[2]



A320

Good lightweight potential

Material: Aluminium Alloys
Joining: Rivets

A350

High lightweight potential

Material: Thermoset composites
Joining: Rivets

NextGen

Highest lightweight potential

Material: Thermoplastic Composites
Joining: Welding

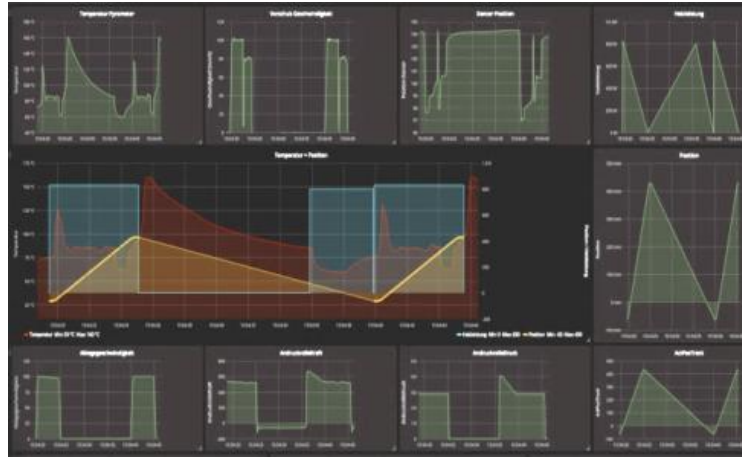
Reduce weight and cost



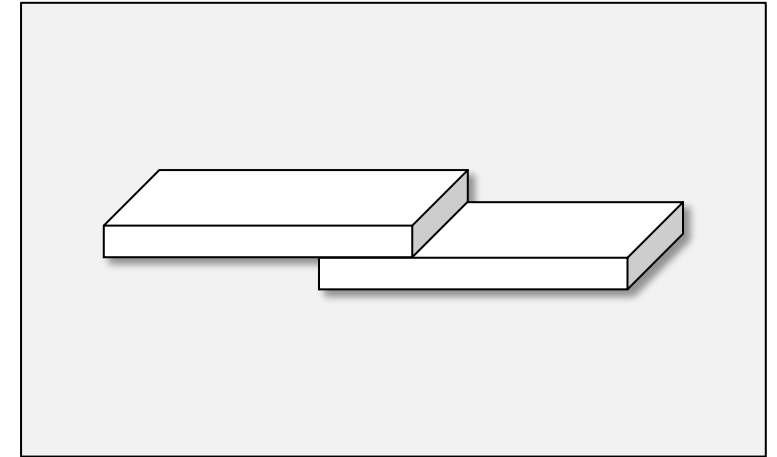
Advantages of welding



Highly automatable processes



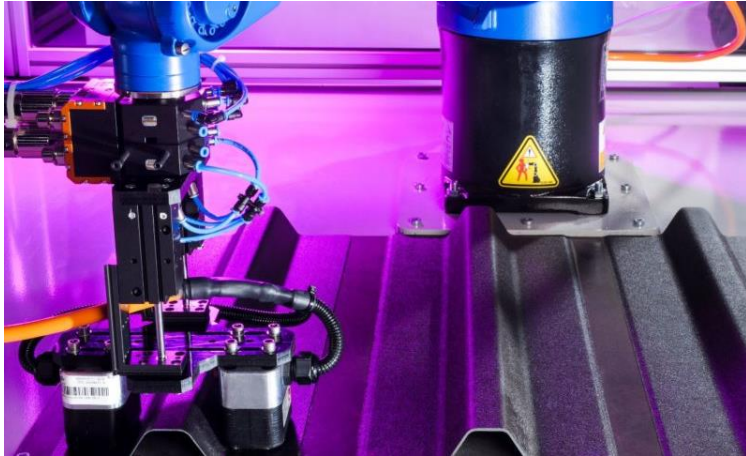
Large datasets to assess joining quality



Fibre-oriented joining design



High potential welding technologies



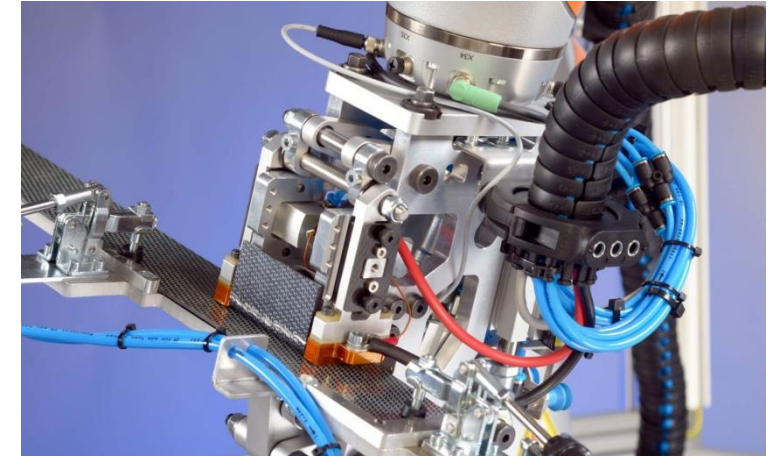
[1]

Induction welding



[2]

Ultrasonic welding

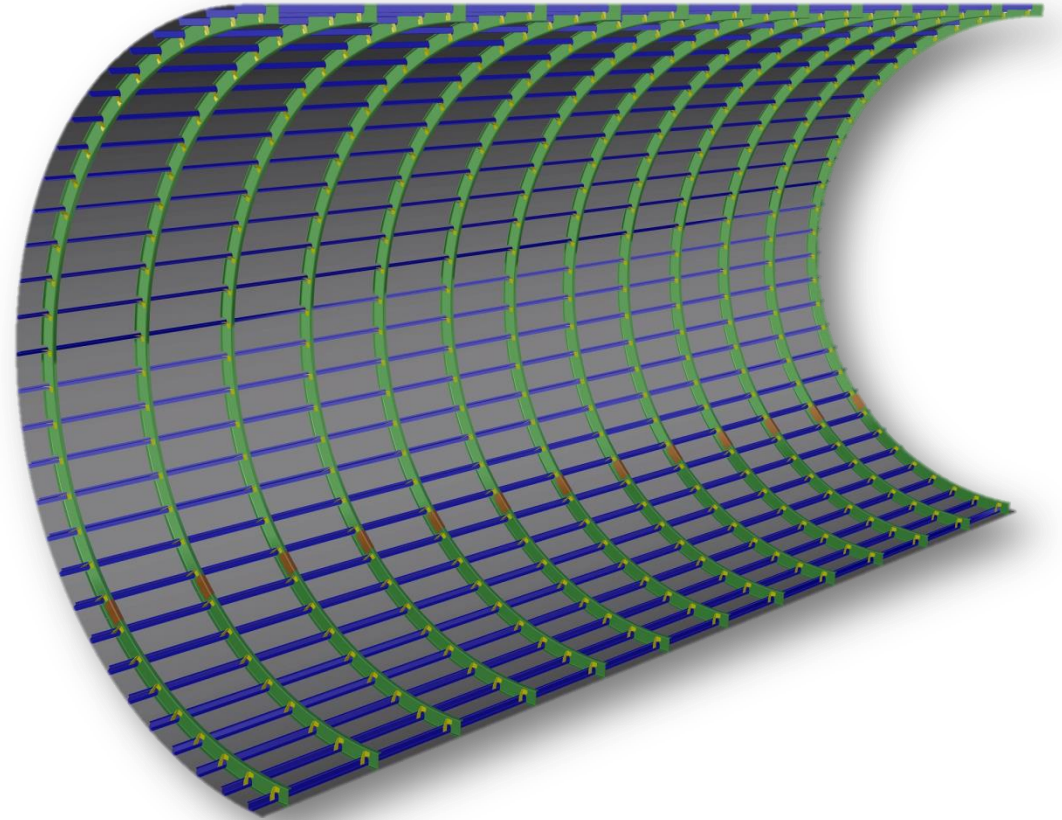
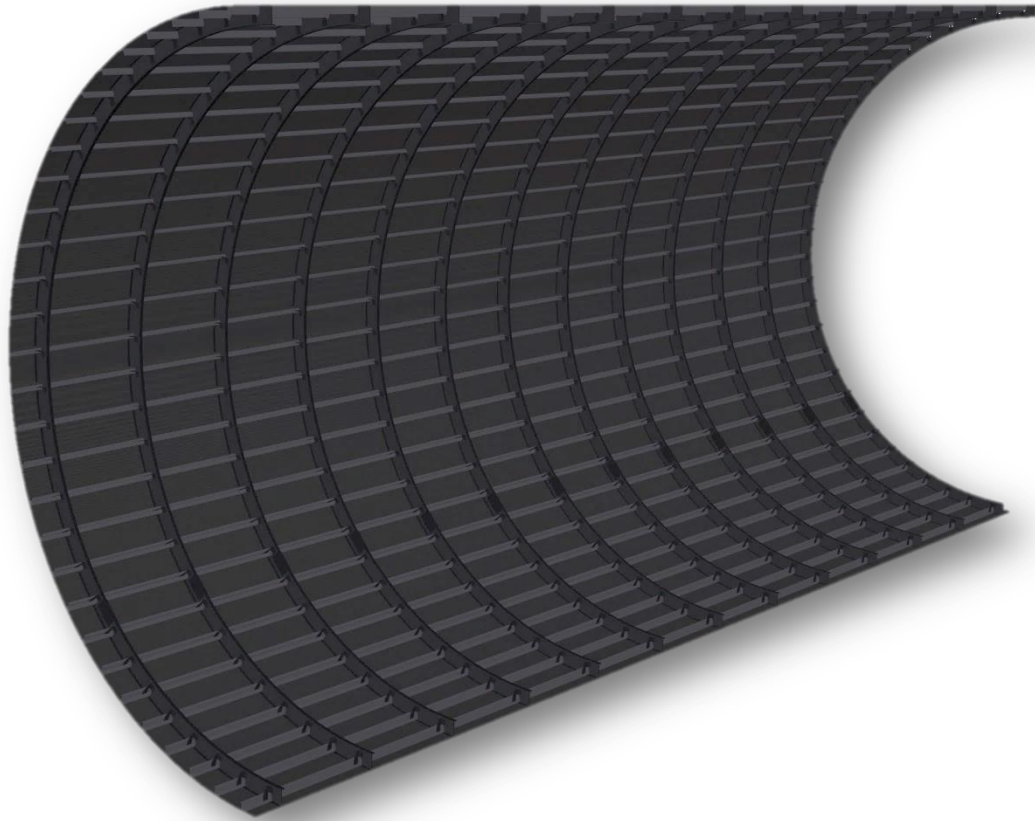


[3]

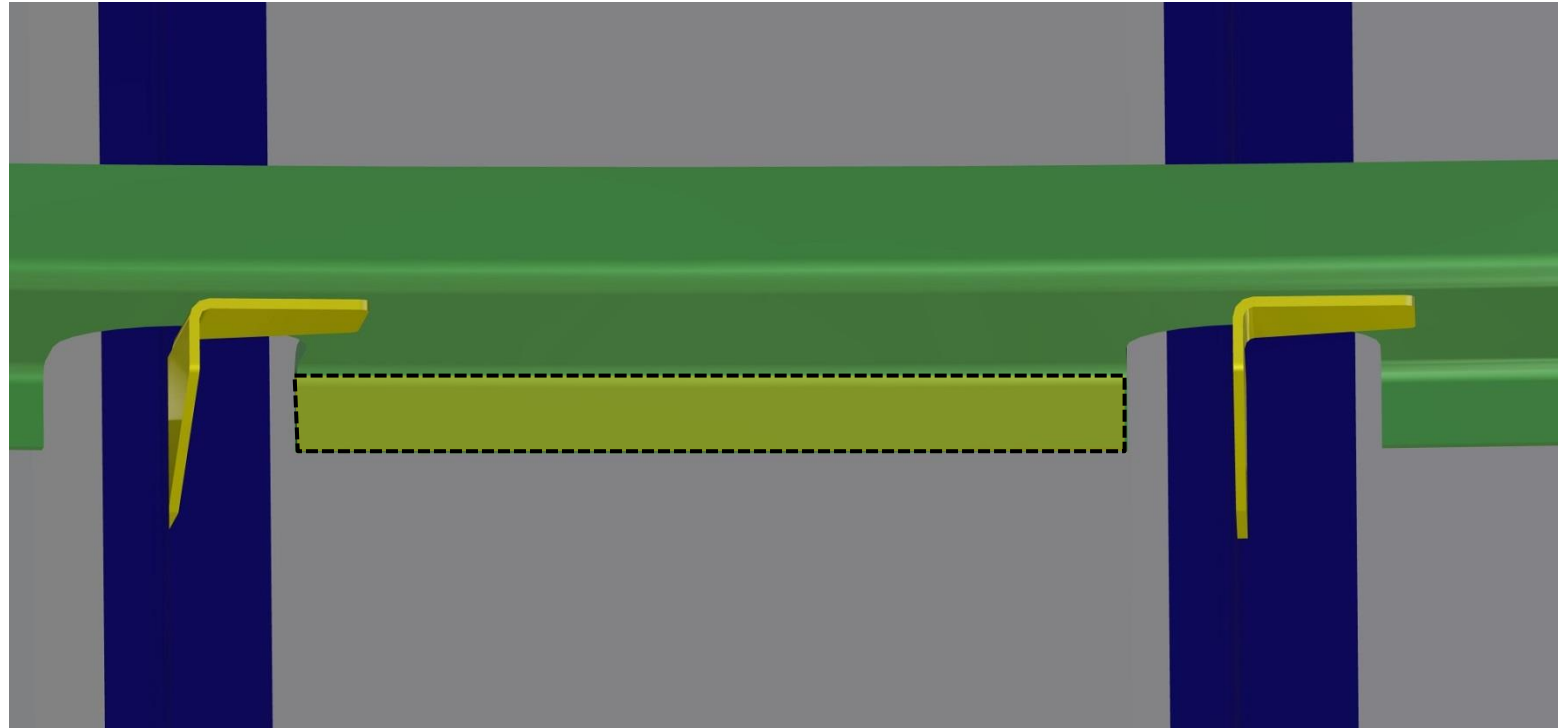
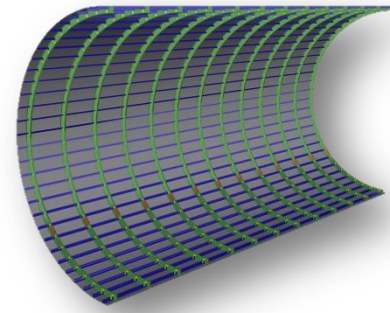
Resistance welding



Future thermoplastic fuselage design



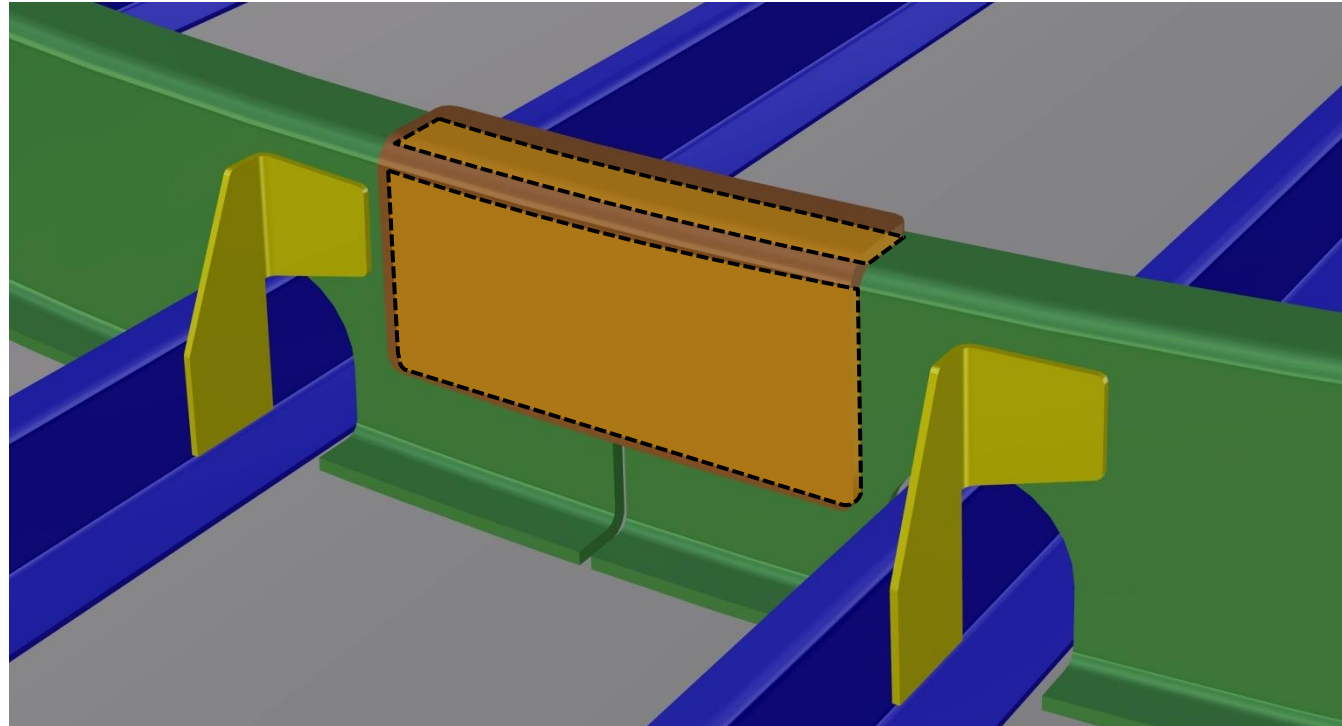
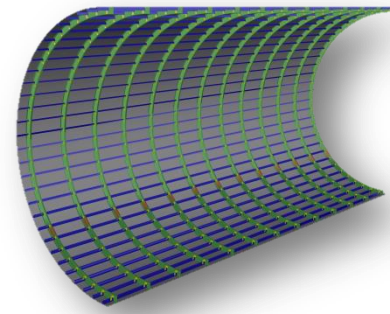
Fuselage applications for resistance welding



Frame-Skin Joint



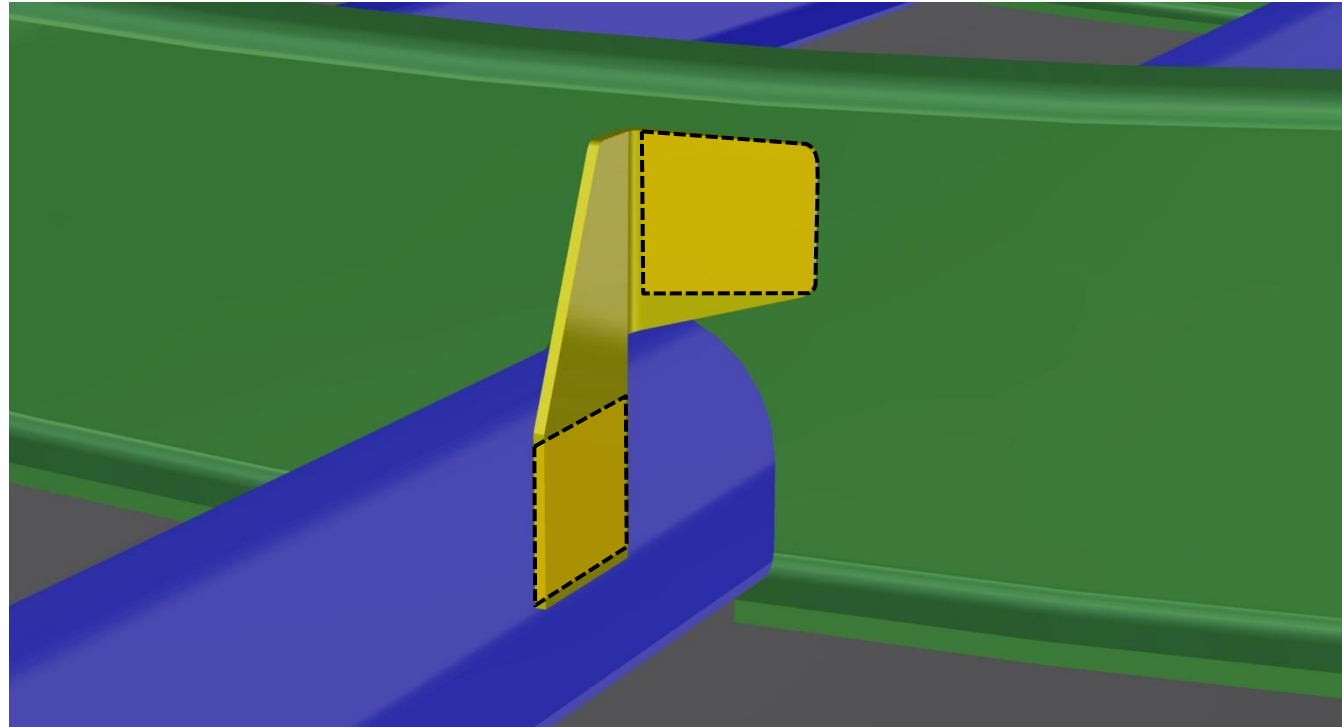
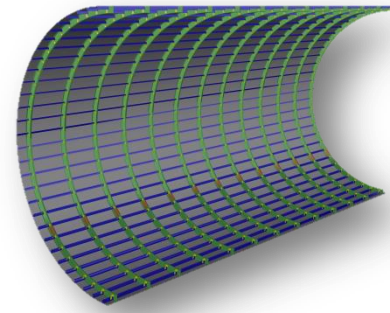
Fuselage applications for resistance welding



Frame Coupling



Fuselage applications for resistance welding



Cleat–Stringer and Cleat–Frame Joints



Test pyramid

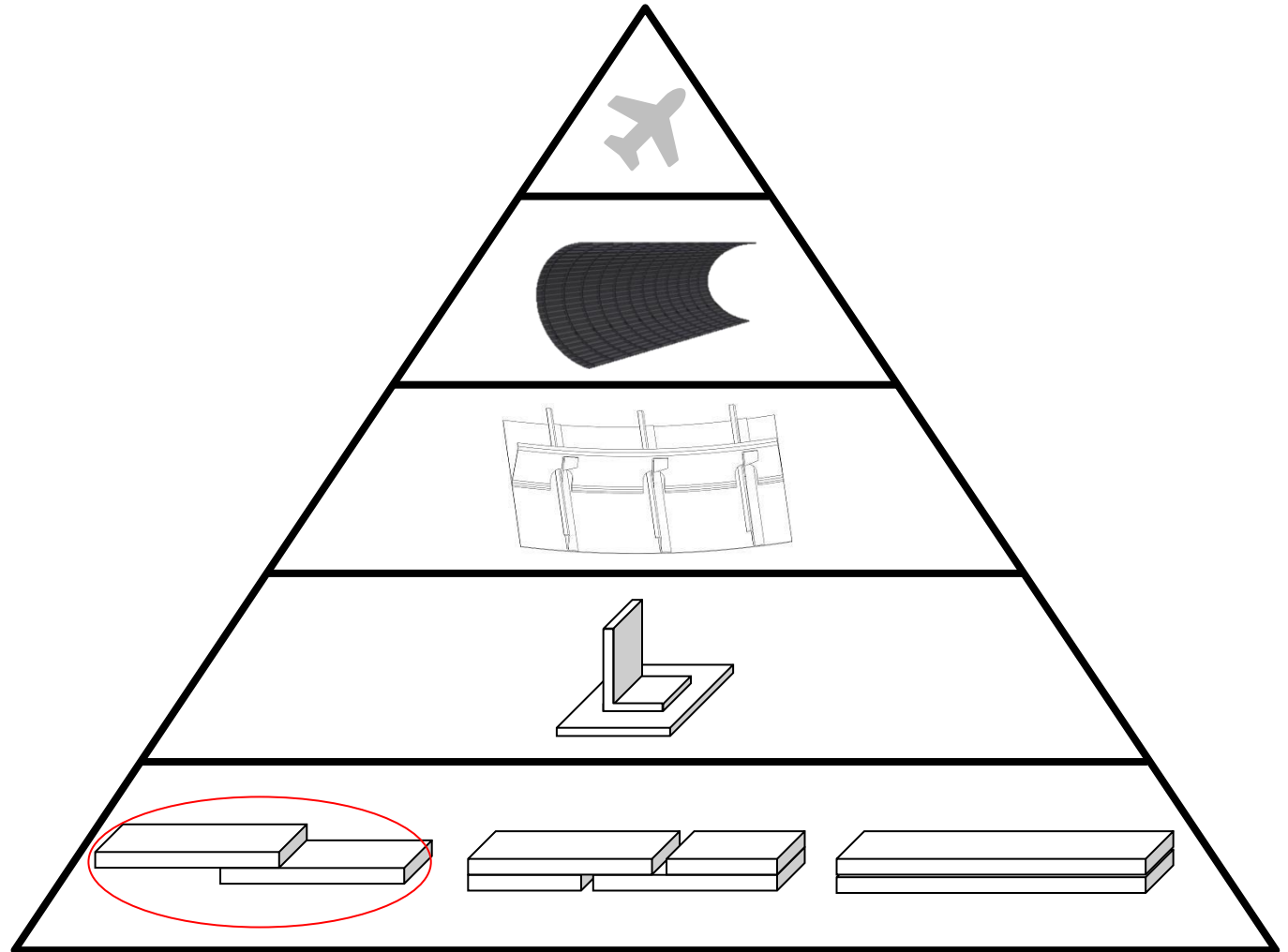
Full Scale: Airplane

Component: Fuselage

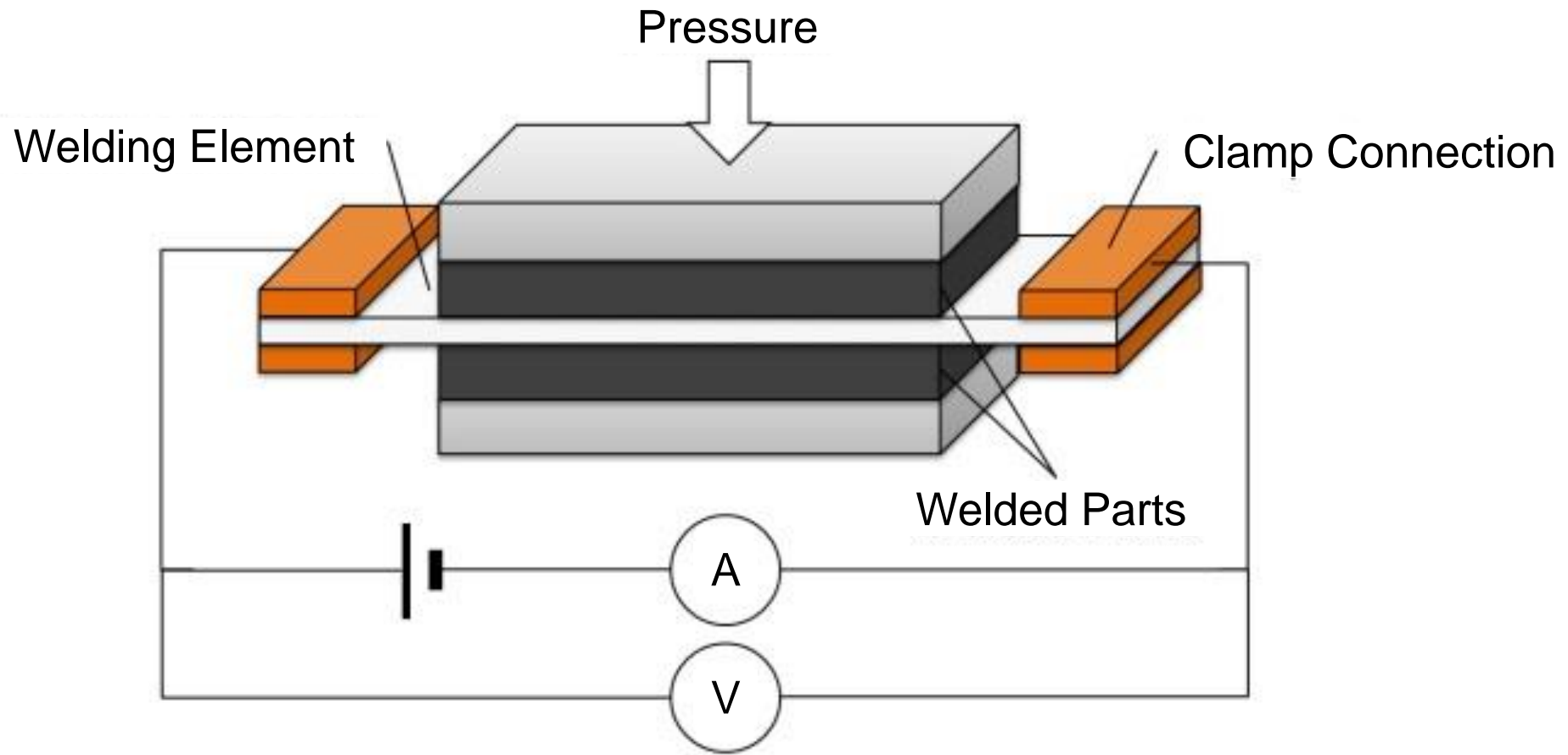
Subcomponent: Stiffened panel

Element: L-angle

Coupons: SLS, ILSS, G1C



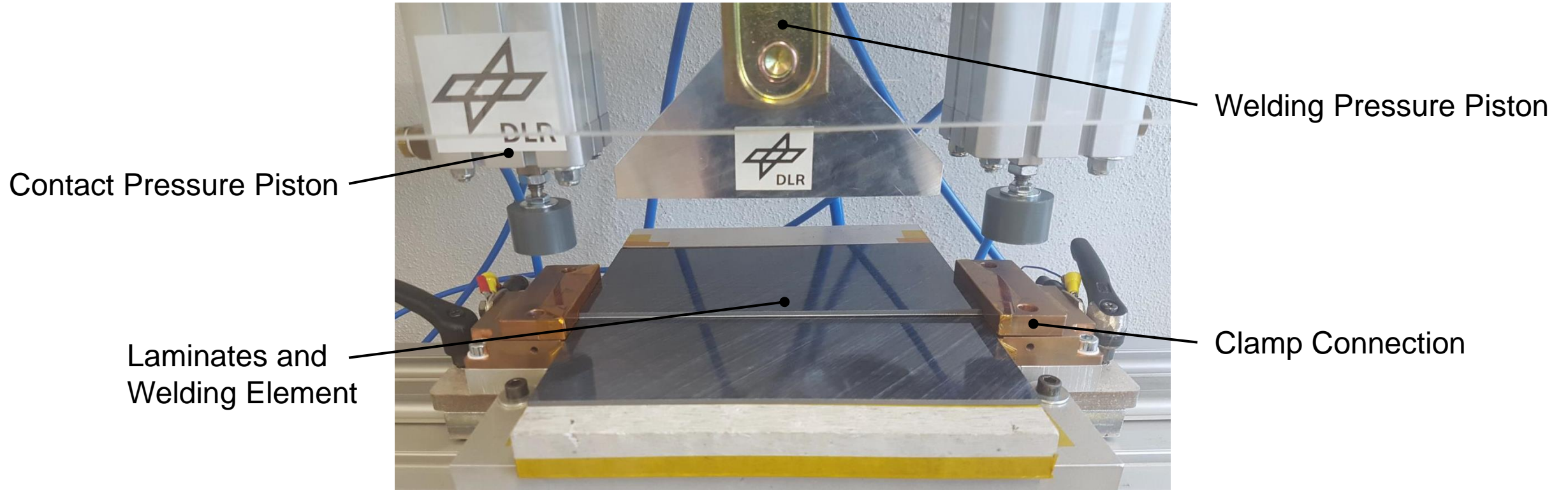
Resistance welding process



Source: D. Stavrov and H. E. N. Bersee, "Thermal Aspects in Resistance Welding of Thermoplastic Composites," 2003.



Resistance welding test rig



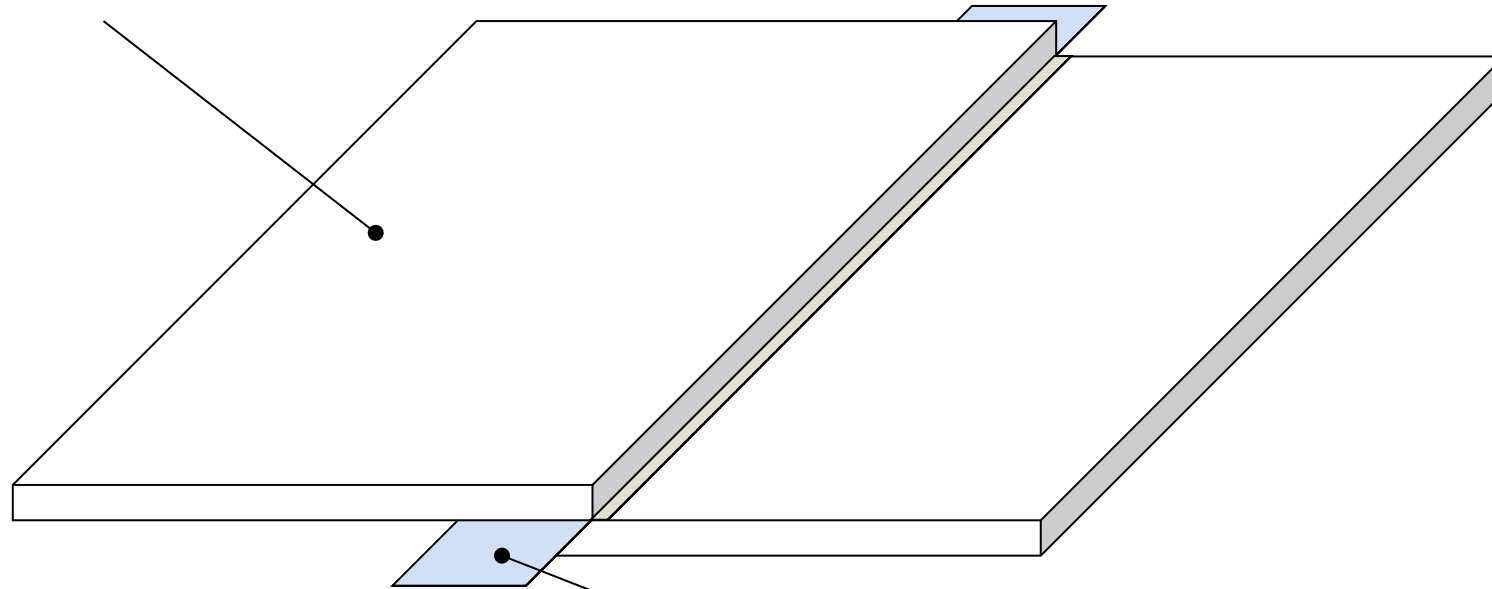
Welding components

CF LM-PAEK Laminate

L = 200 mm

W = 100 mm

T = 2,2 mm



CF/GF LM-PAEK Welding element

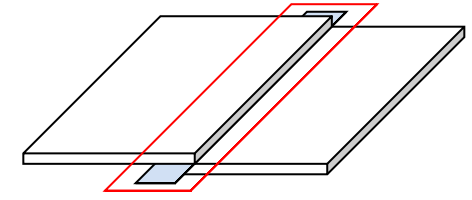
L = 260 mm

W = 25 mm

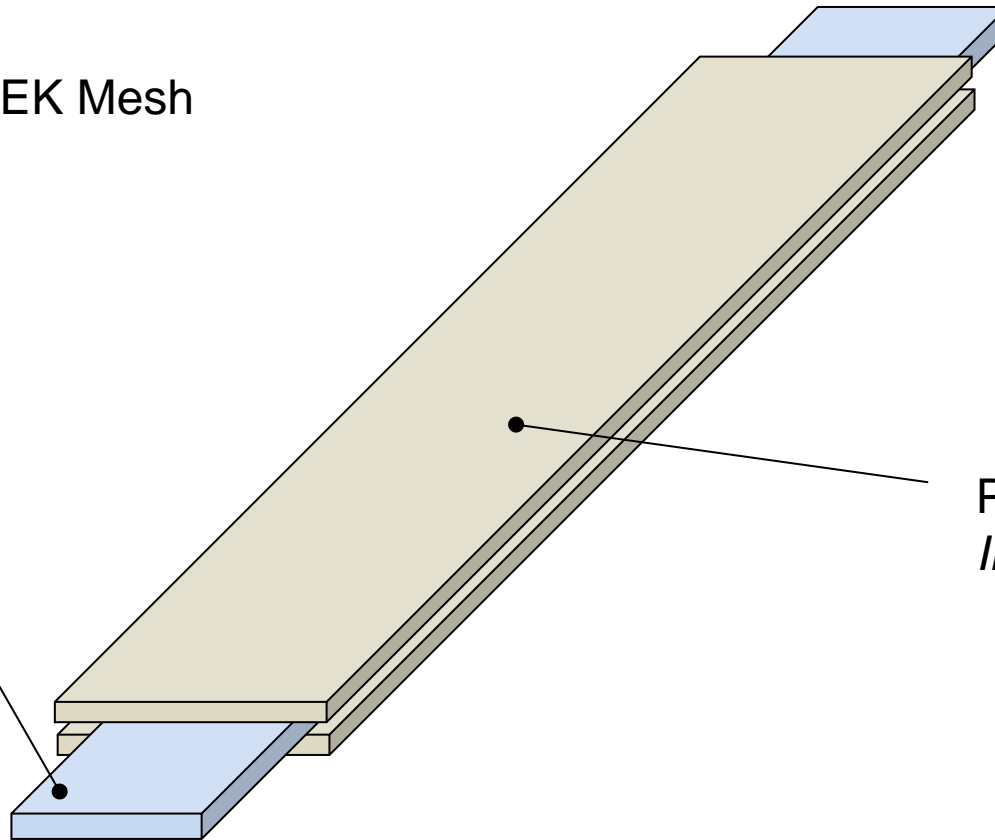
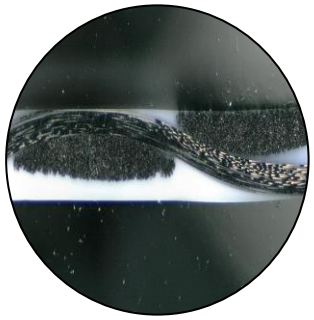
T = 0,5 mm



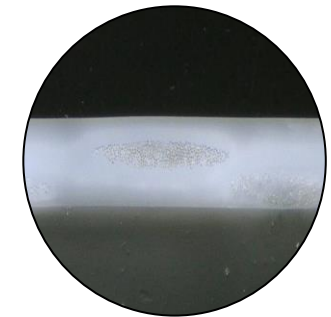
Welding element



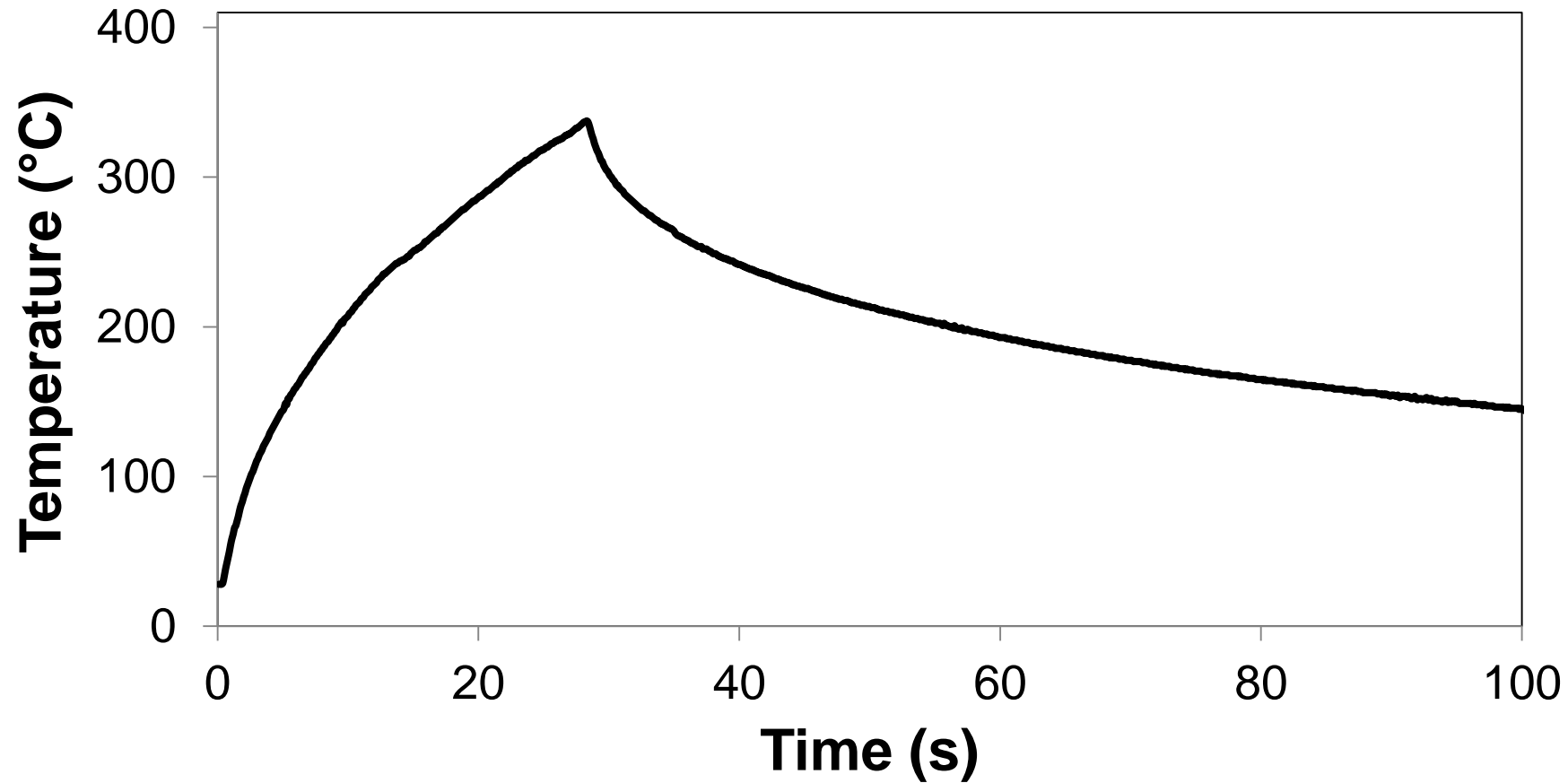
Preconsolidated CF LMPAEK Mesh
Conductor



Preconsolidated GF LMPAEK Mesh
Insulator



Welding Process: Temperature progression



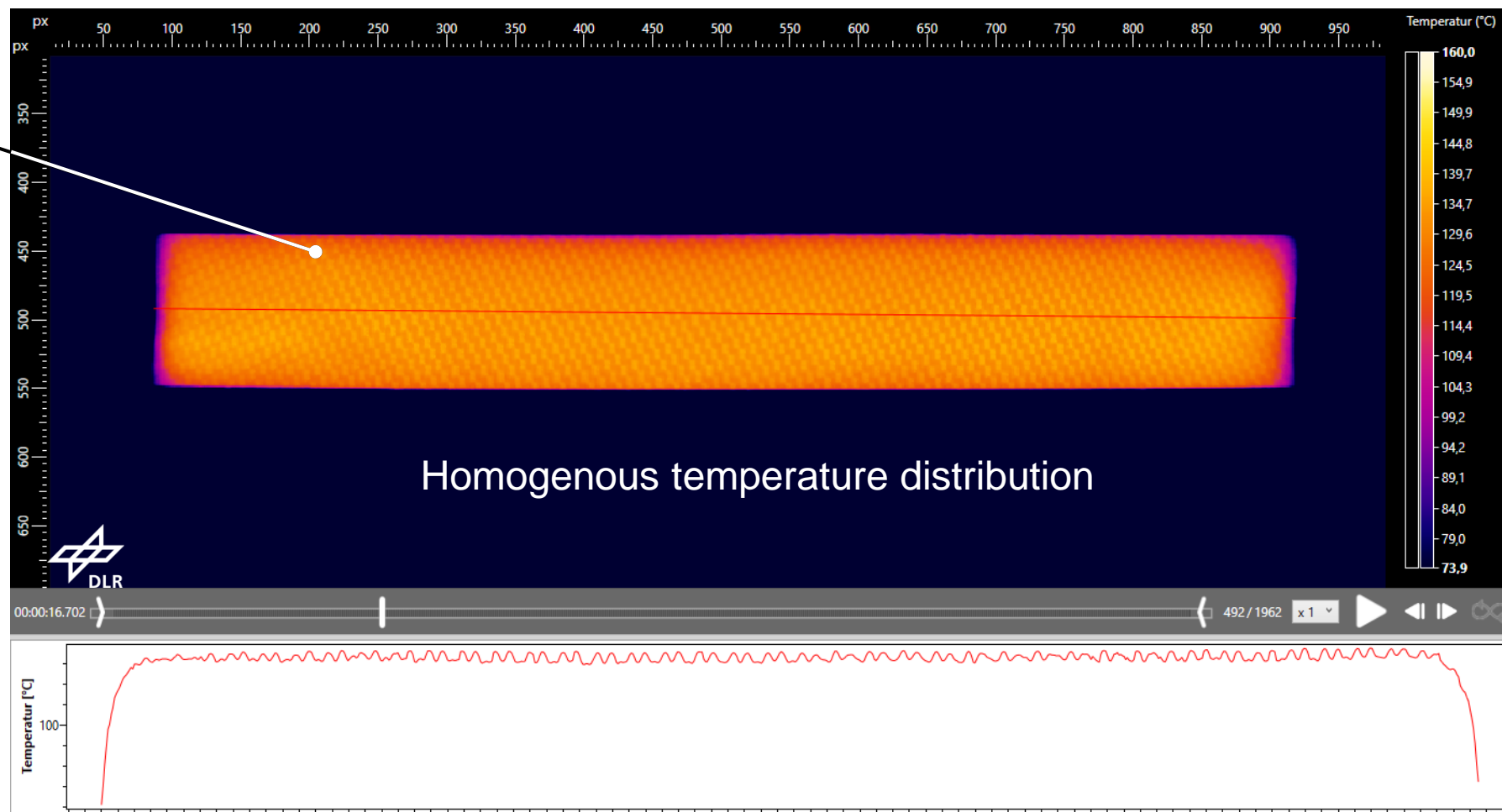
Process temperature: 335 °C

Heating time: 28 s



Welding Process: Temperature distribution

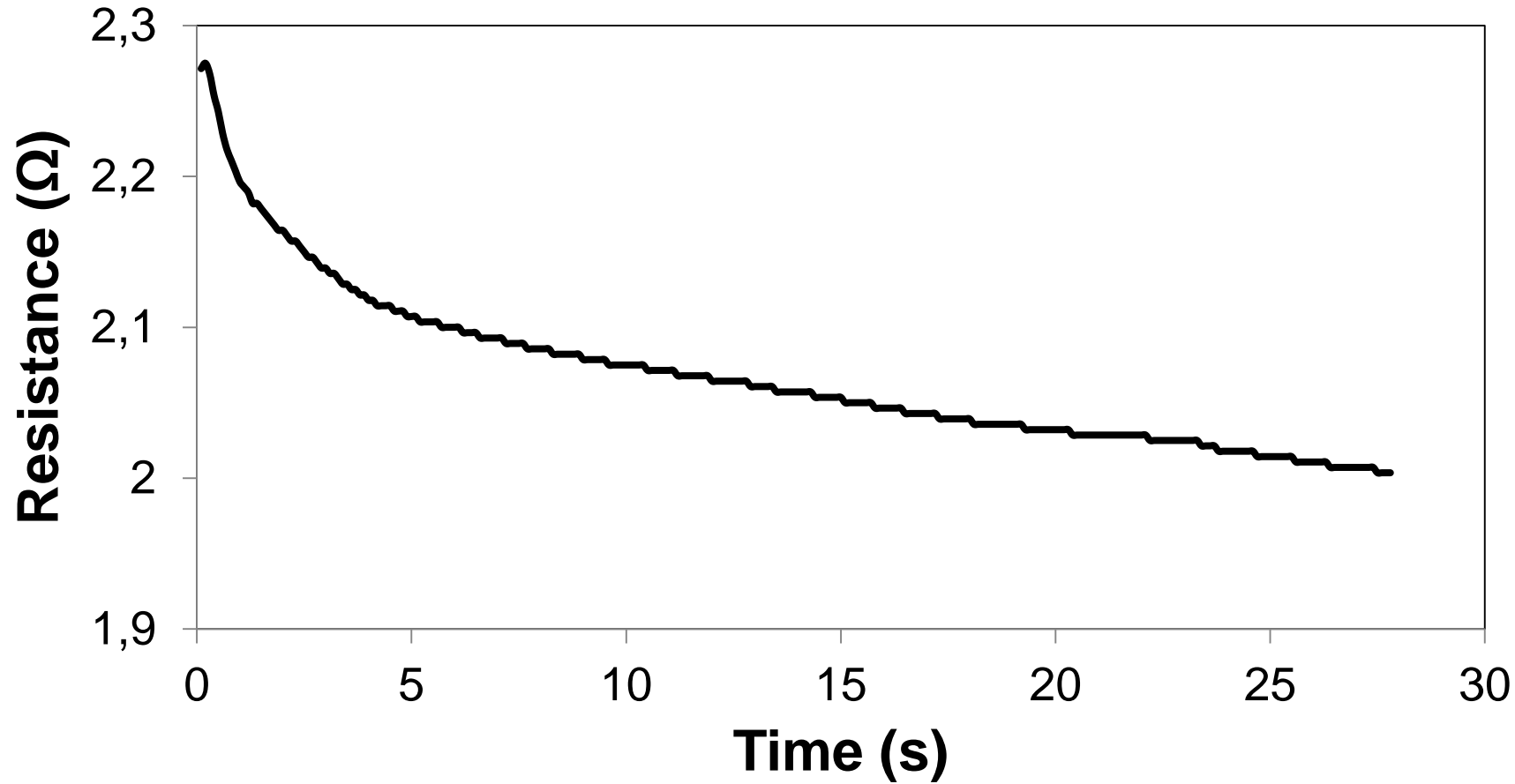
Carbon fibre fabric



compared to UD-Tapes,
fabrics show better
uniformity of
temperature distribution



Welding Process: Resistance progression

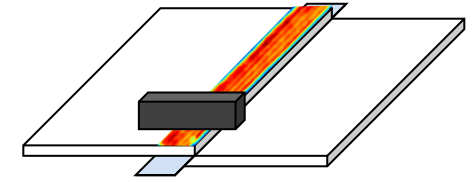


Carbon fibres =
Hot conductor

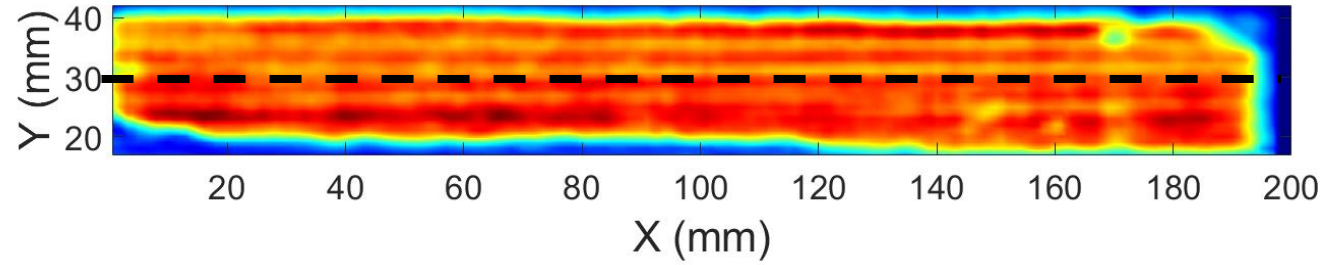
Welding element =
Temperature sensor (R~T)



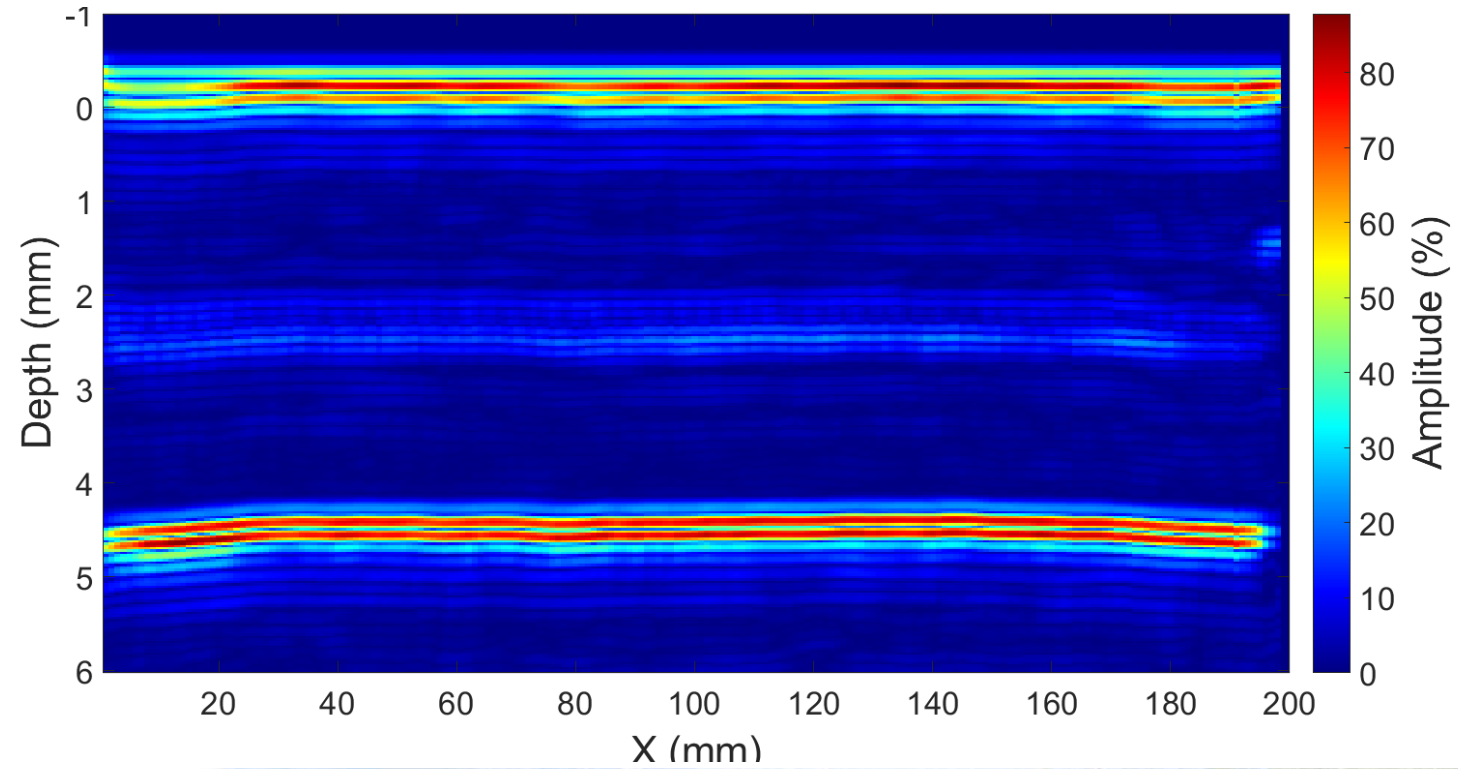
Investigation of welding area (NDT)



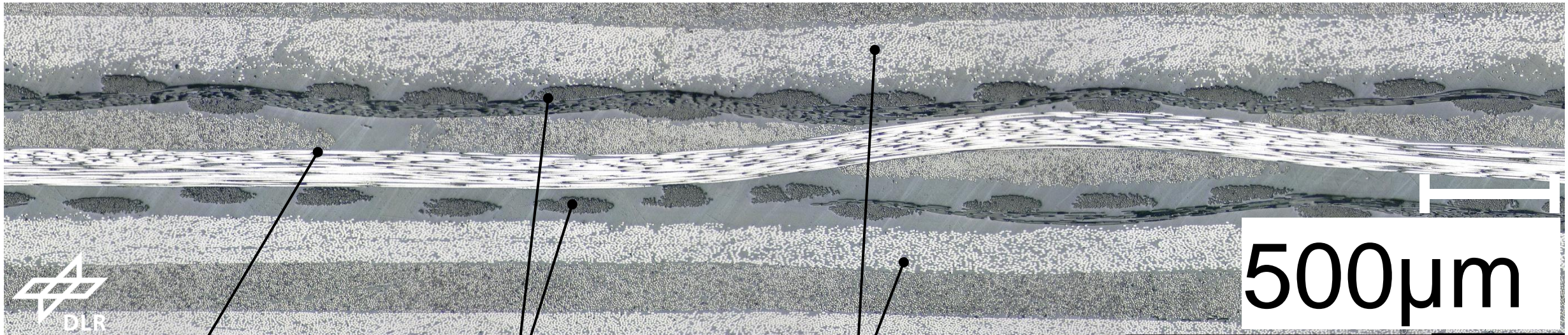
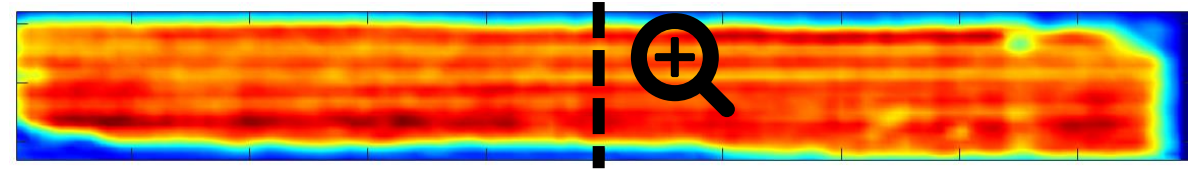
C-Scan:



B-Scan:



Investigation of welding area (cross section samples)



CF Conductor

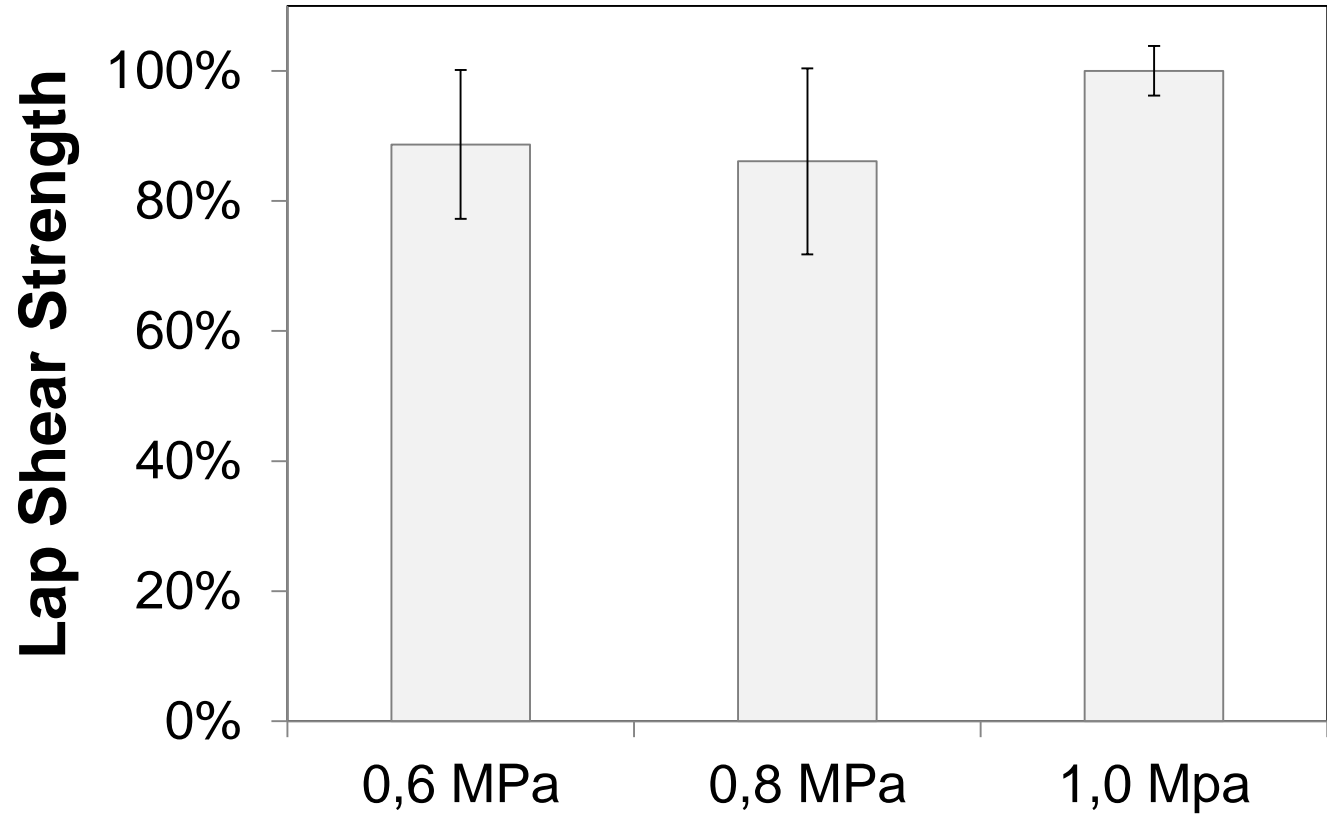
GF Insulator

Laminate



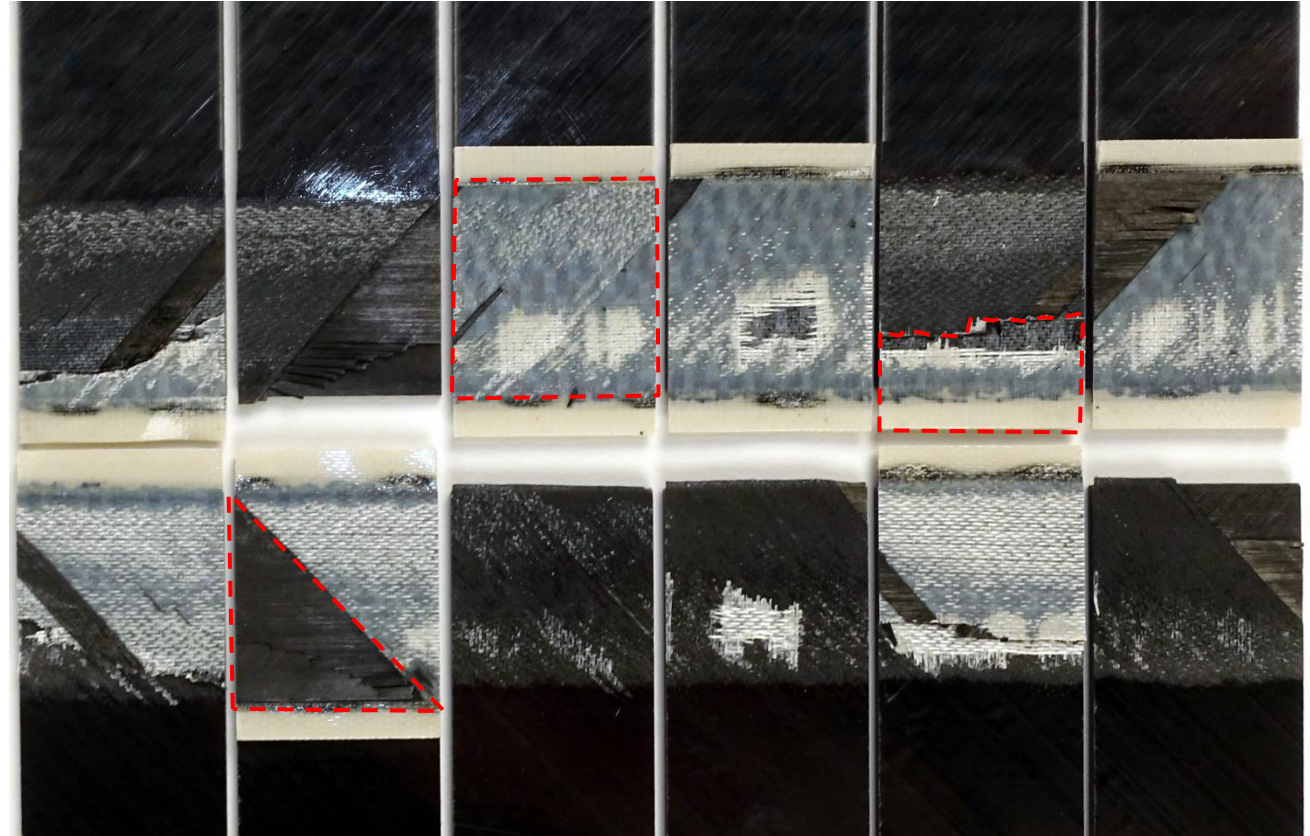
Single Lap Shear test results

- According ASTM D5868
 - Tested area: 1 sq. inch
 - In total 18 samples
- Study of different welding pressures
- Optimum at higher pressures



Fracture Surfaces

- Out of 18 samples:
 - Intralaminar failure
 - laminate: 13
 - welding element: 3
 - interfacial failure: 2



Conclusion

- Carbon fibres are suitable as conductors for the resistance welding process
- LowMelt-PAEK matrix materials can be processed ($T_m=305\text{ °C}$)
- Resistance welding process performs welds with low void content and can be used in primary structures



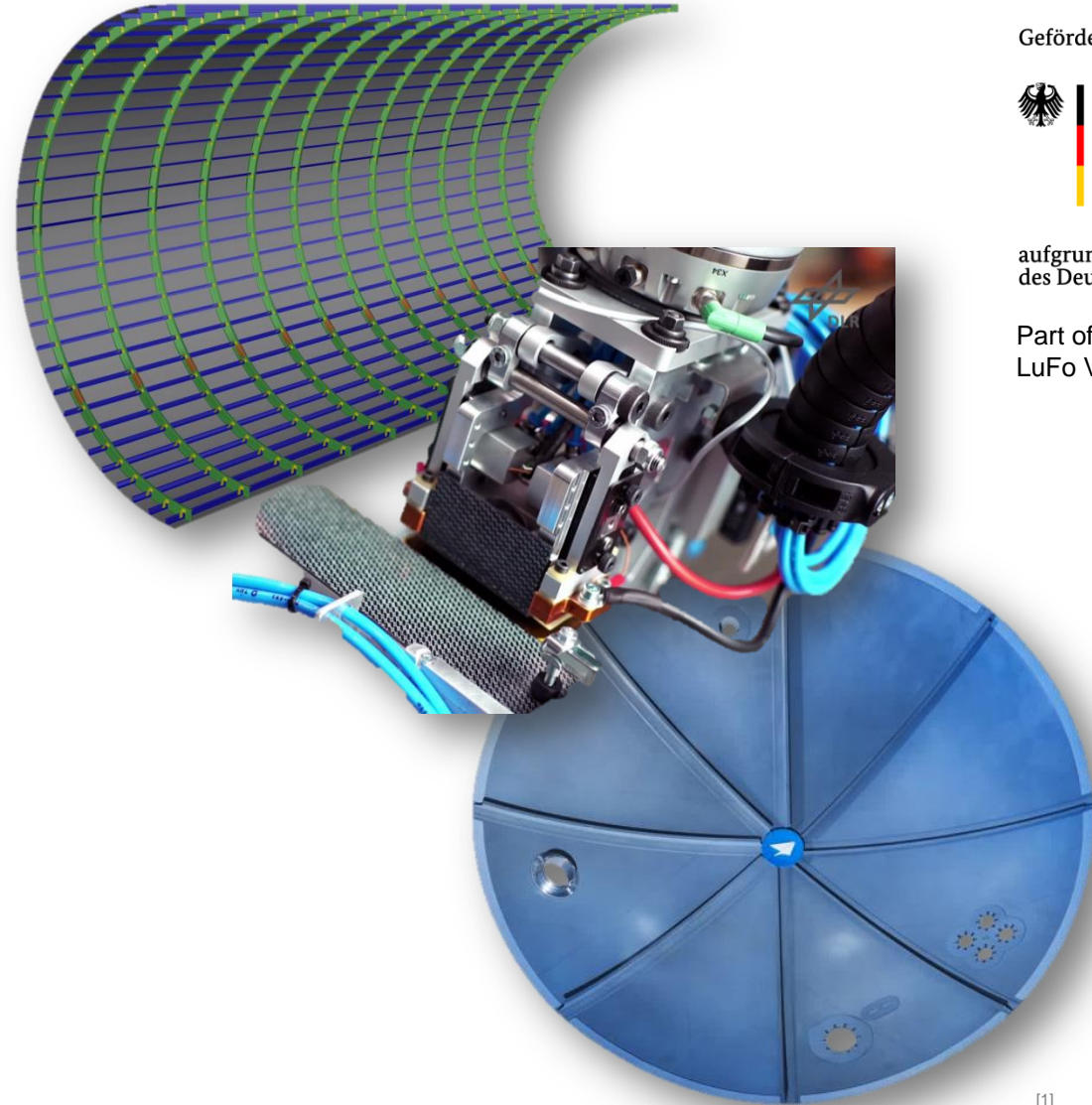
Contact

DLR
Institute of Structures and Design

Department for Component Design and
Manufacturing Technologies

Pfaffenwaldring 38 – 40
70569 Stuttgart

Simon Bauer M.Sc.
+49 711 6862 744
Simon.Bauer@dlr.de



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[1]