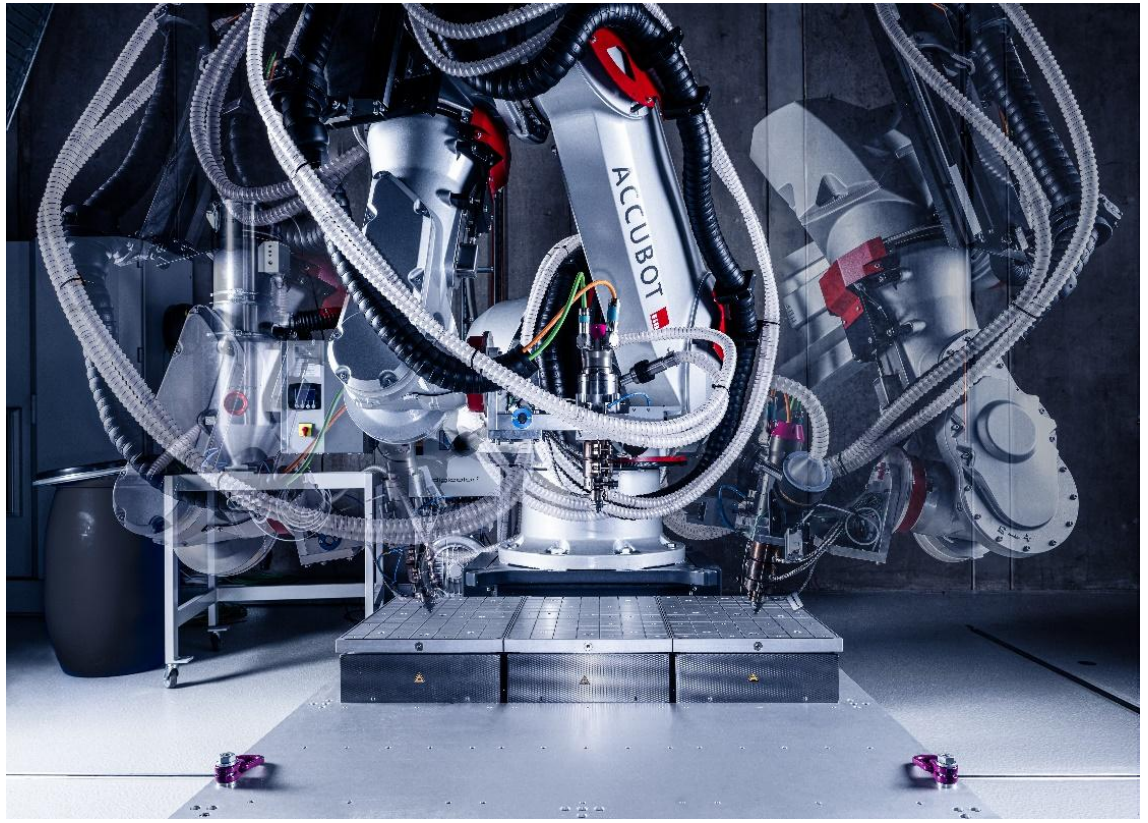
THERMOANALYSEVERFAHREN ZUR QUALITÄTSSICHERUNG IM FASERVERSTÄRKTEN 3D-DRUCK

Hochleistungstechnologie Thermoanalyse & Rheologie -- 11.06.2026 Braunschweig
Jan-Uwe R. Schmidt, Erik Johannsen, Souvik Chakraborty

DLR

Agenda

- Overview Strategic field AddCompS™
- Quality Aspects and Motivation
- Thermal Analyses to assure quality

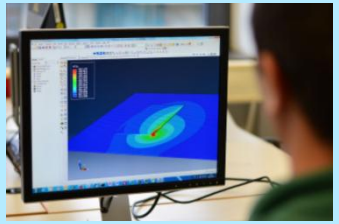


Strategic field – AddCompS™ – Additive Composite Structures

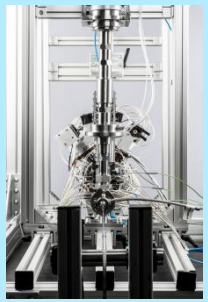


Functionalization of thermoplastics for improved performance

<< How can additive technologies contribute an added value for light weight structures >>

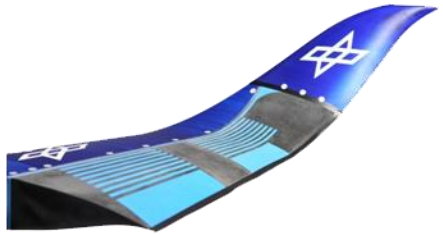


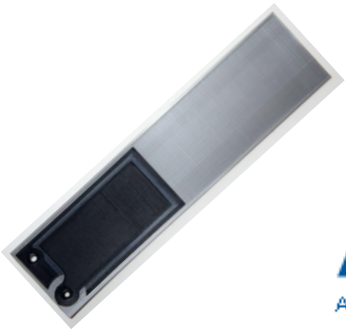
Simulation of additive Extrusion



Printing with short & endless fiber reinforced materials



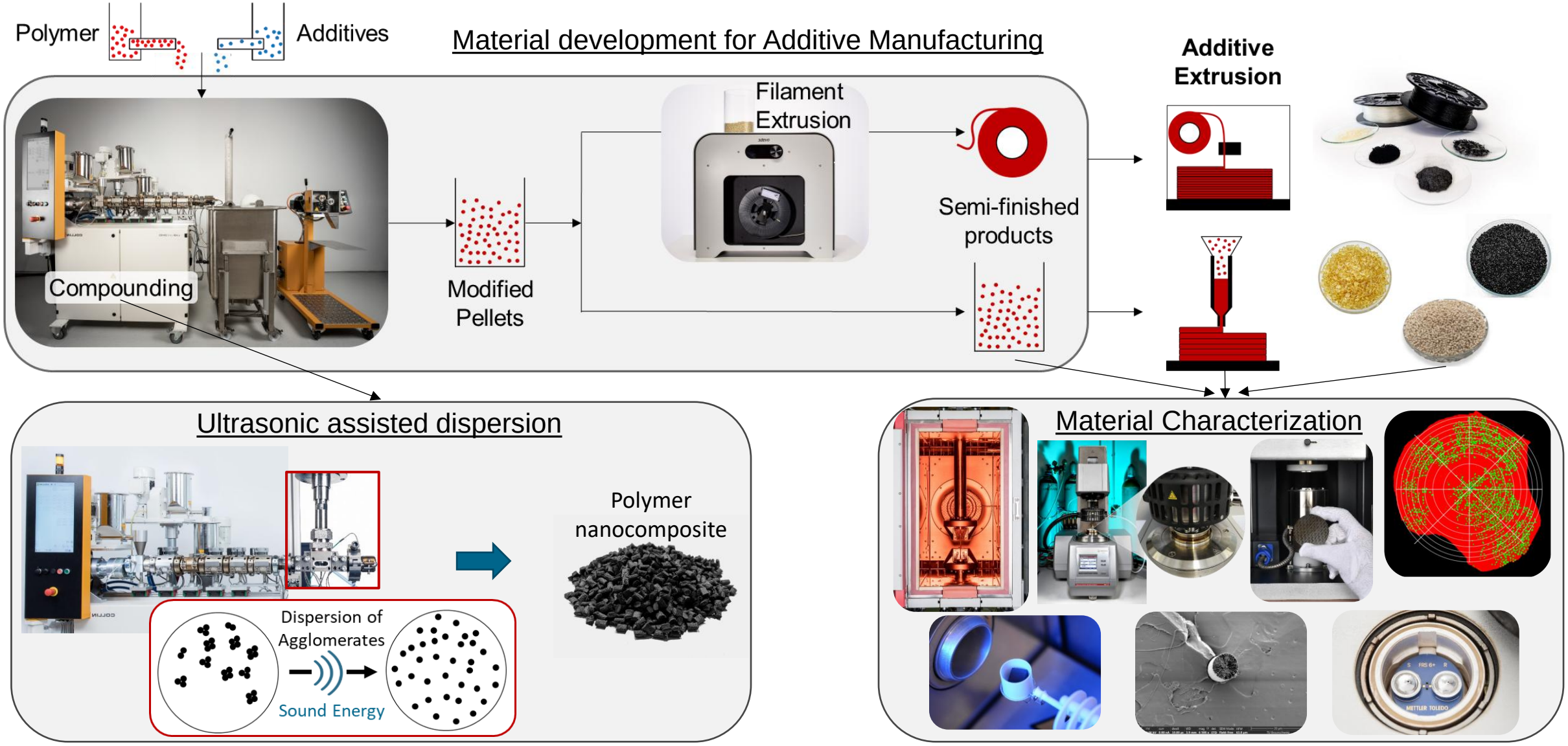




ADDITIVE EXTRUSION

- Combination of manufacturing techniques
- Printed pressure actuated cells
- Sensors printed into structures
- Innovation Lab

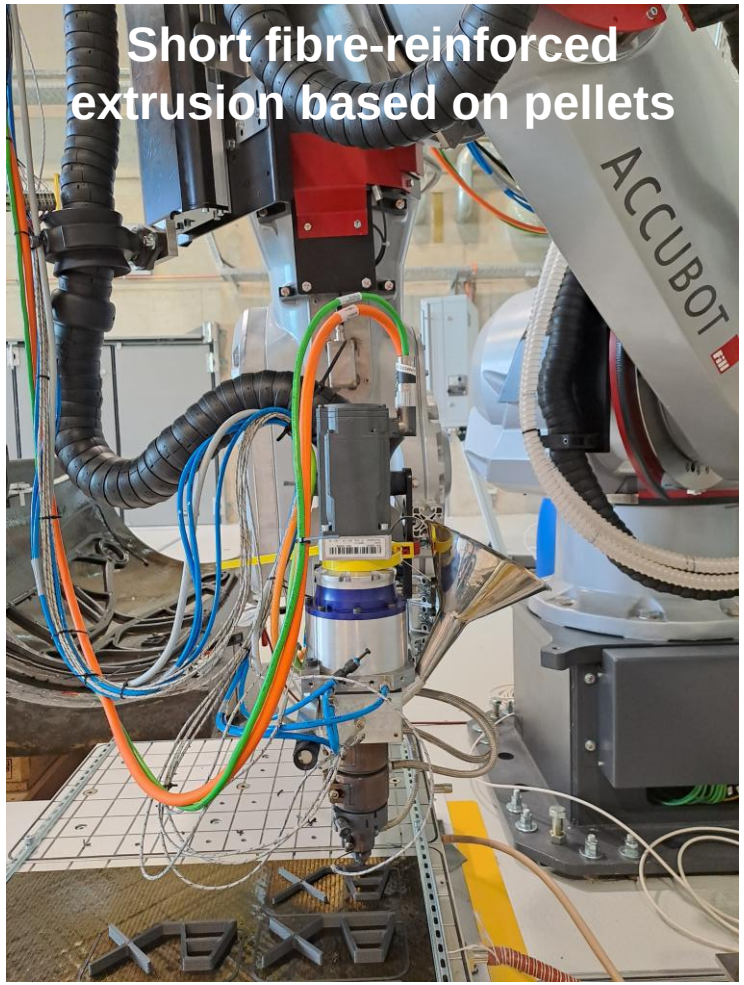
Compounding and Characterization of functionalized Materials

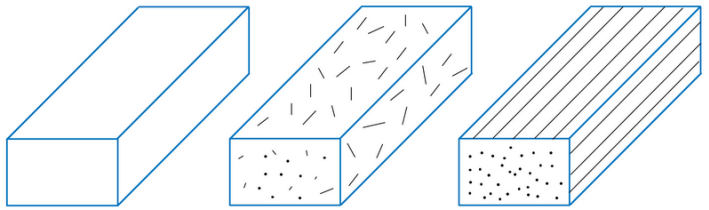


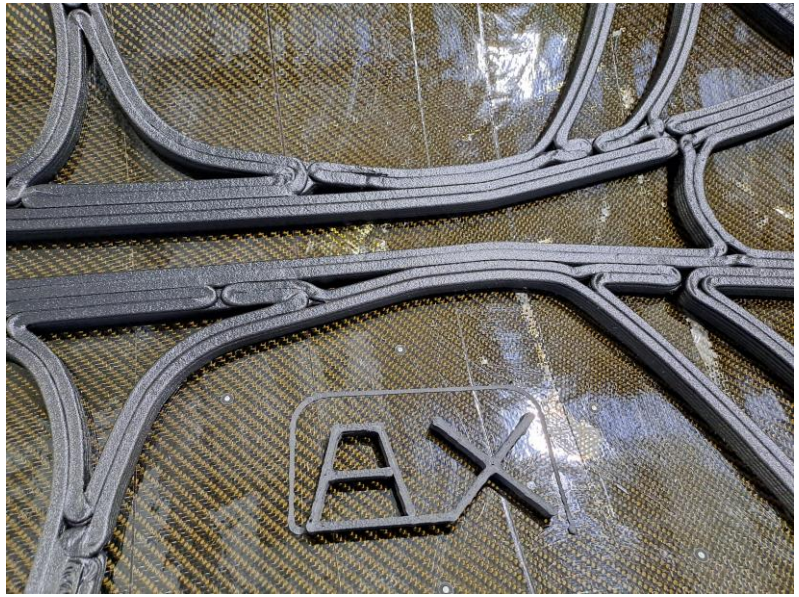
ENDLOSEFFEKT

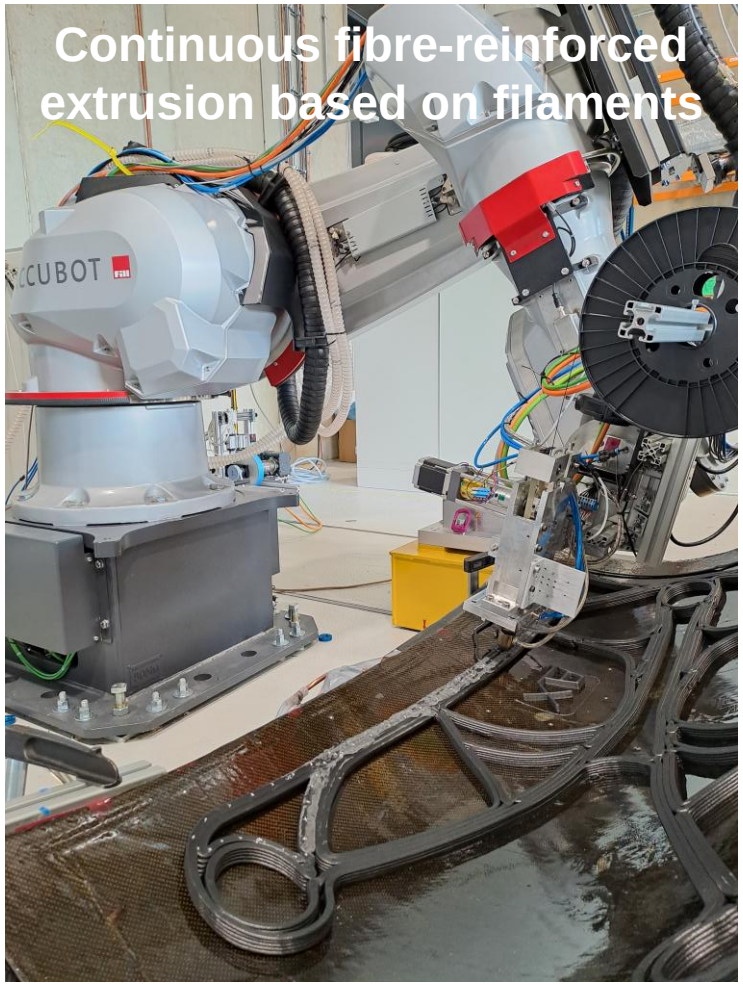


Combination of short & continuous fibre-reinforced material for Additive Functionalization of a multi-curved thermoset shell



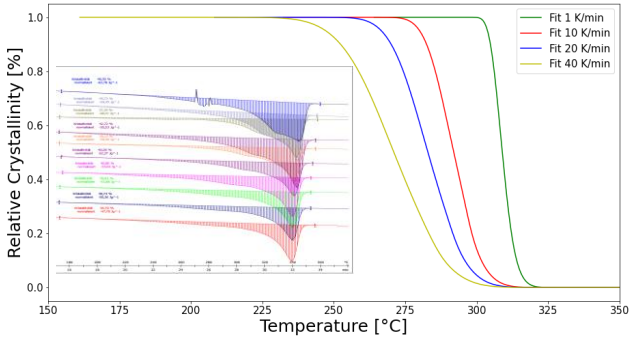




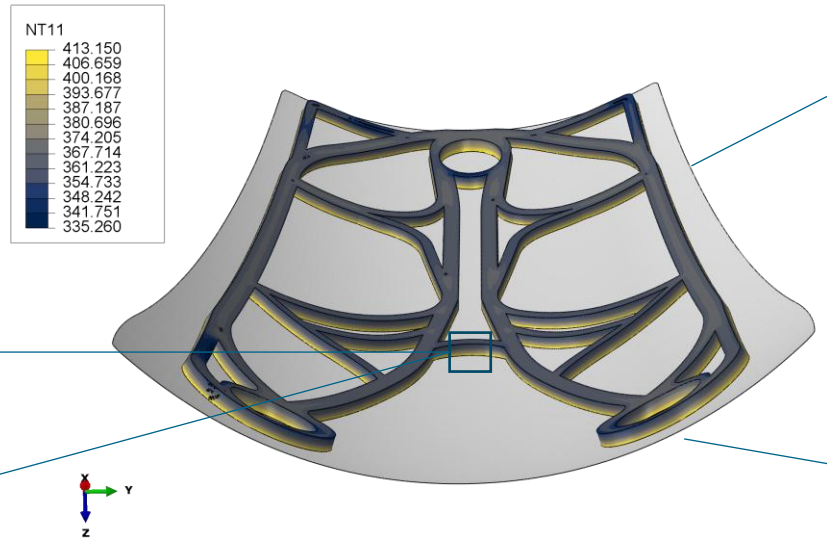


Simulation

Crystallization kinetics

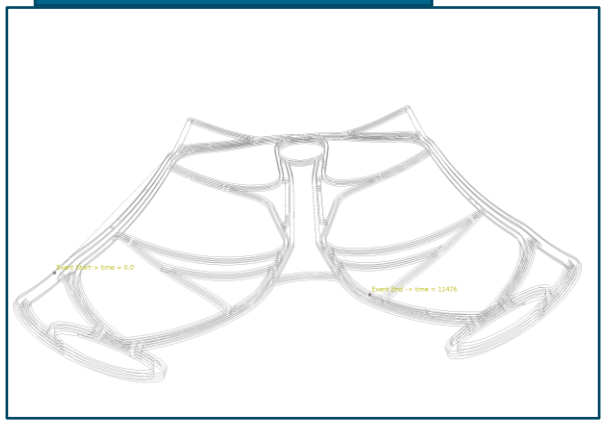


AM Process-Simulation

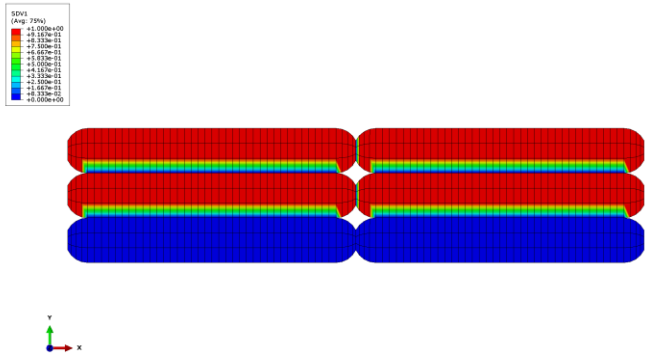


- Temperature fields
- Residual stresses
- Distortion

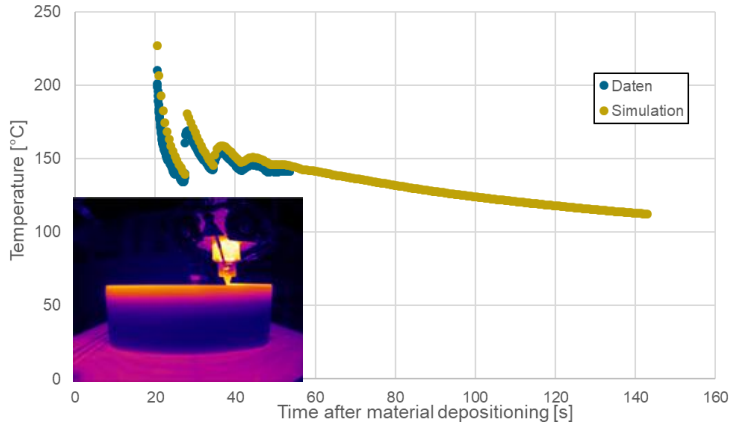
Gcode converter



Bonding strength



Validation



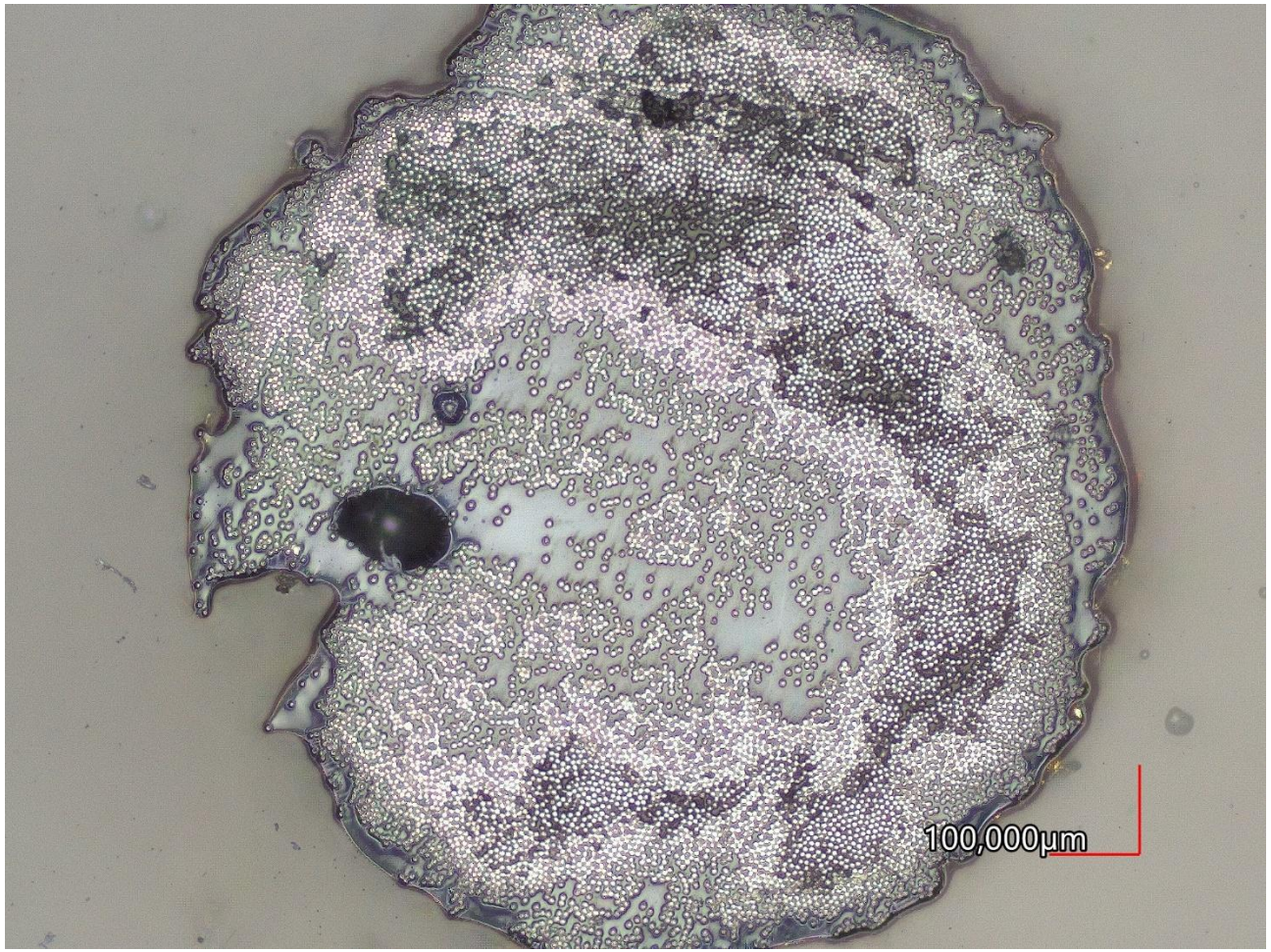


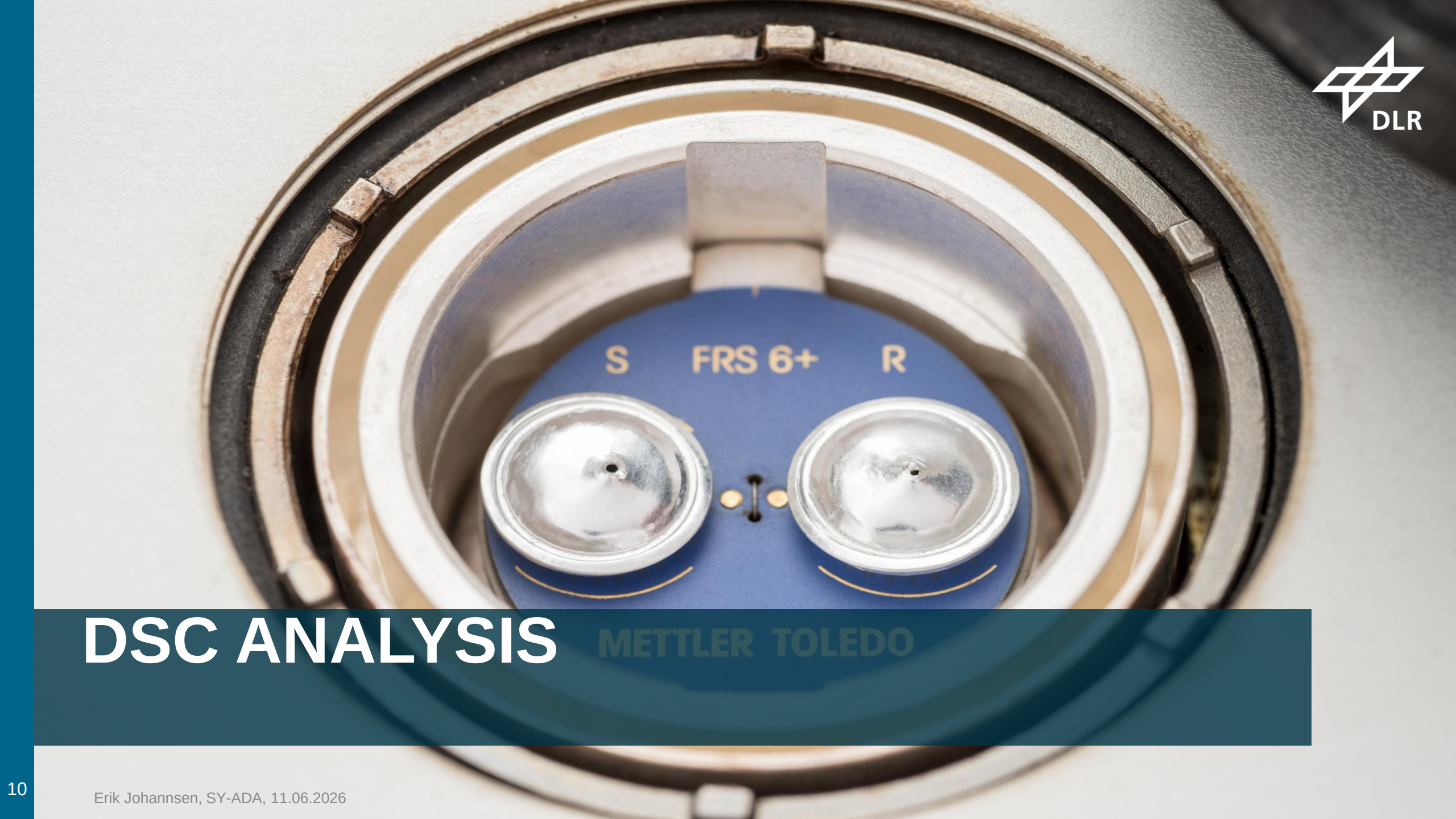
THERMAL ANALYSIS

Erik Johannsen, SY-ADA, 11.06.2026

Quality Aspects and Motivation

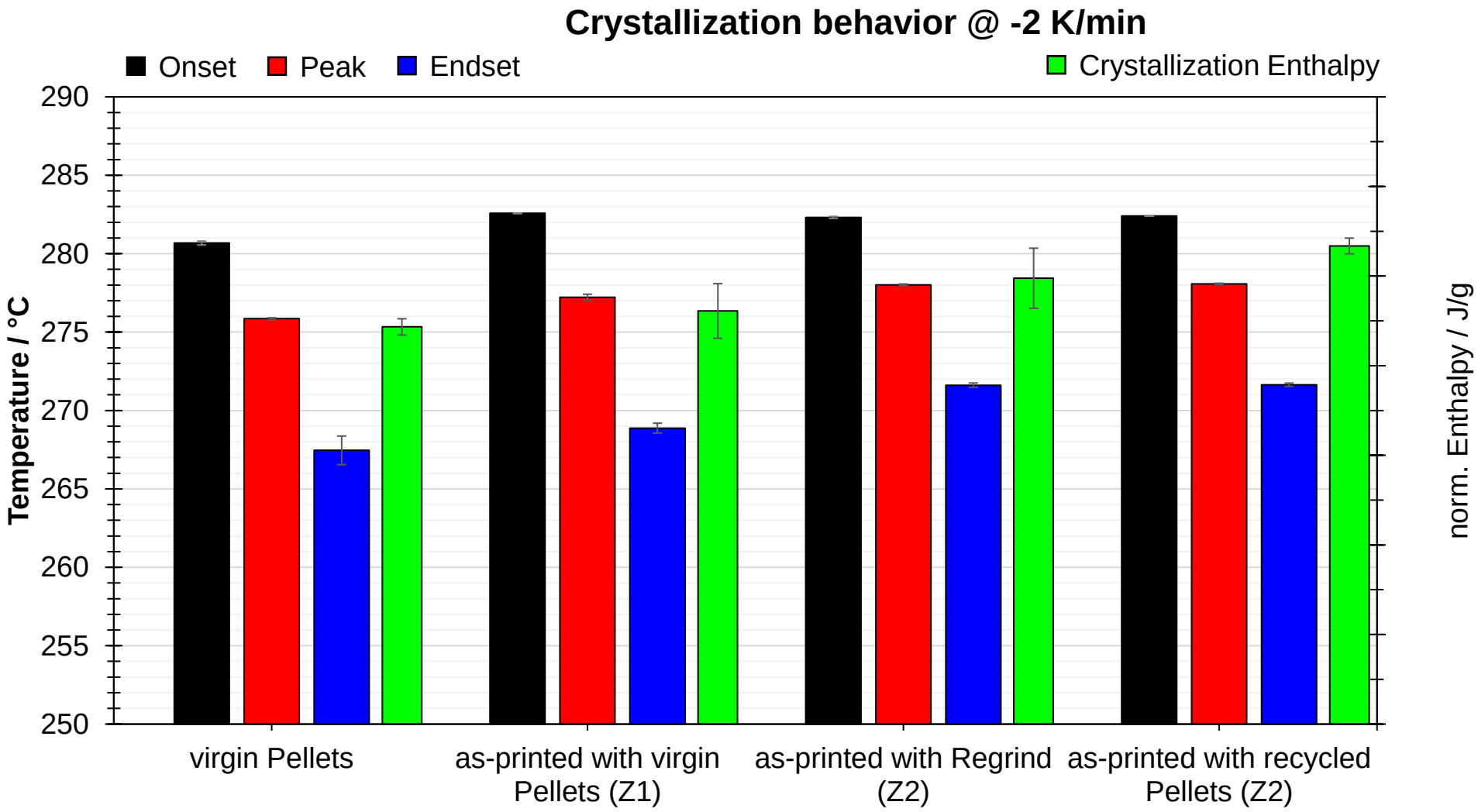
- Continuous fiber filament manufacturing:
  - Impregnation quality
  - Processability
  - Crystallinity
- Printing:
  - Interlayer bonding
  - Material integrity after thermal exposure
  - Crystallinity



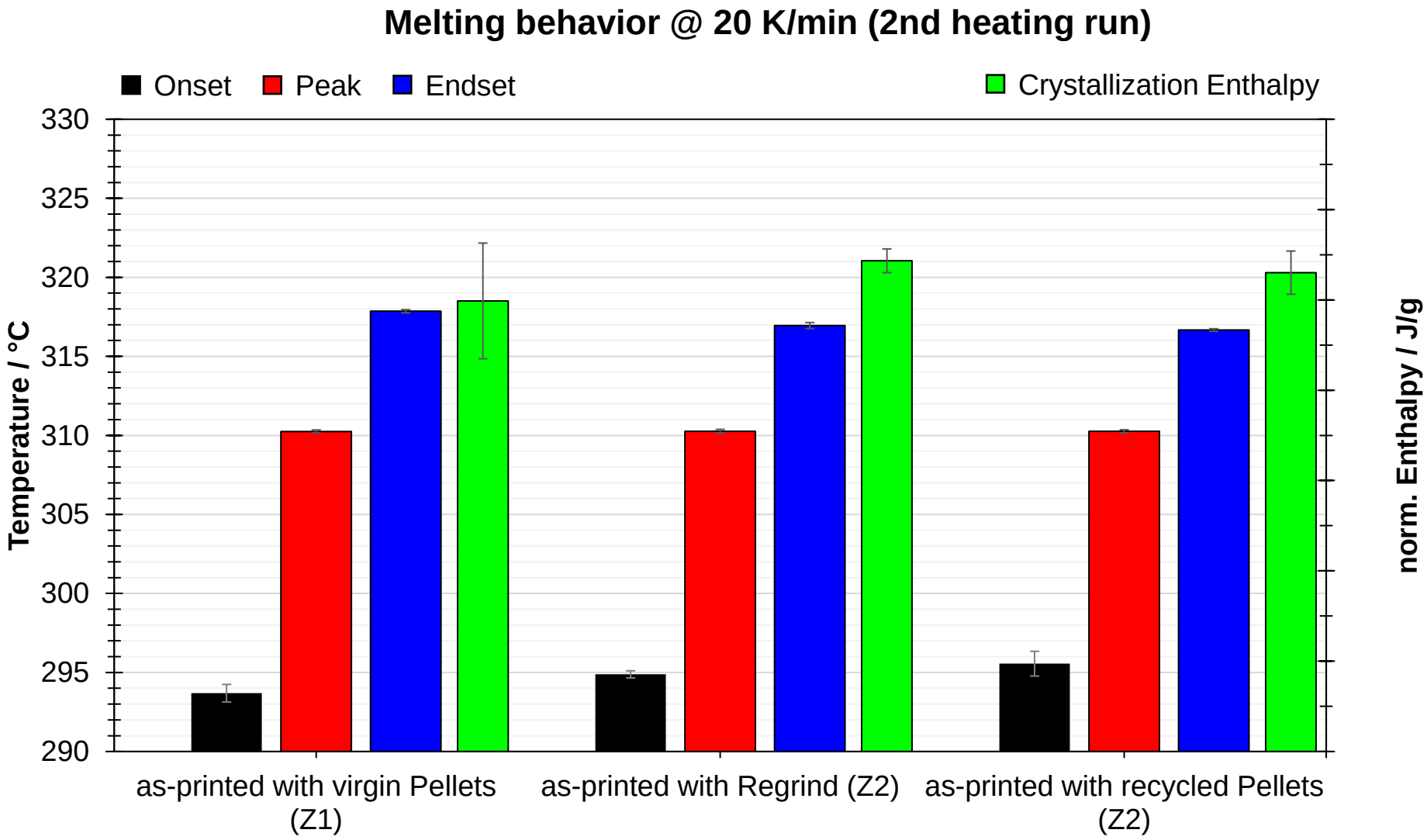


DSC ANALYSIS

DSC Analysis Results

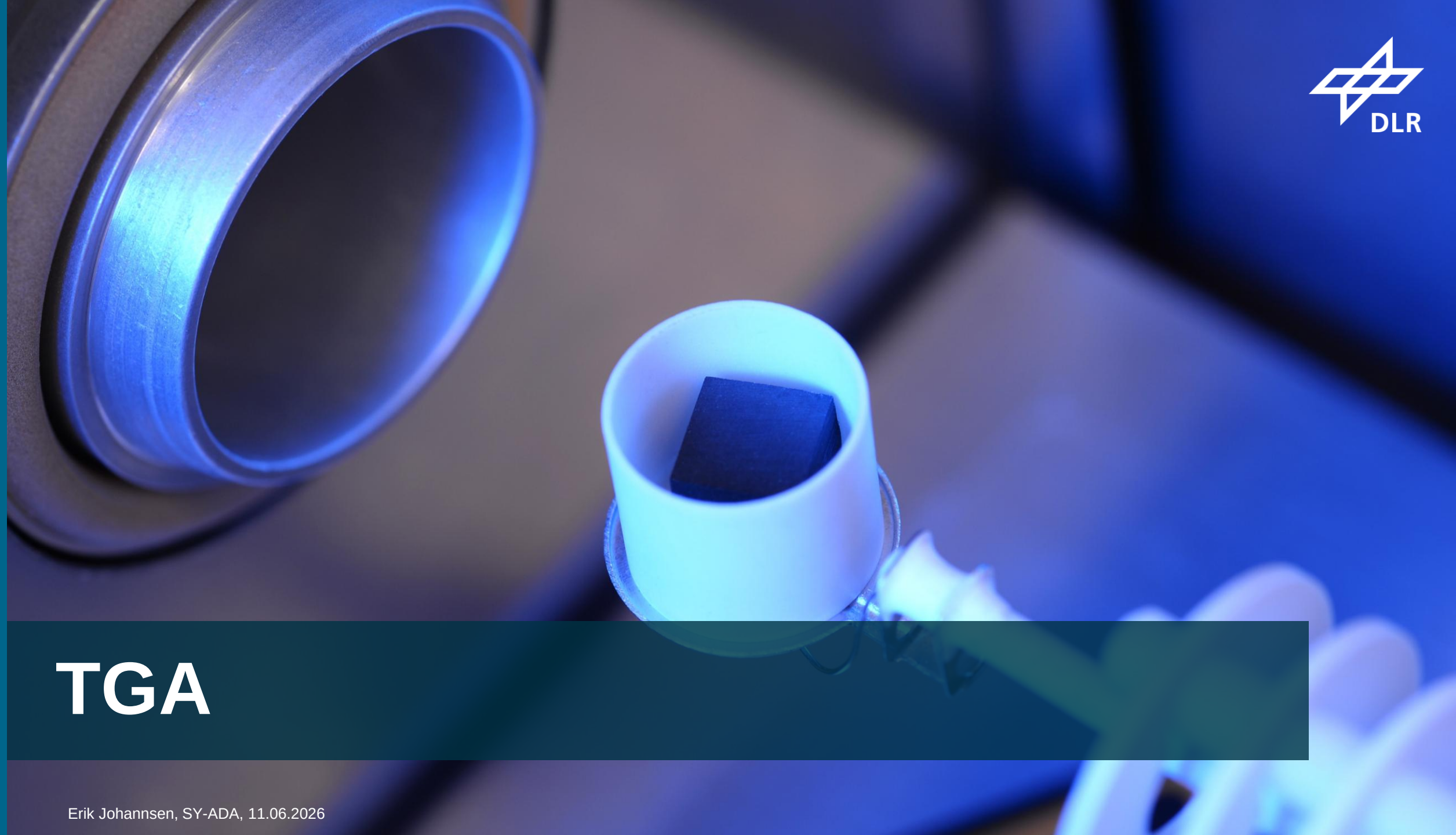


DSC Analysis Results



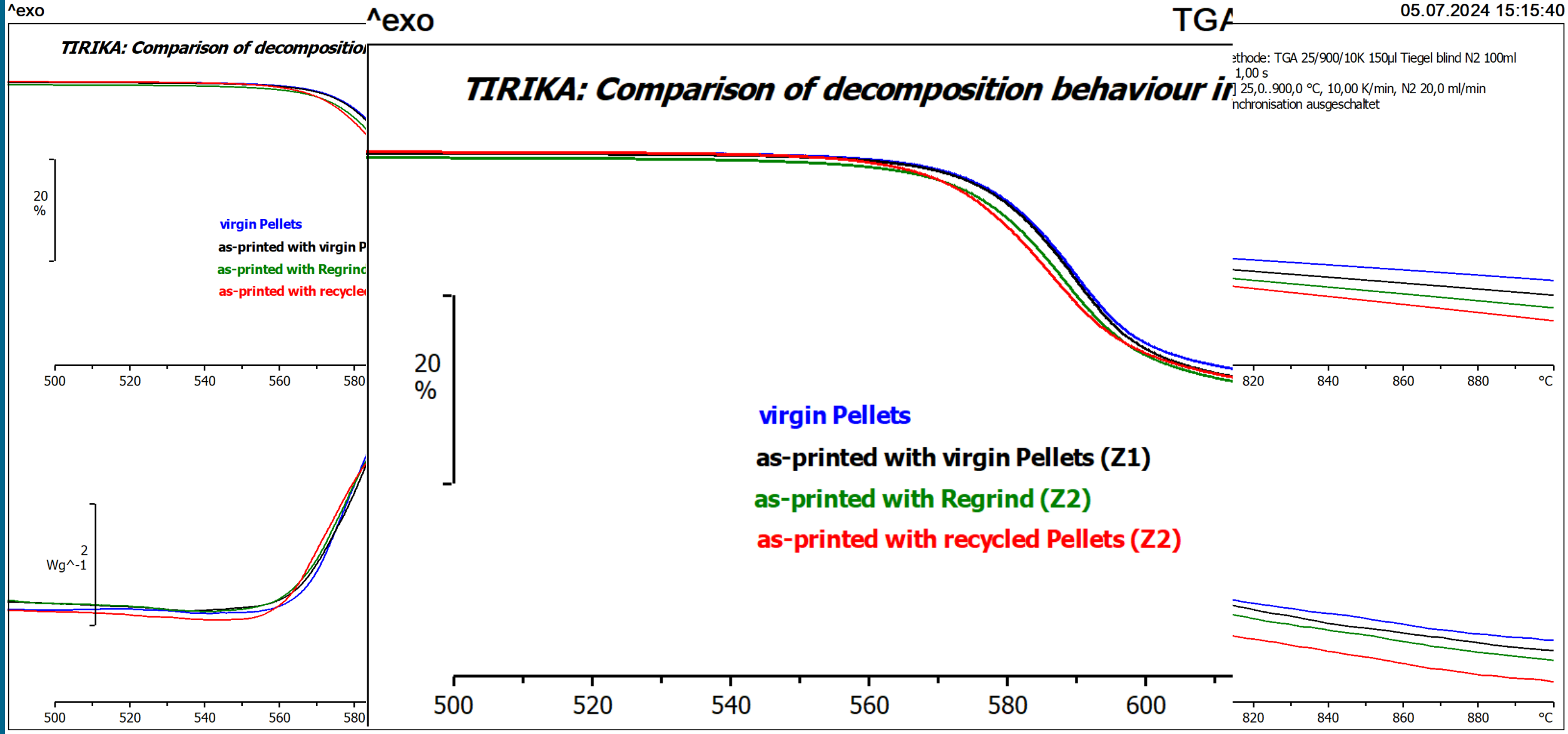
Key findings DSC

- Crystallization temperatures showed only minor differences between virgin, regrind and recycled materials.
- Melting behavior remained largely unchanged after processing.
- Comparable enthalpies indicate similar crystalline structures.
- DSC indicates comparable thermal behavior of recycled feedstocks.



TGA

TGA Results


^exo
TIRIKA: Comparison of decomposition behaviour in
20
%
virgin Pellets
as-printed with virgin Pellets (Z1)
as-printed with Regrind (Z2)
as-printed with recycled Pellets (Z2)
500
520
540
560
580
600
2
Wg^-1
820
840
860
880
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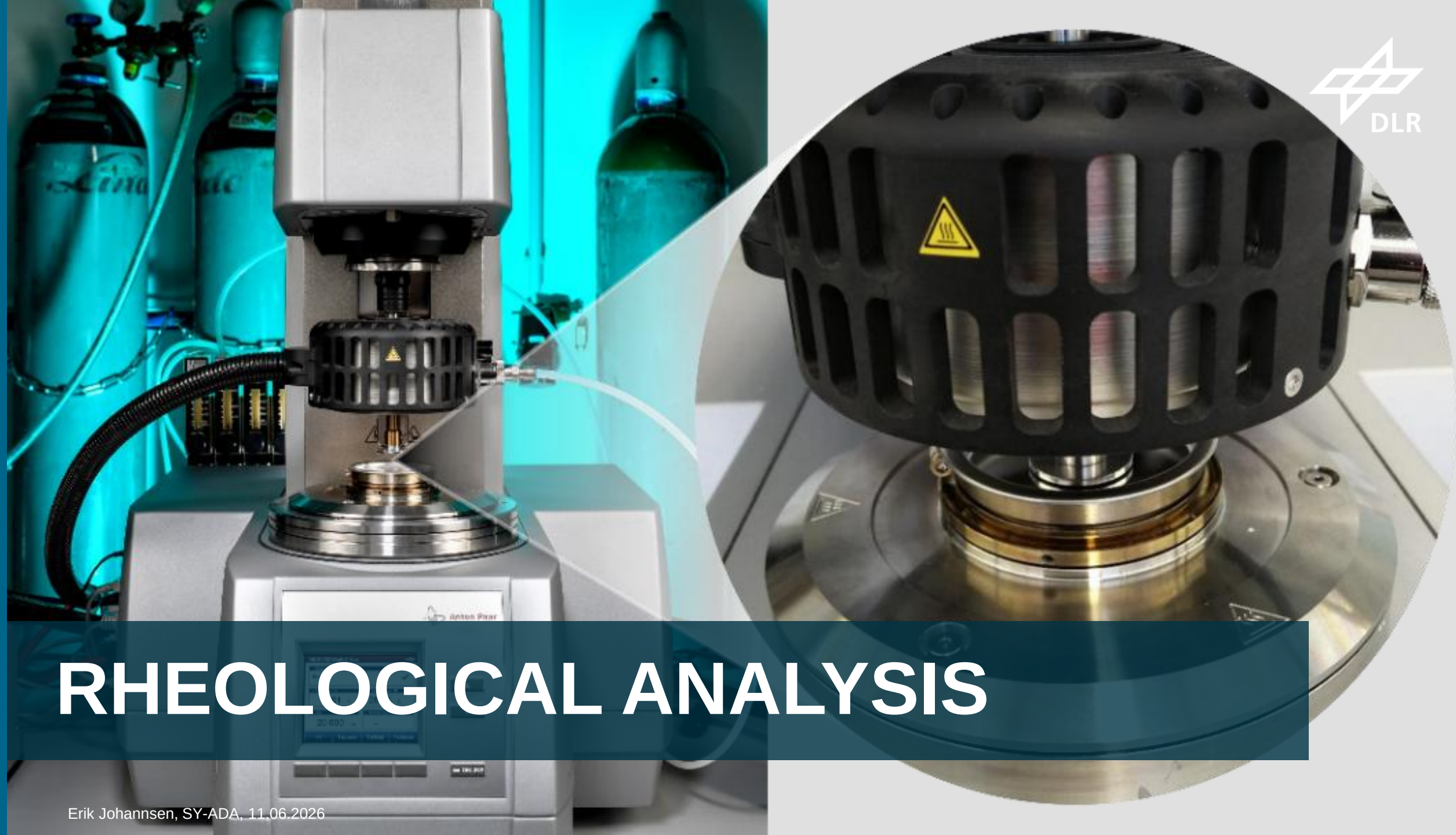
05.07.2024 15:15:40
ethode: TGA 25/900/10K 150µl Tiegel blind N2 100ml
1,00 s
25,0..900,0 °C, 10,00 K/min, N2 20,0 ml/min
nchronisation ausgeschaltet

Key findings TGA

- TGA enables determination of fiber and matrix content.
- Thermal stability can be assessed under defined conditions.
- Material composition can be verified after processing.
- TGA provides an efficient tool for feedstock quality control.

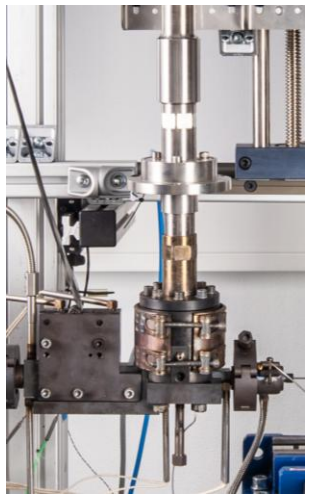


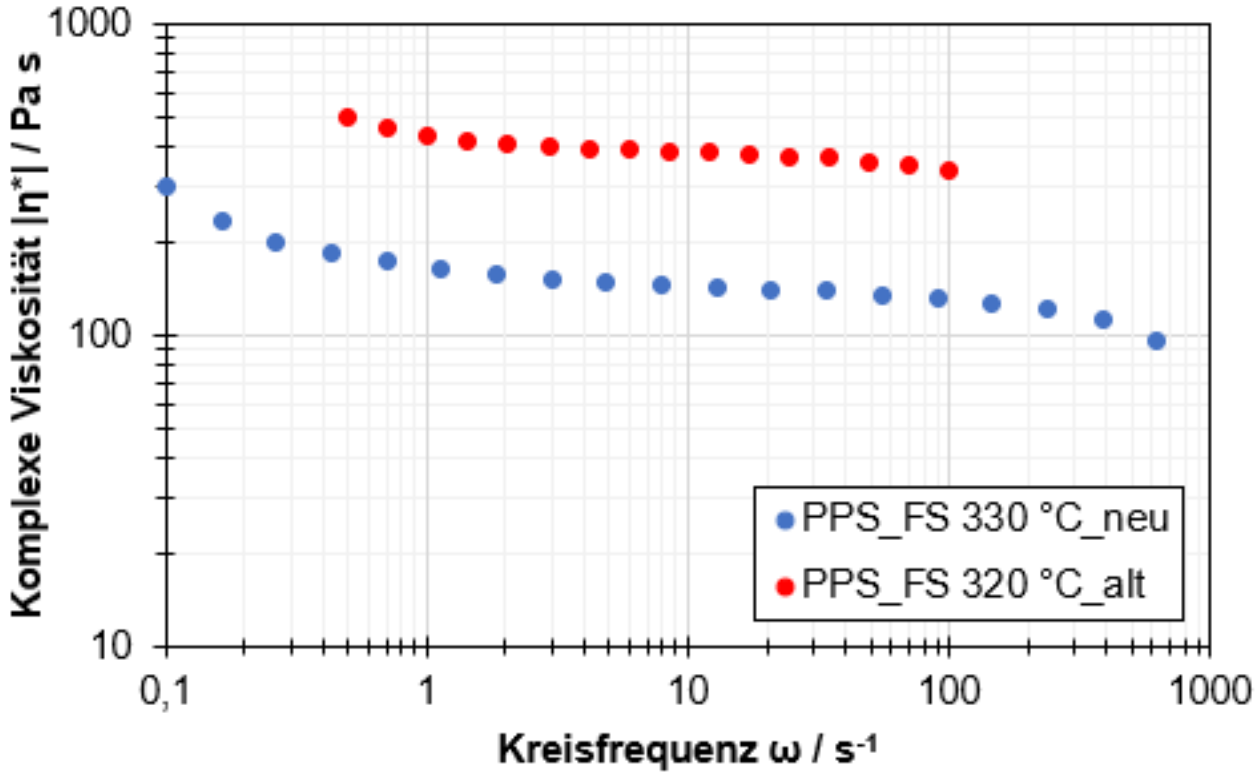
RHEOLOGICAL ANALYSIS

Shear-Dependent Viscosity

- Pronounced shear-thinning behavior observed
- Flow characteristics strongly depend on shear rate
- Relevant for impregnation and extrusion performance

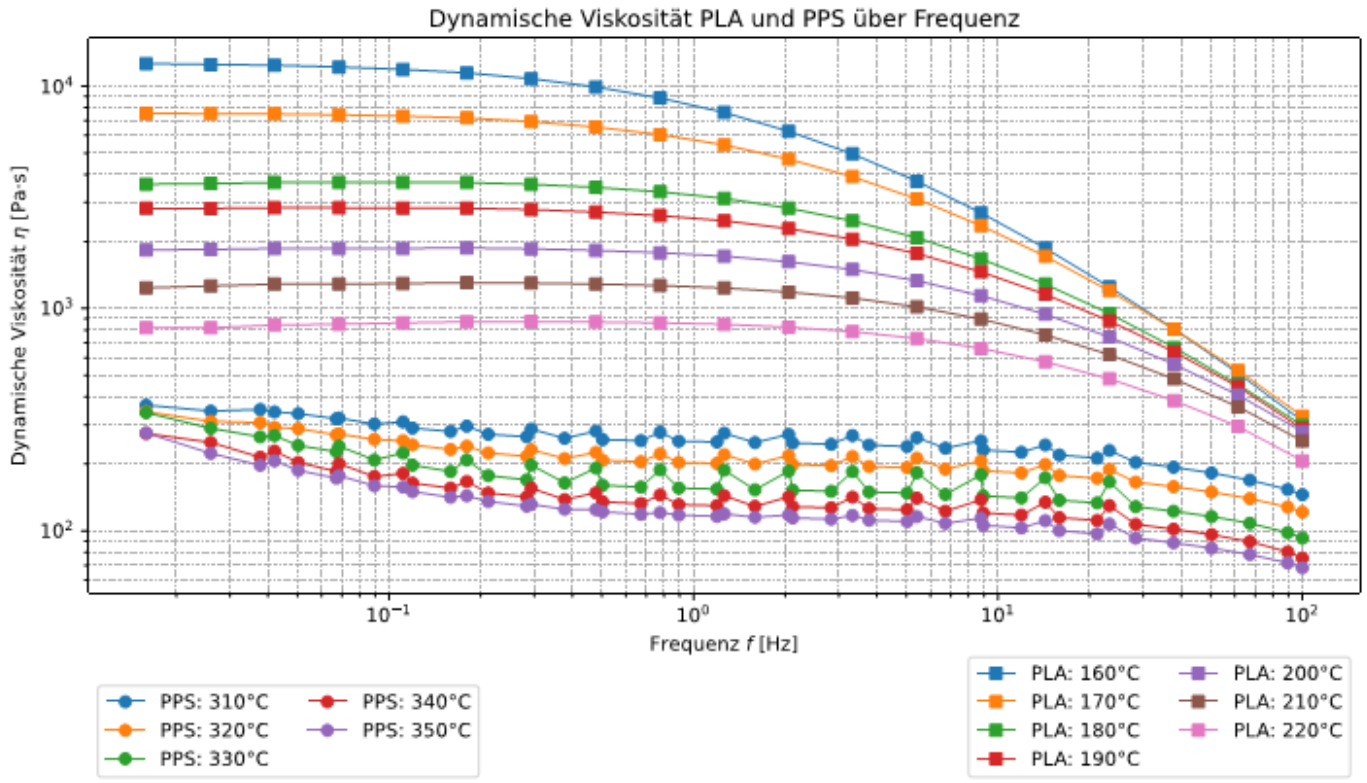






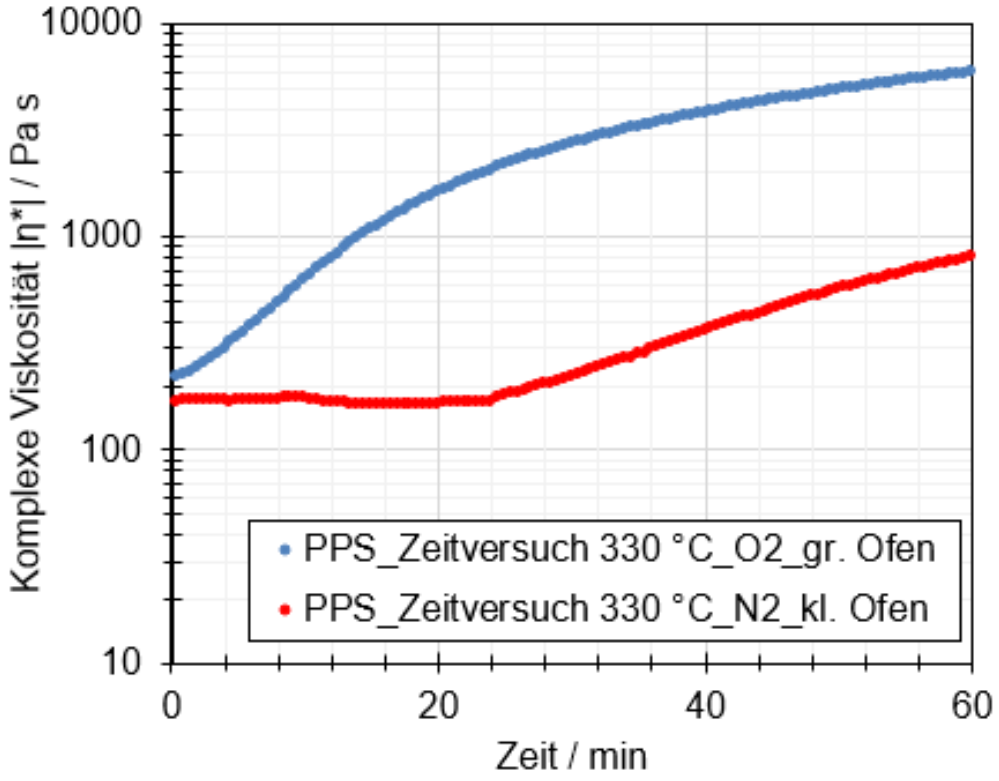
Comparison between different materials

- Distinct rheological behavior observed between material systems
- Material architecture influences flow characteristics
- Differences can affect impregnation efficiency
- Rheology enables material-specific process optimization



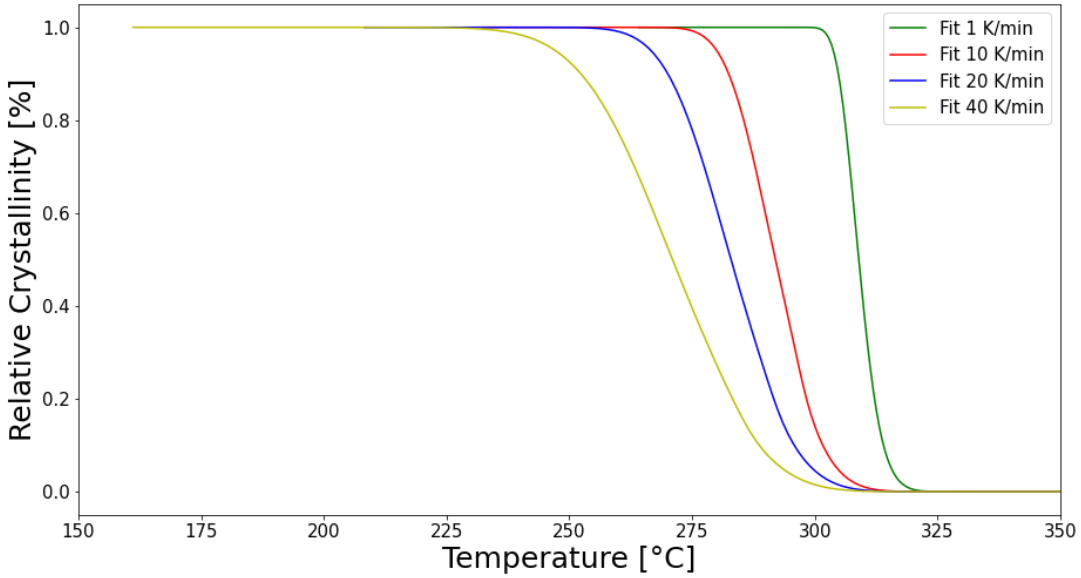
Influence of time under elevated temperature

- Viscosity changes with increasing thermal exposure time
- Indicates molecular changes during processing
- Useful for assessing thermal stability of feedstock materials
- Supports the definition of processing windows



Crystallization kinetics

- Crystallization behavior is affected by thermal history
- Kinetics govern microstructure development during cooling
- Influences dimensional stability and mechanical performance
- Supports process parameter optimization



Conclusion

- DSC revealed only minor differences in crystallization and melting behavior between virgin and recycled feedstocks.
- TGA enables assessment of material composition and thermal stability.
- Rheological analyses provide insights into processability and degradation mechanisms.
- Thermal analysis methods provide valuable tools for quality assurance in fiber-reinforced additive manufacturing.

Impressum

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