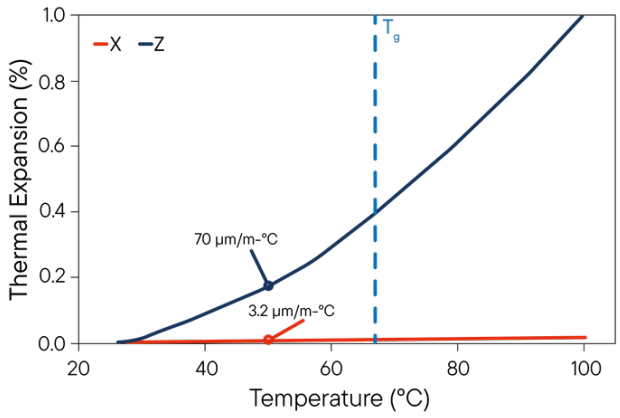
Anisotropic Thermal Expansion of Carbon Fiber Reinforced PA6

Dilatometry Analysis of Additively Manufactured Components

Dilatometry is a powerful tool for evaluating the dimensional stability of fiber-reinforced polymers. In this application example, a 40 wt.% carbon fiber reinforced PA6 manufactured by large-format additive manufacturing was analyzed using the LINSEIS DIL L75 Horizontal. The measurements reveal the influence of fiber orientation on thermal expansion behavior.

Measurement Setup

- Instrument: LINSEIS DIL L75 Horizontal
- Sample: 40 wt.% carbon fiber reinforced PA6
- Temperature Range: 25 °C to 100 °C
- Measurement: Coefficient of Thermal Expansion (CTE)
- Application: Additive manufacturing and tooling materials



The dilatometric measurement reveals a pronounced anisotropy in the thermal expansion behavior of the investigated carbon fiber reinforced PA6 material.
Key observations include:

- CTE in X-direction: 3.2 µm/m·K
- CTE in Z-direction: 70 µm/m·K
- More than 20× higher expansion in build direction
- Significant increase in thermal expansion near the glass transition (~67 °C)
- Strong influence of carbon fiber orientation on dimensional stability

The results demonstrate the suitability of dilatometry for evaluating thermal expansion anisotropy and optimizing additively manufactured polymer components for thermally demanding applications.

Interpretation

The observed behavior can be attributed to:

- Alignment of carbon fibers along the print direction
- Restriction of matrix expansion in X-direction
- Higher polymer mobility near Tg

This results in:

- Reduced warpage
- Improved dimensional stability
- Enhanced performance of tooling applications

Industrial Relevance

Dilatometry measurements support:

- Additive manufacturing optimization
- Tool and fixture development
- Warpage prediction
- Material qualification
- Thermal design of polymer components

Conclusion

The LINSEIS DIL L75 Horizontal enables precise characterization of anisotropic thermal expansion in fiber-reinforced polymers. The results highlight the importance of print orientation for dimensional stability and thermal performance in additively manufactured components.

Source:
Barera, G., Dul, S., Pegoretti, A.
Screw Extrusion Additive Manufacturing of Carbon Fiber Reinforced PA6 Tools.
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Adapted from dilatometric measurements performed using a LINSEIS DIL L75 PT Horizontal.