Dilatometric investigation of the annealing behavior of CrGr

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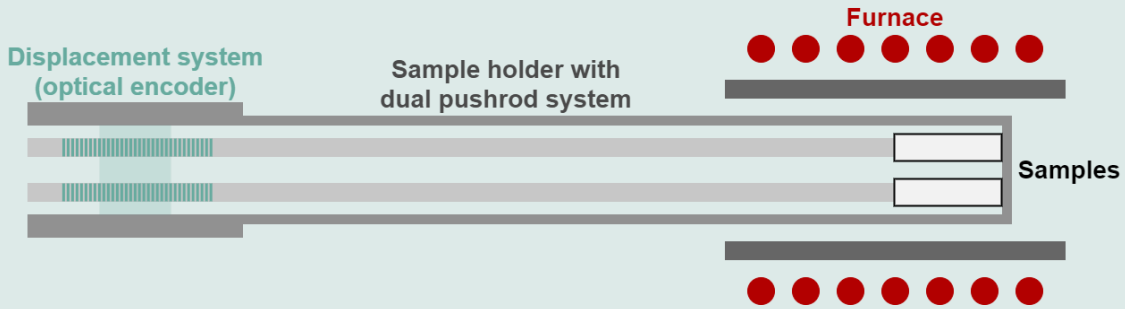
11/8/2023

Push-rod DIL

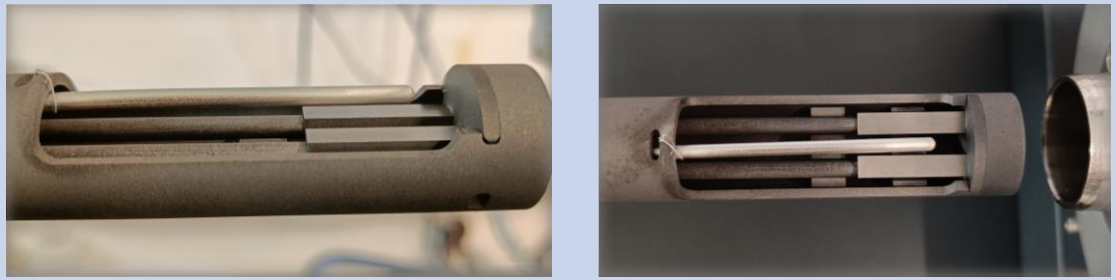
ranging from -175 to 2000°C



Test setup and matrix

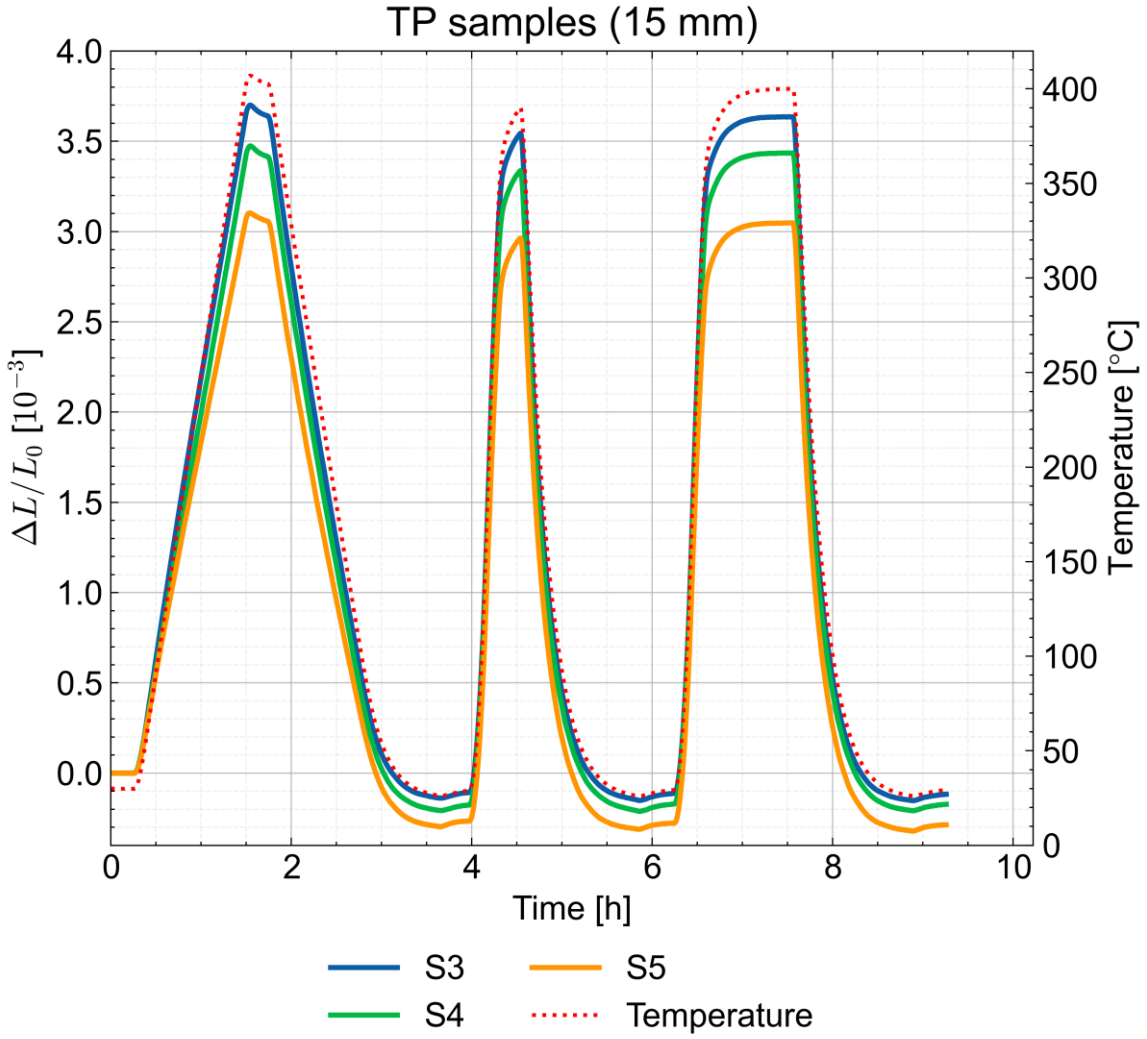
Dimensional behavior of CrGr

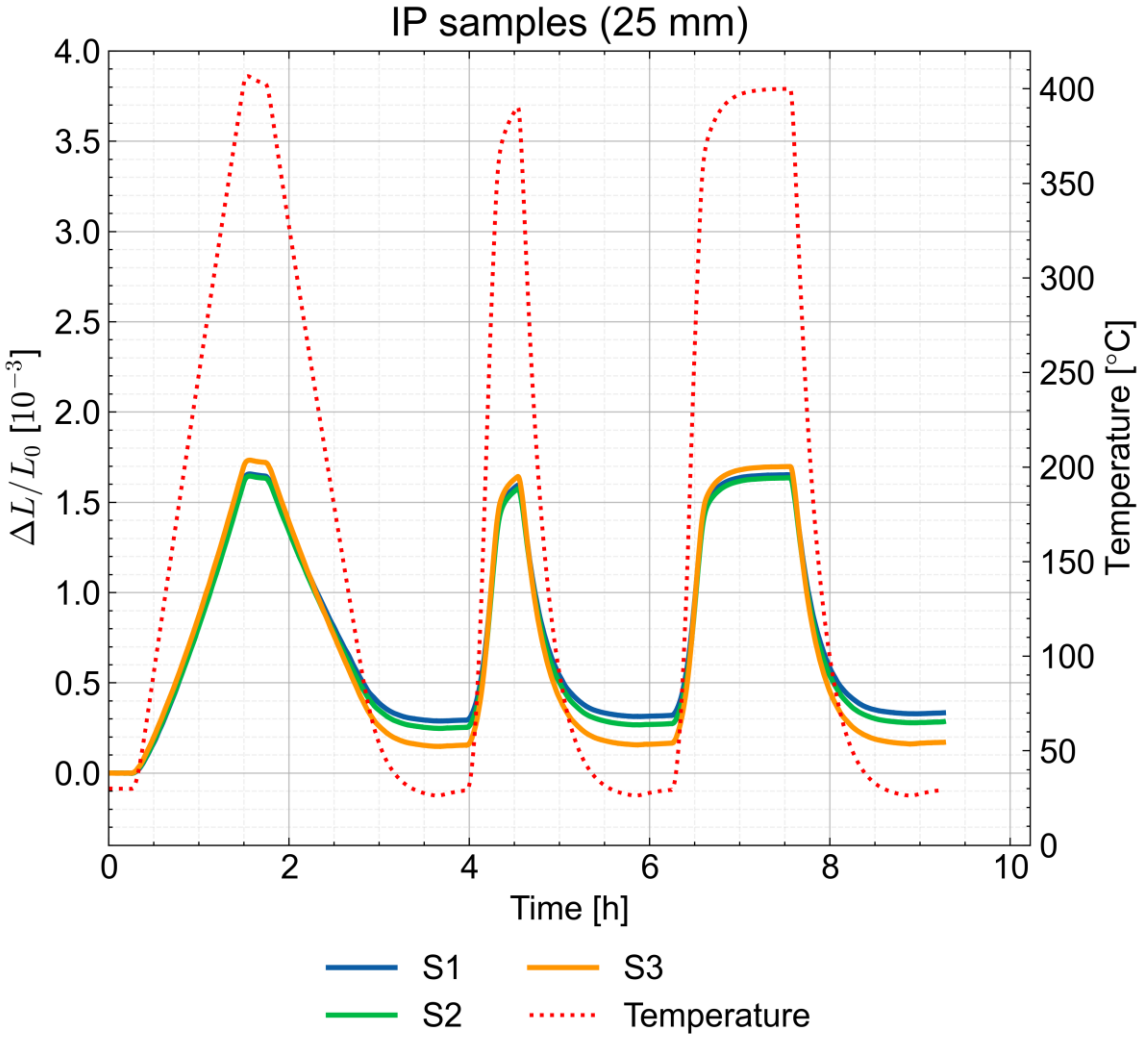
- **Multiple thermal cycles with varying temperature profile**
- **Application in industry and collimators**
  - 400°C and 1000°C
  - Study of permanent changes in length
- **Effect of annealing at 1400°C**
- **Preliminary determination of the CTE**
- **3 samples per direction (IP/TP)**



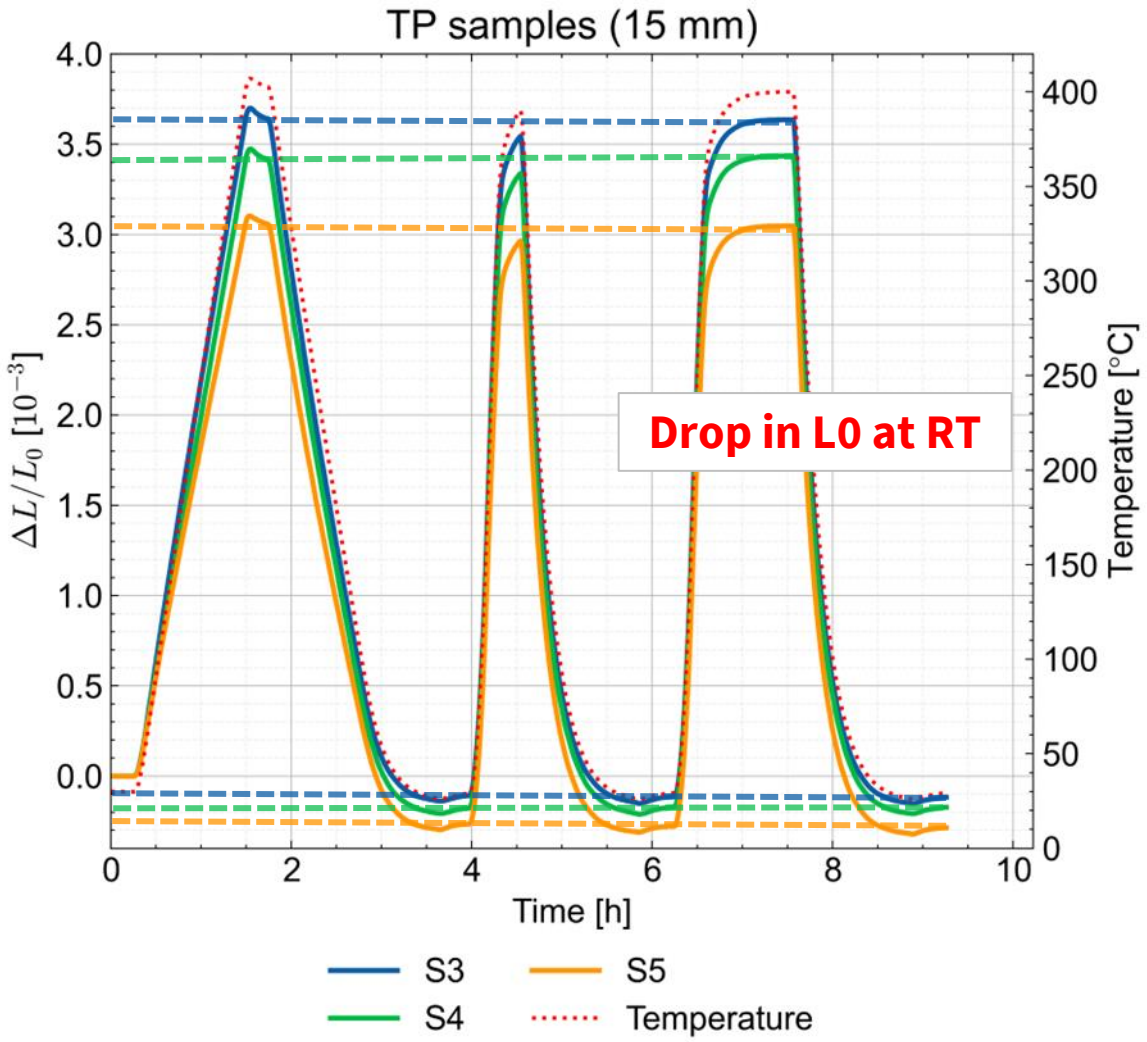
View on in-plane samples installed in graphite sample holder

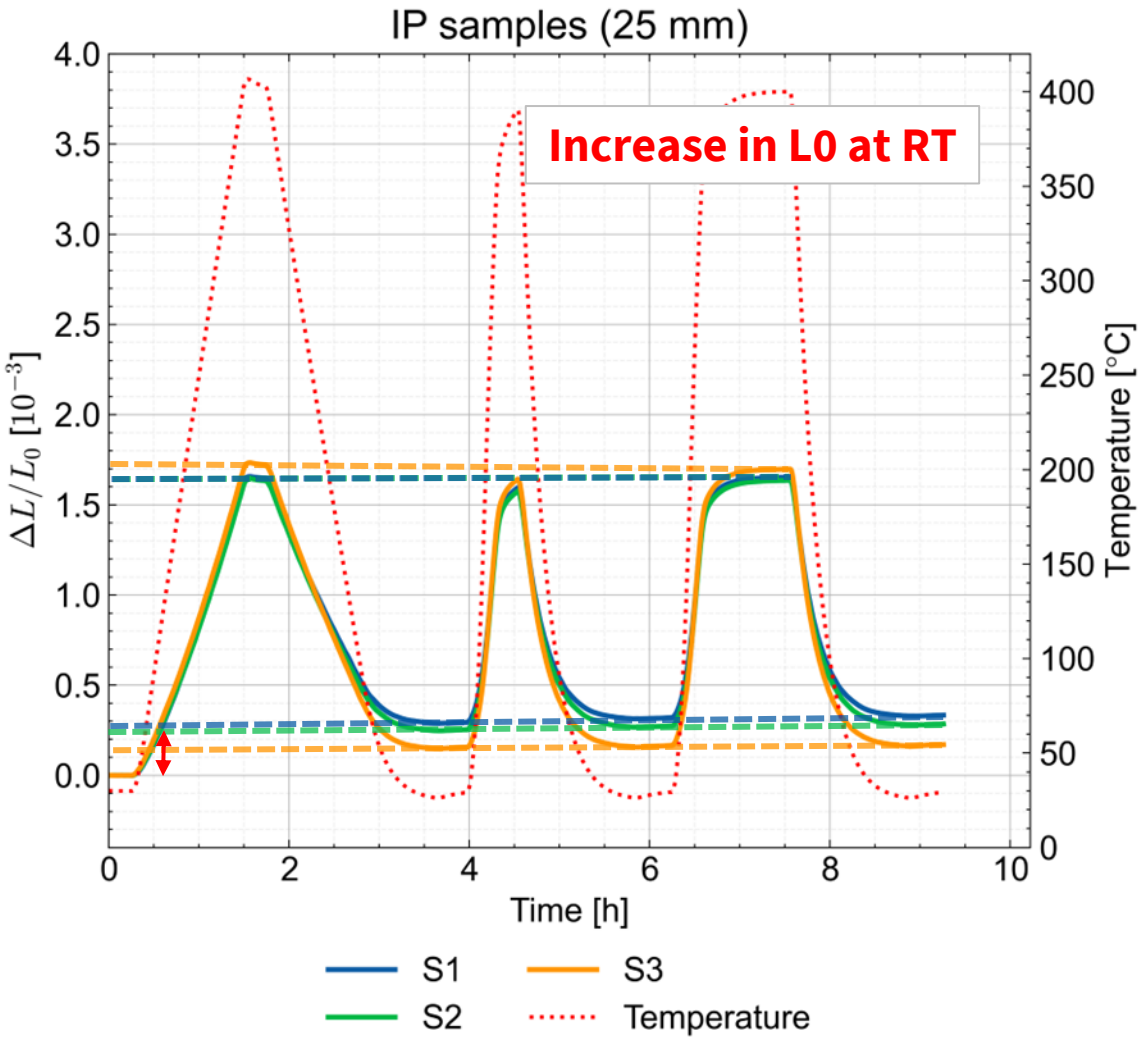
Industrial application – Cycles from RT to 400°C



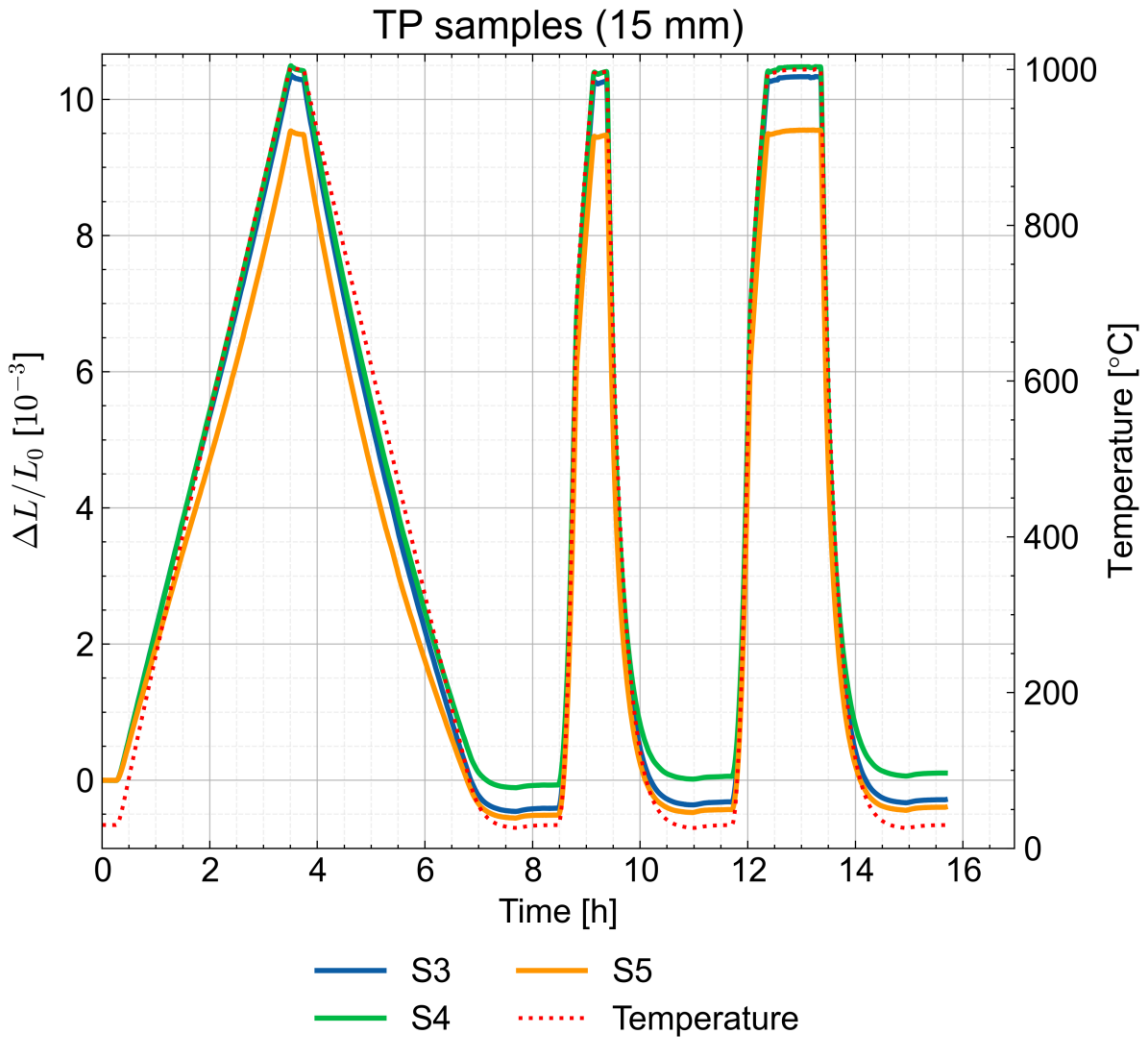


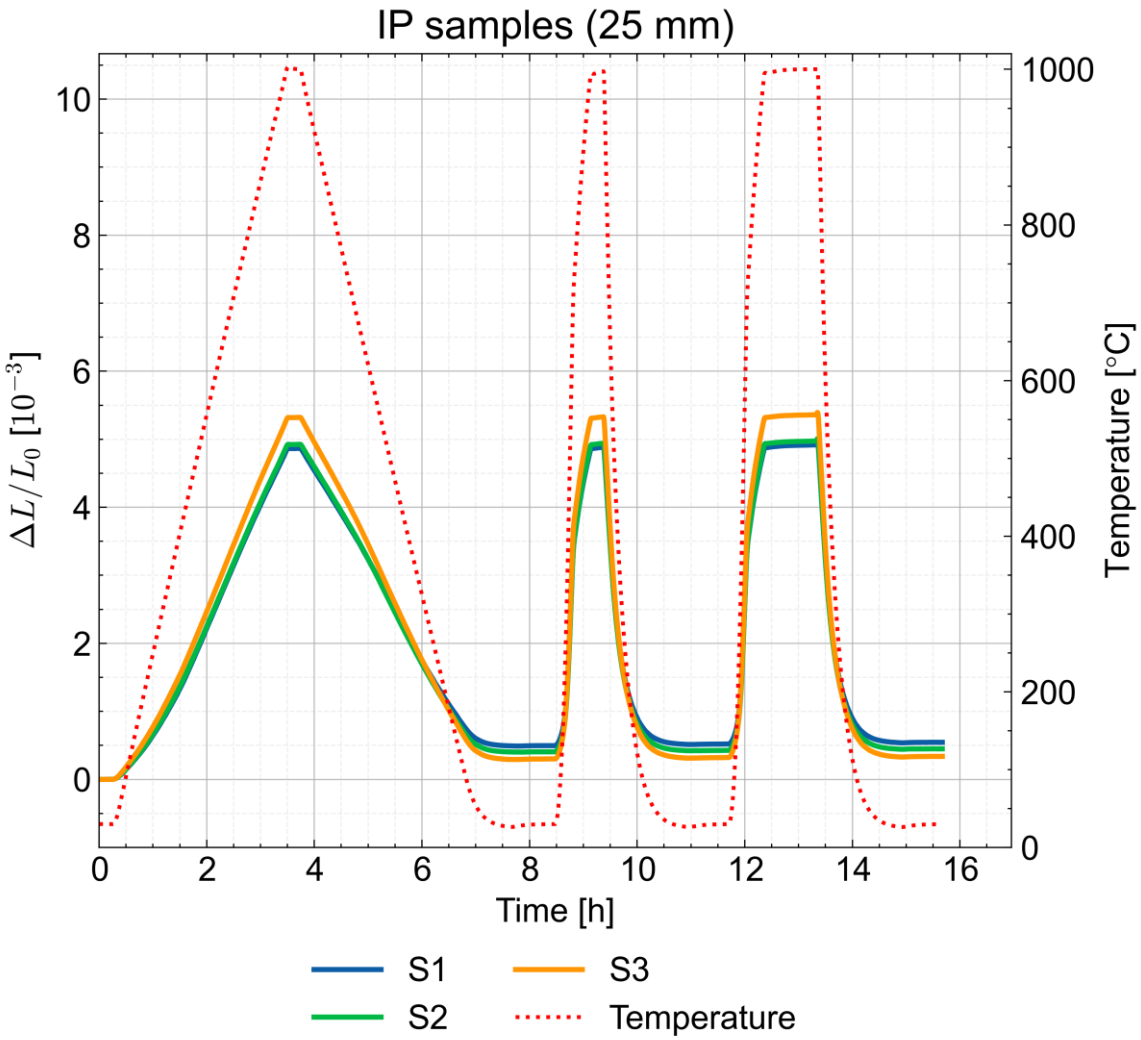
Industrial application – Cycles from RT to 400°C



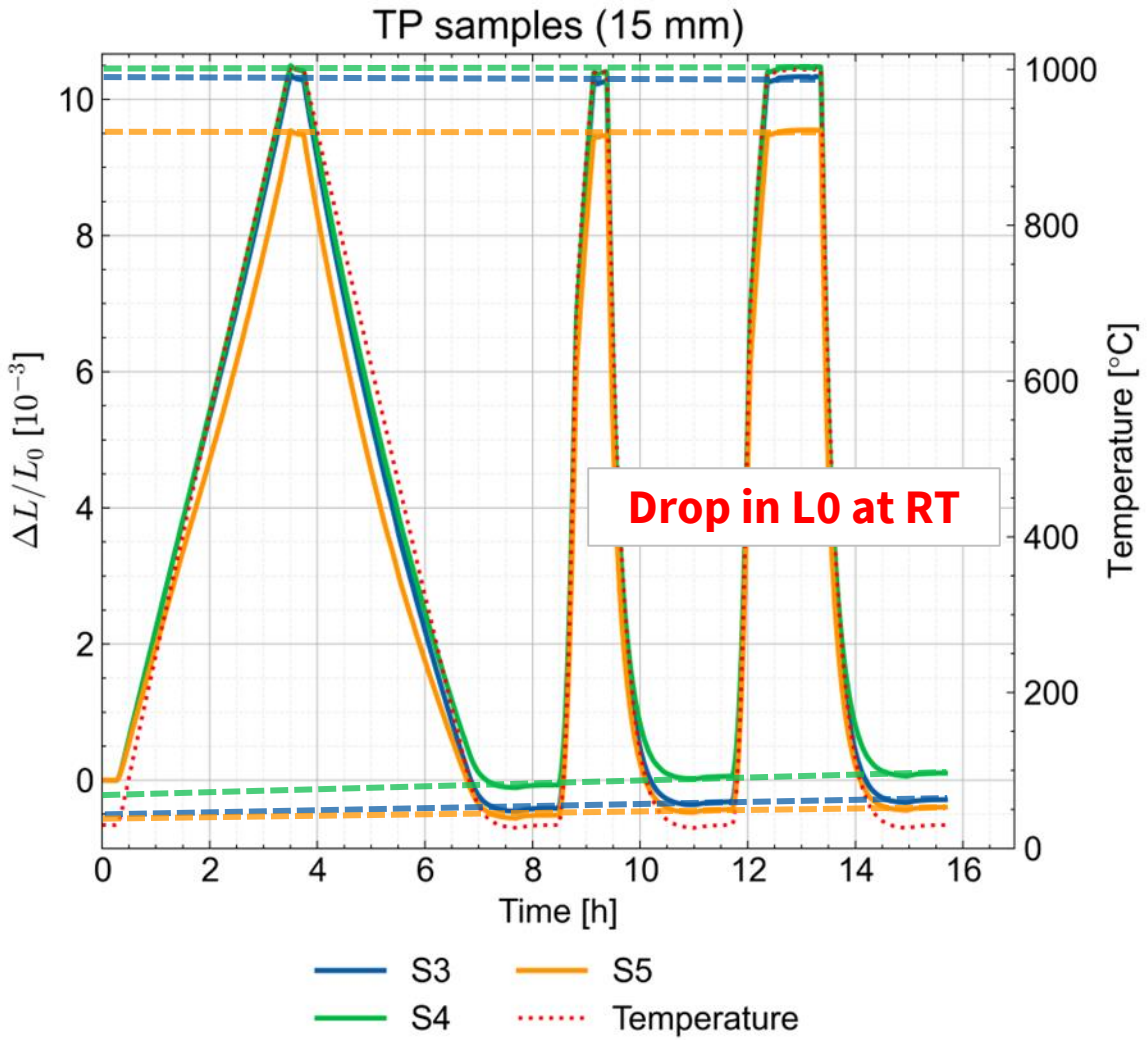


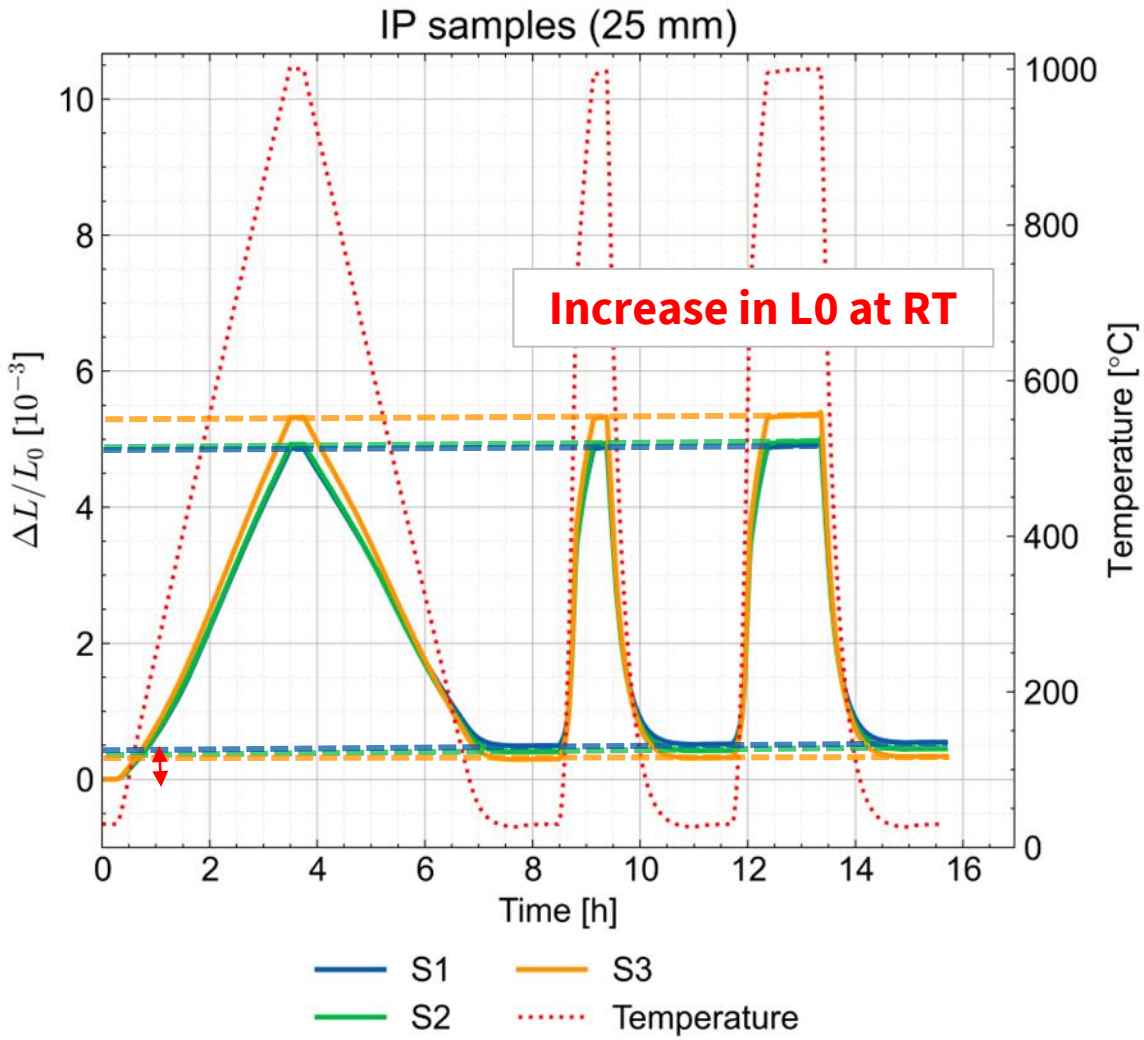
Collimator application – Cycles from RT to 1000°C



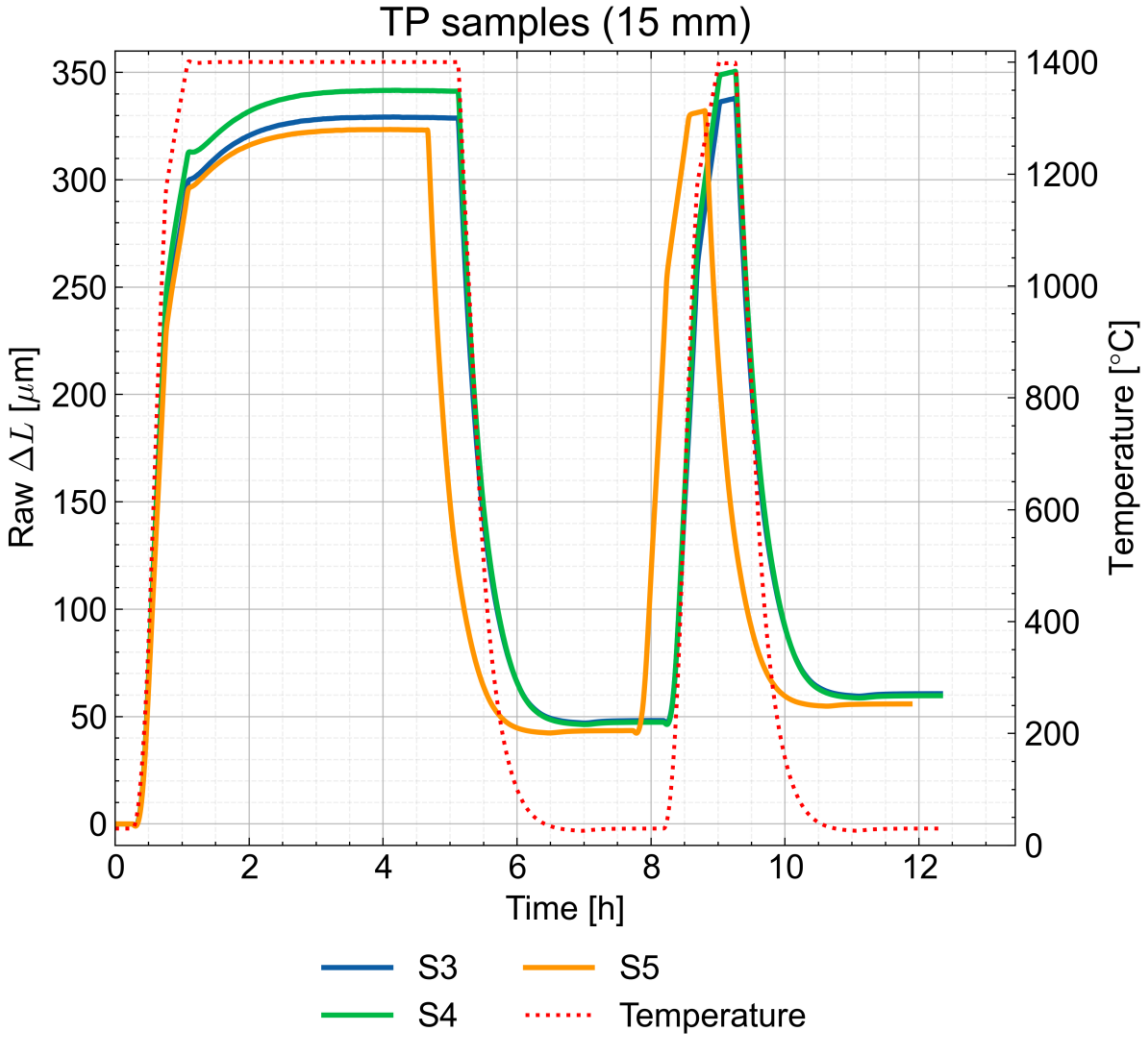


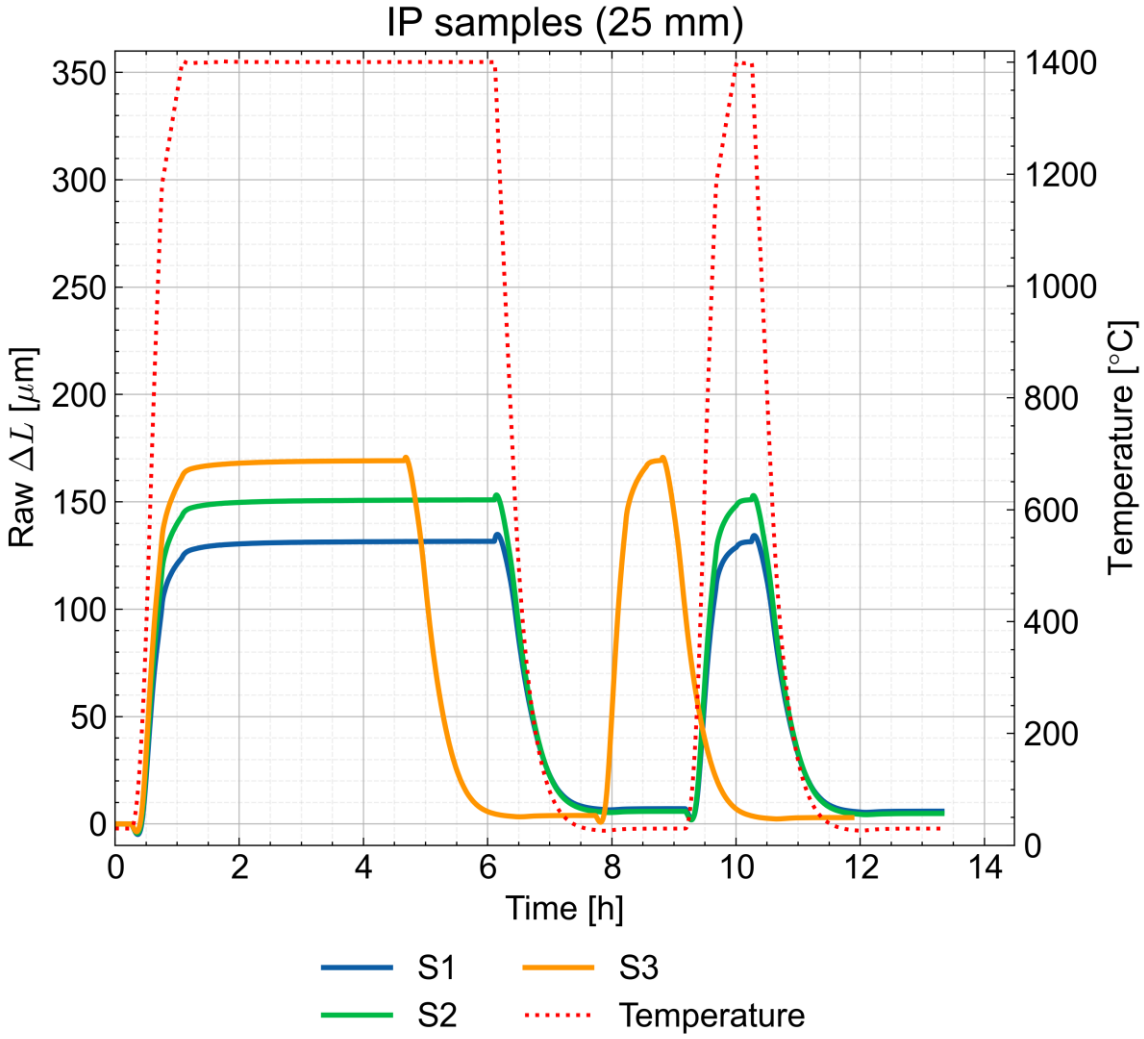
Collimator application – Cycles from RT to 1000°C



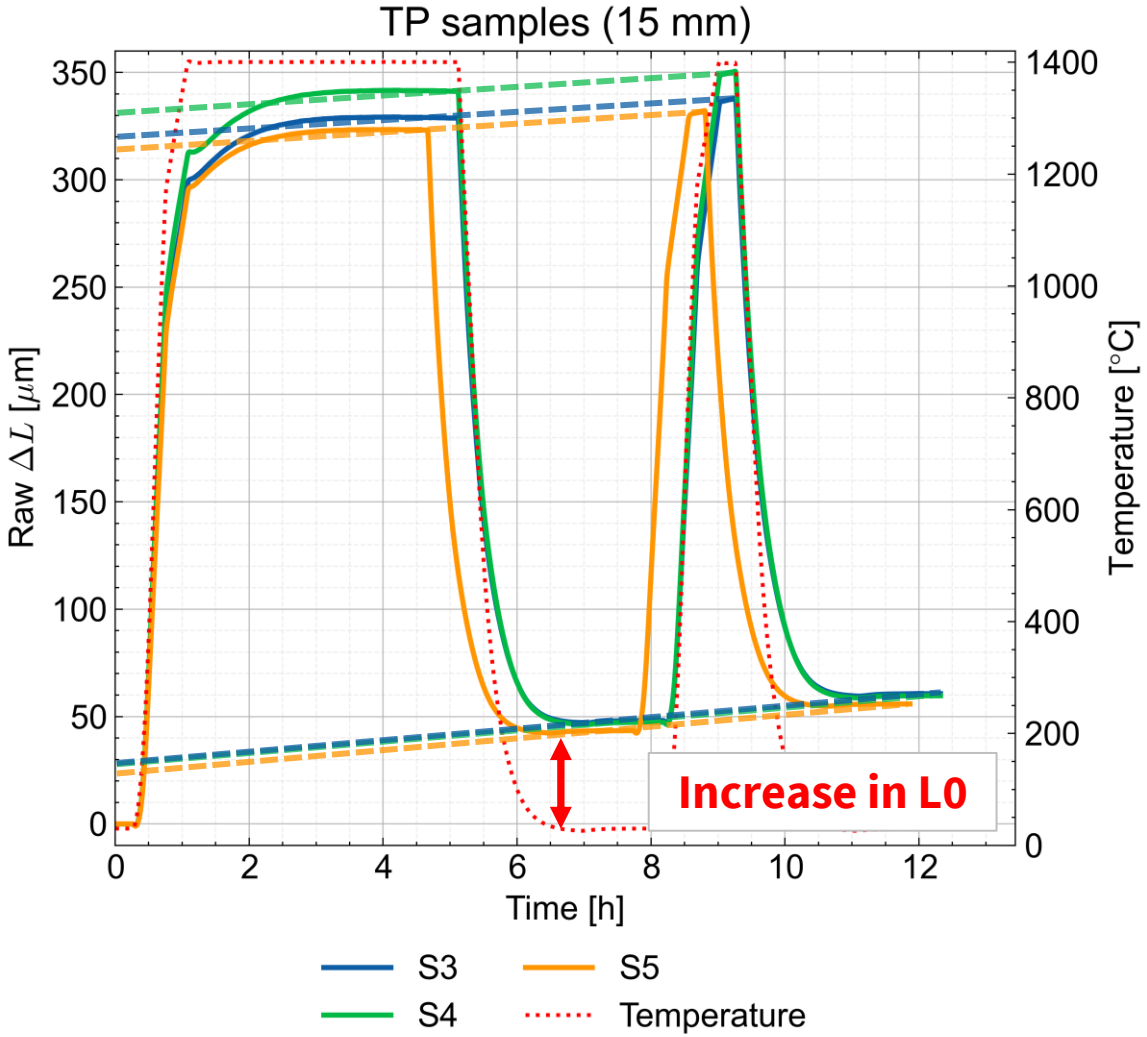


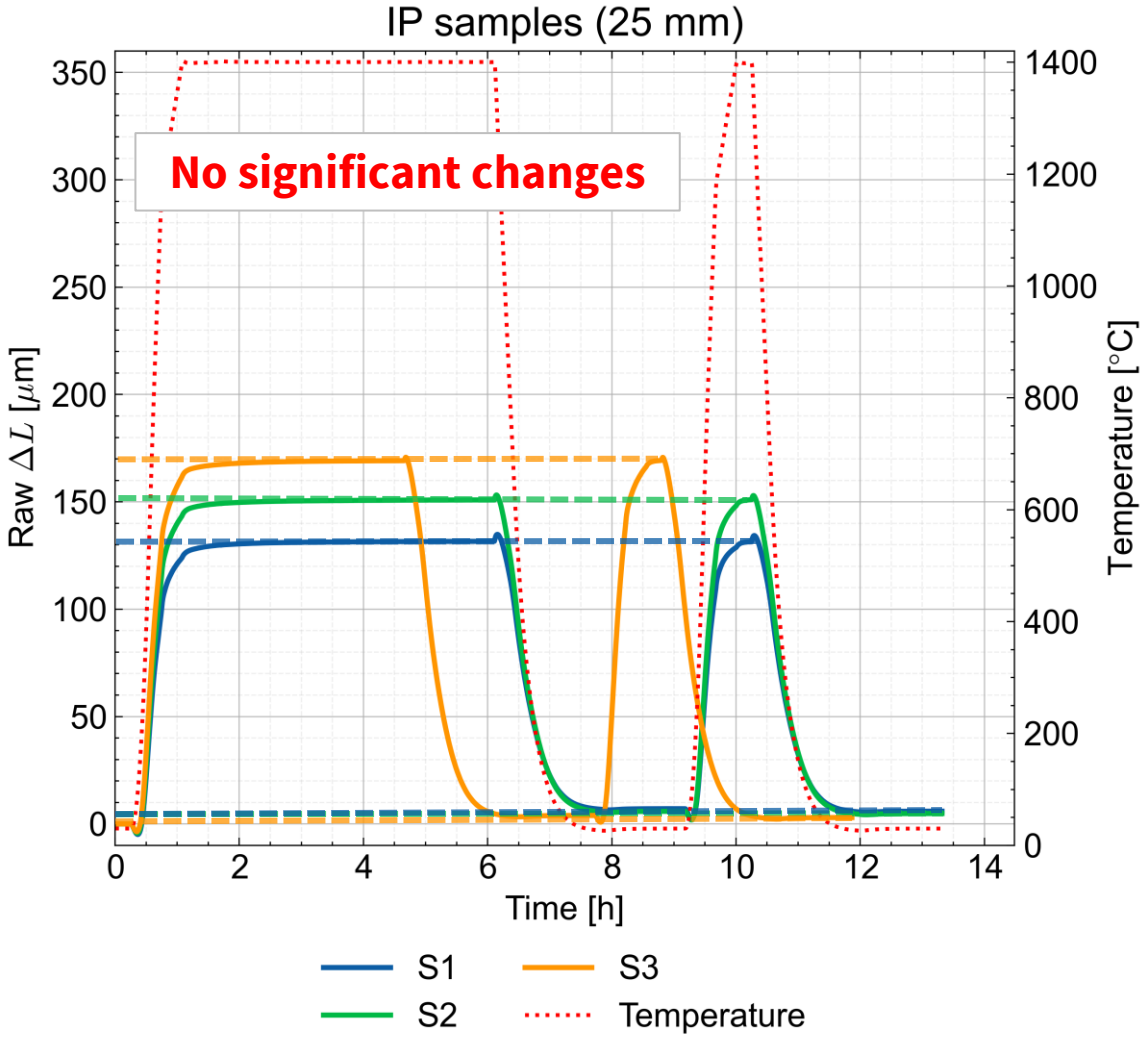
Annealing at 1400°C (only raw dilatation)



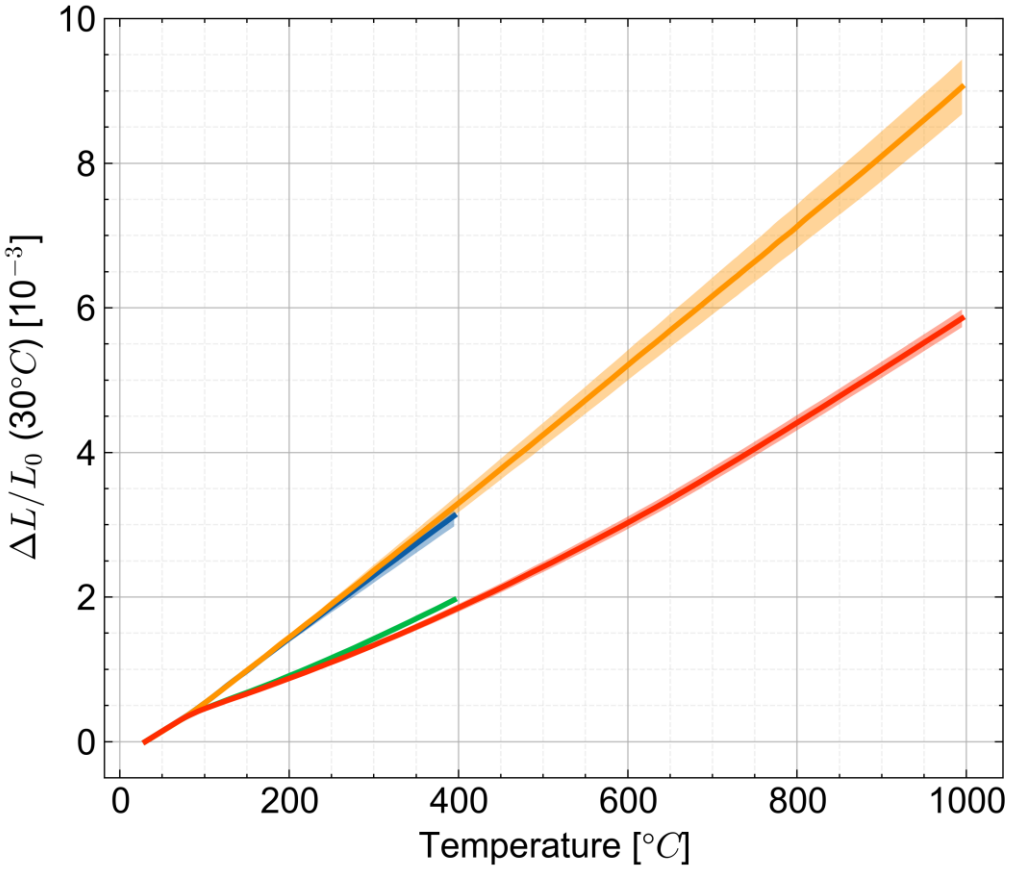


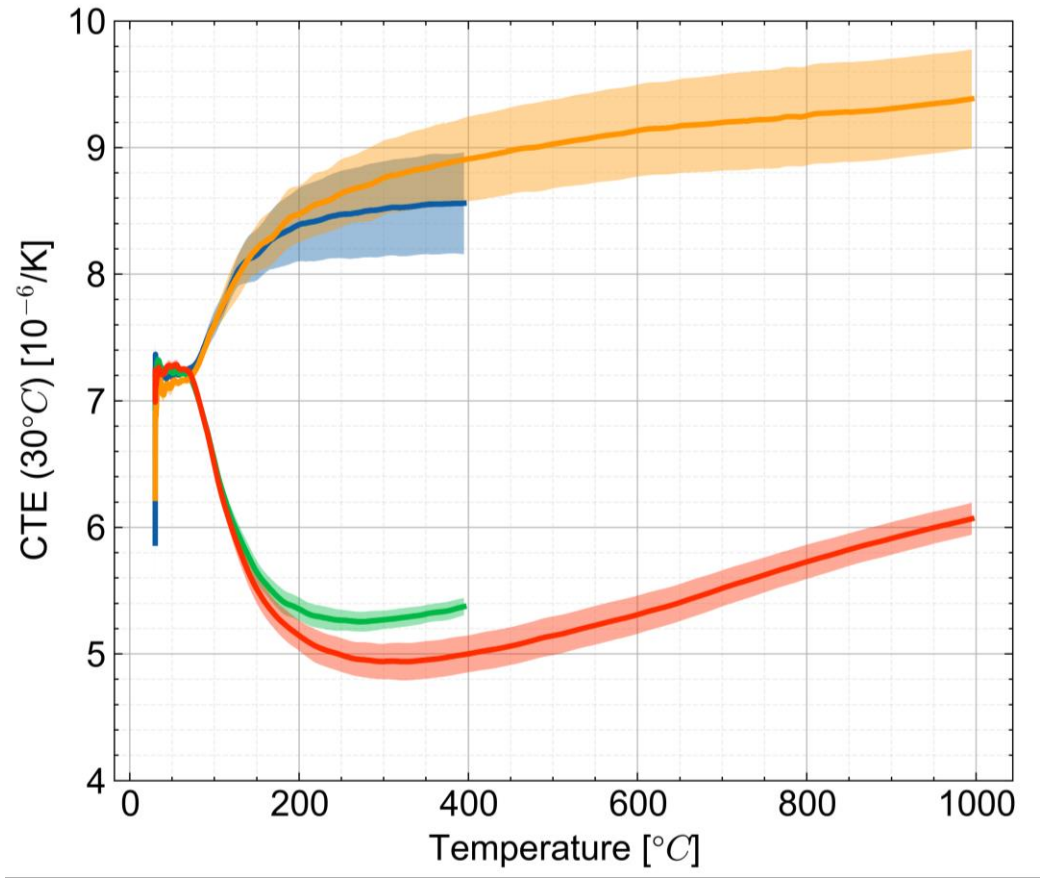
Annealing at 1400°C (only raw dilatation)





dL/L0 and CTE





TP samples (15 mm)
IP samples (25 mm)
TP samples (15 mm)
IP samples (25 mm)

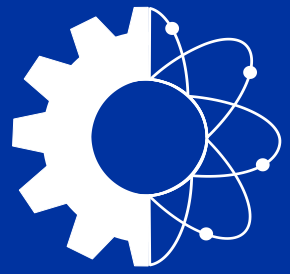
Conclusion

Trans-plane

- **After the first cycle at 400 and 1000°C, there is a permanent reduction in the sample length L0 at RT**
  - 400°C → $< 0.3 \cdot 10^{-3}$ $(< 5\mu m)$
  - 1000°C → $< 0.6 \cdot 10^{-3}$ $(< 8\mu m)$
- **However, after the isothermal step at 1400°C, the sample length L0 at RT is significantly increased (about 45-50 µm)**
- $\boldsymbol{CTE \approx 9 \cdot 10^{-6}/K}$

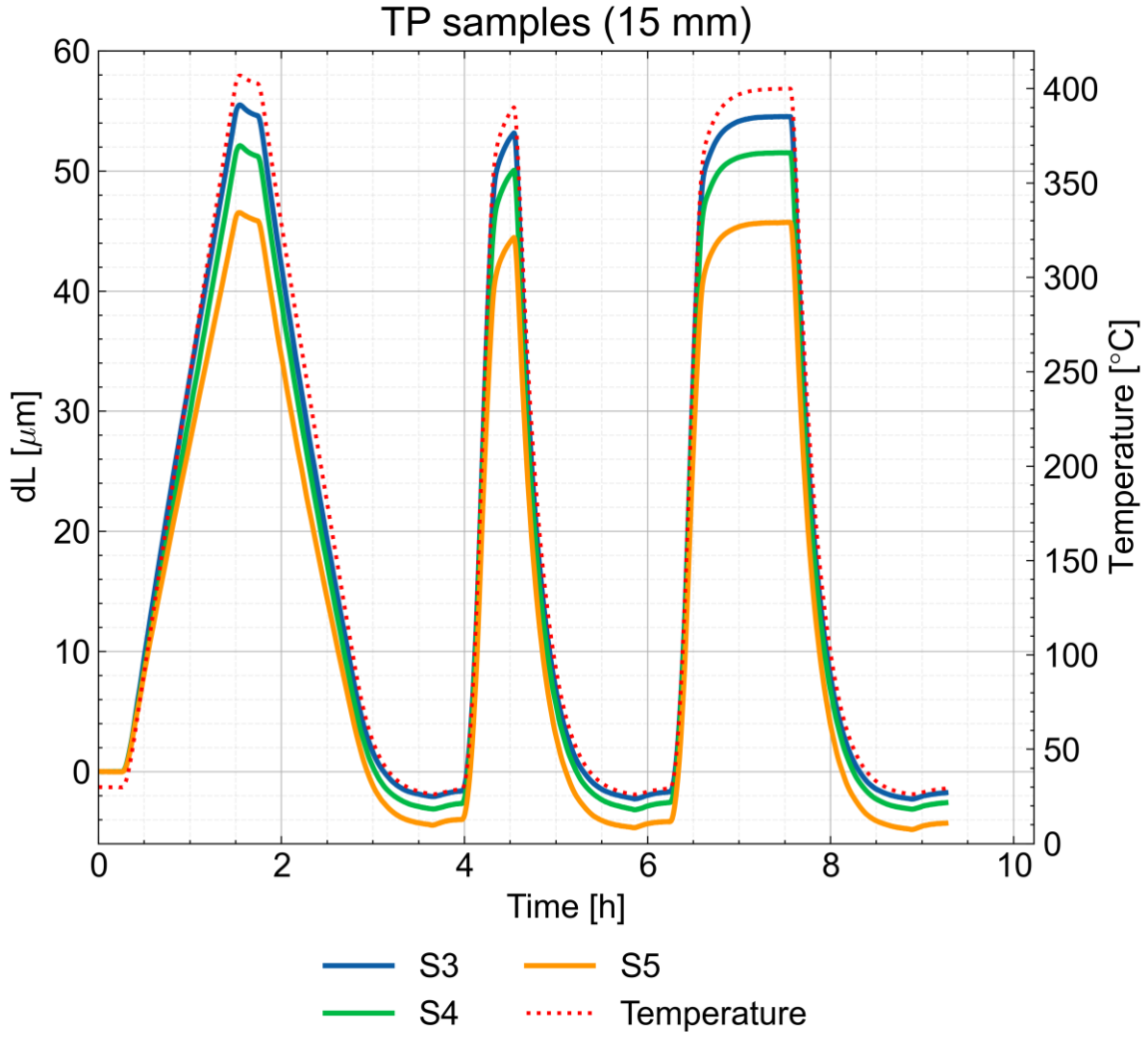
In-plane

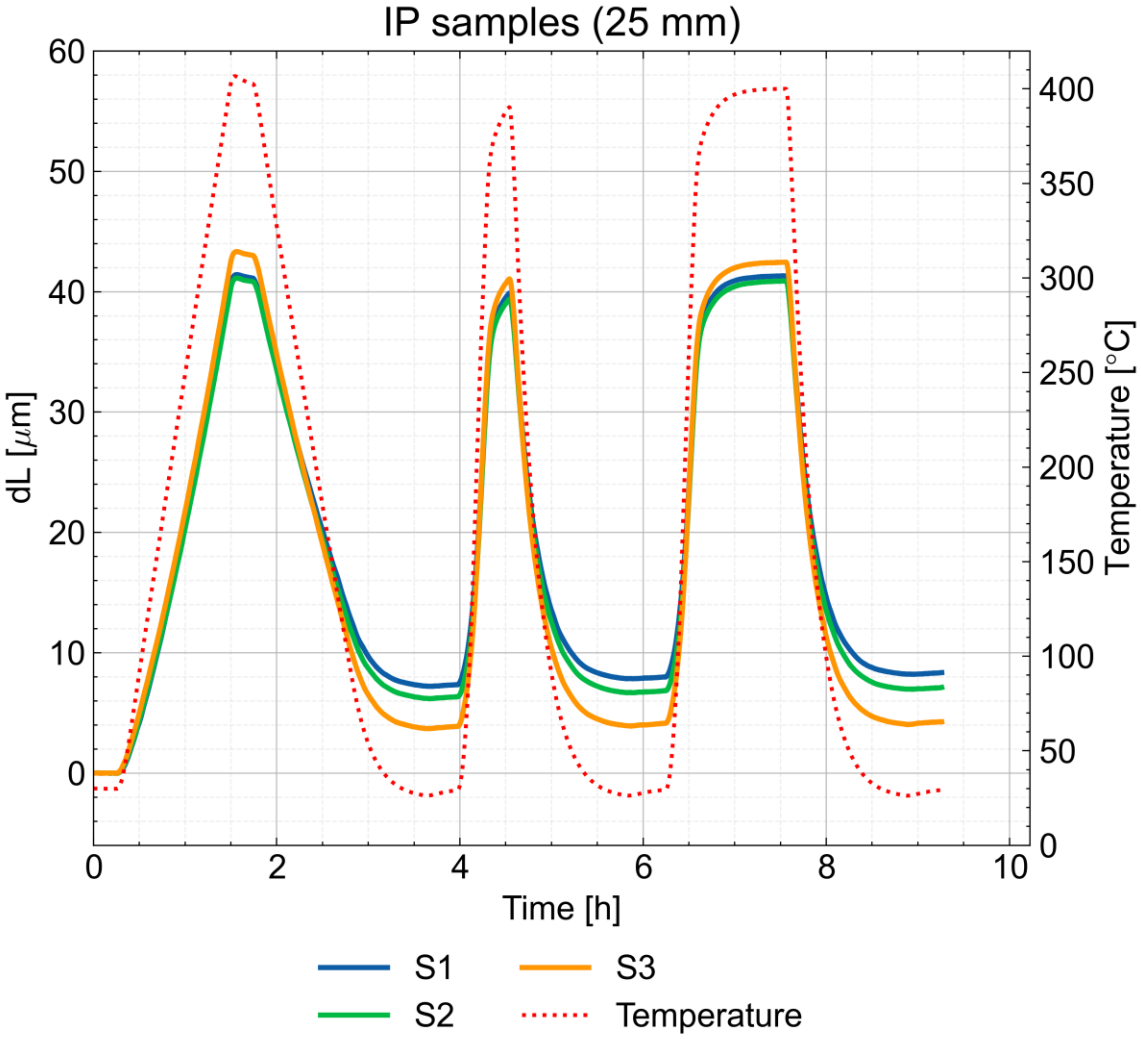
- **Generally lower expansion compared to TP samples**
- **After the first cycle at 400 and 1000°C, the sample length is permanently increased**
  - 400°C → $< 0.3 \cdot 10^{-3}$ $(< 8\mu m)$
  - 1000°C → $< 0.6 \cdot 10^{-3}$ $(< 14\mu m)$
- **After the annealing, there is also an increase in L0, but only by about 3 – 7 µm**
- $\boldsymbol{CTE \approx 5.5 \cdot 10^{-6}/K}$



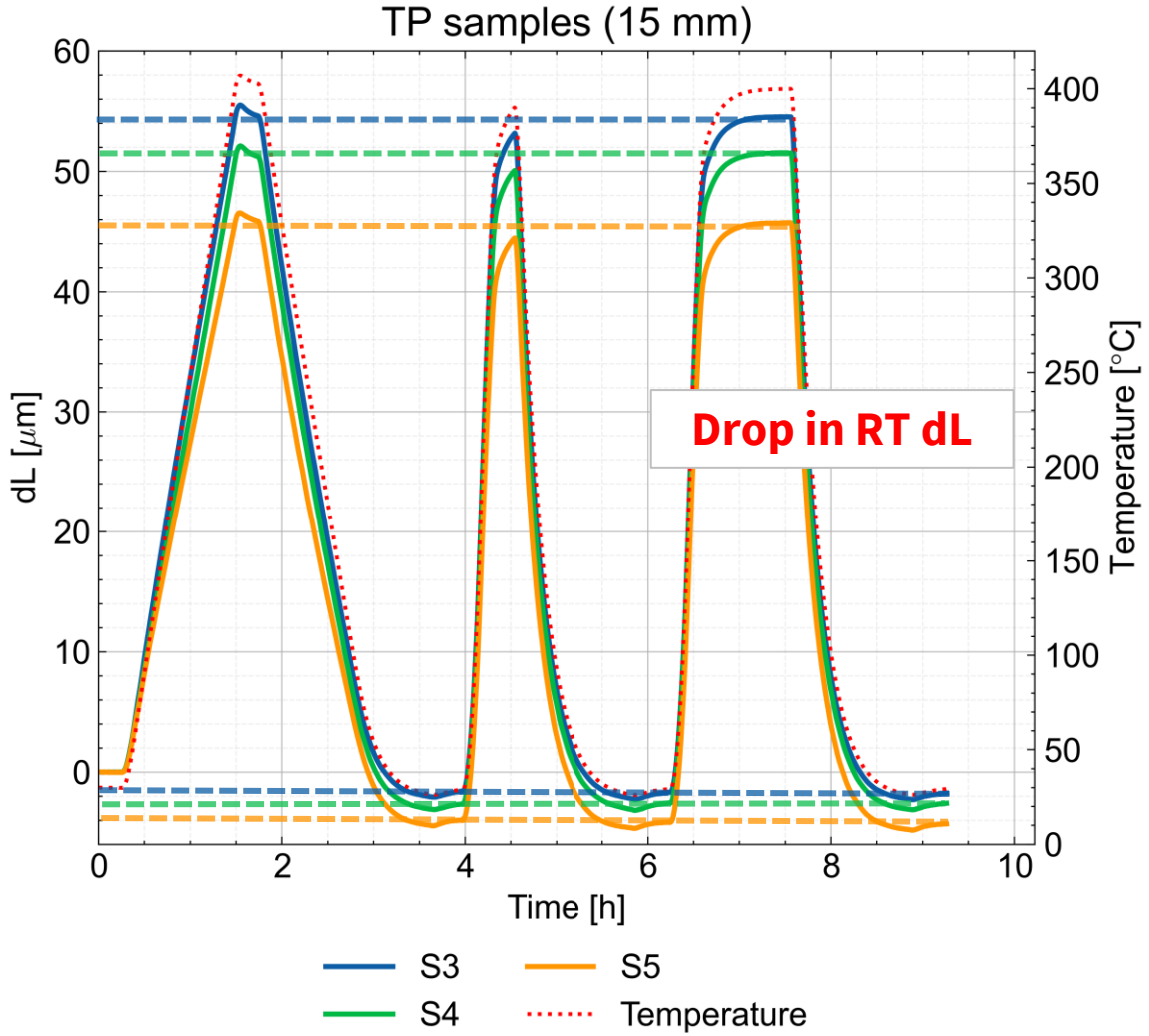
Engineering Department

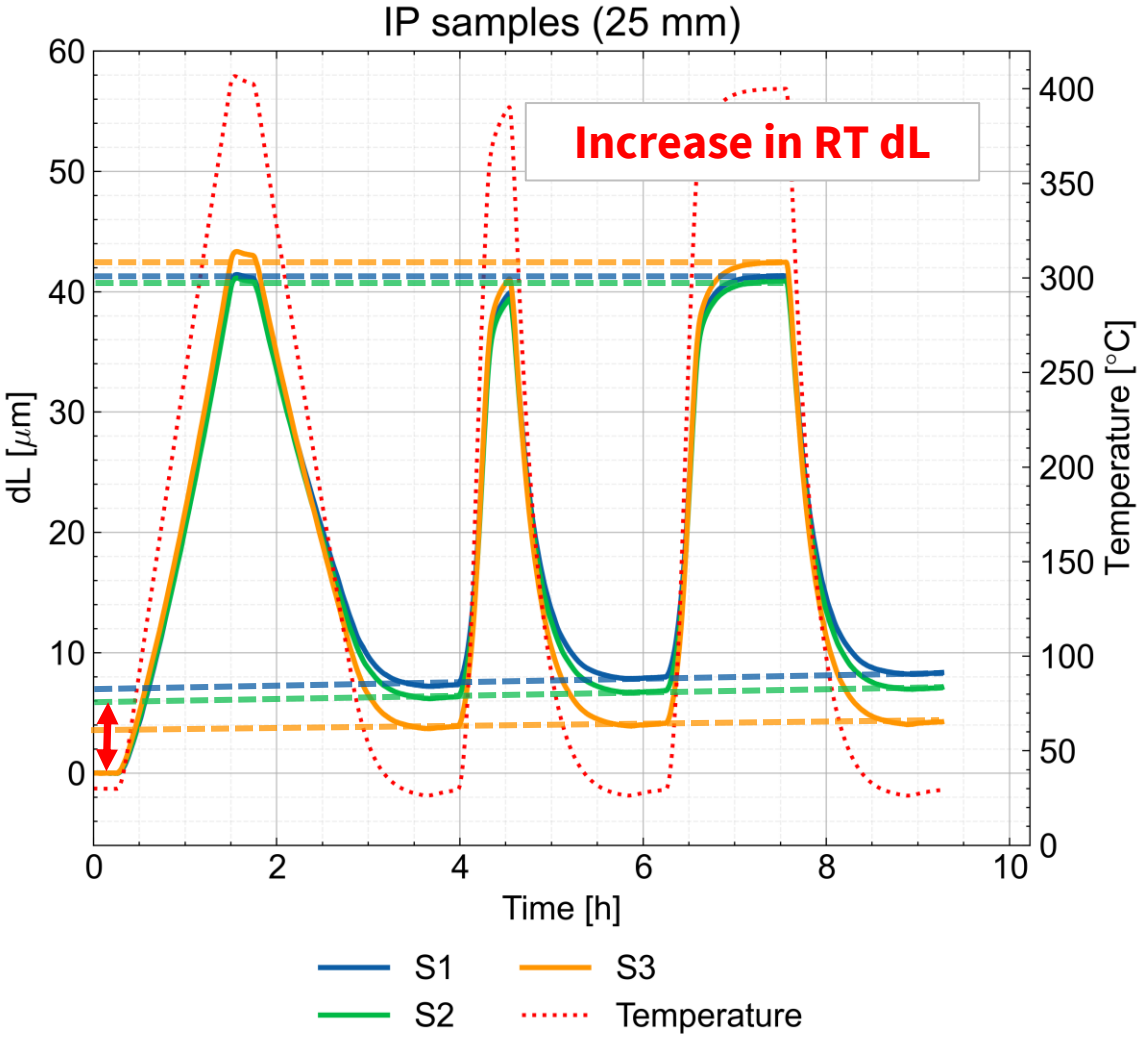
Industrial application – Cycles from RT to 400°C



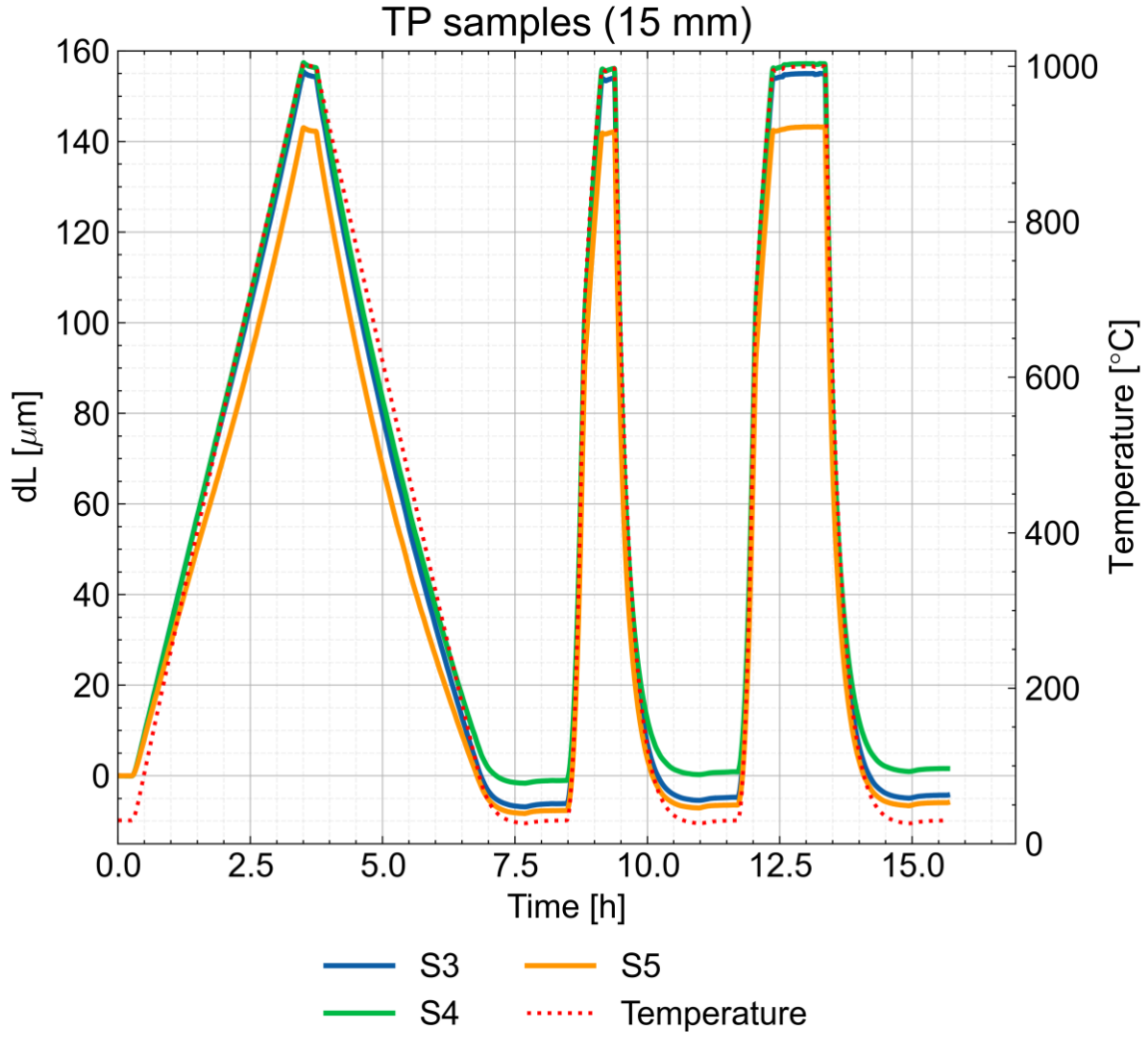


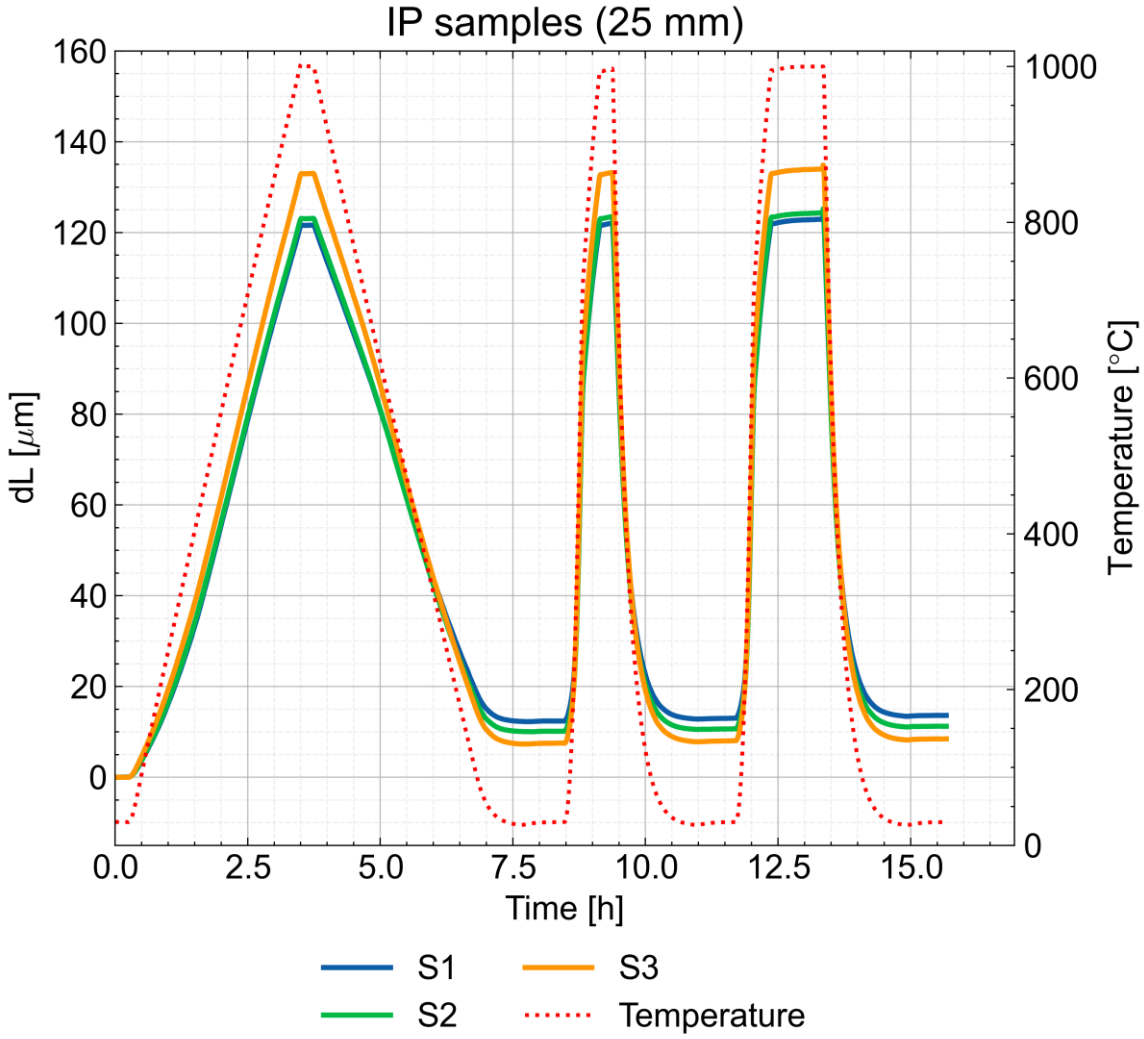
Industrial application – Cycles from RT to 400°C



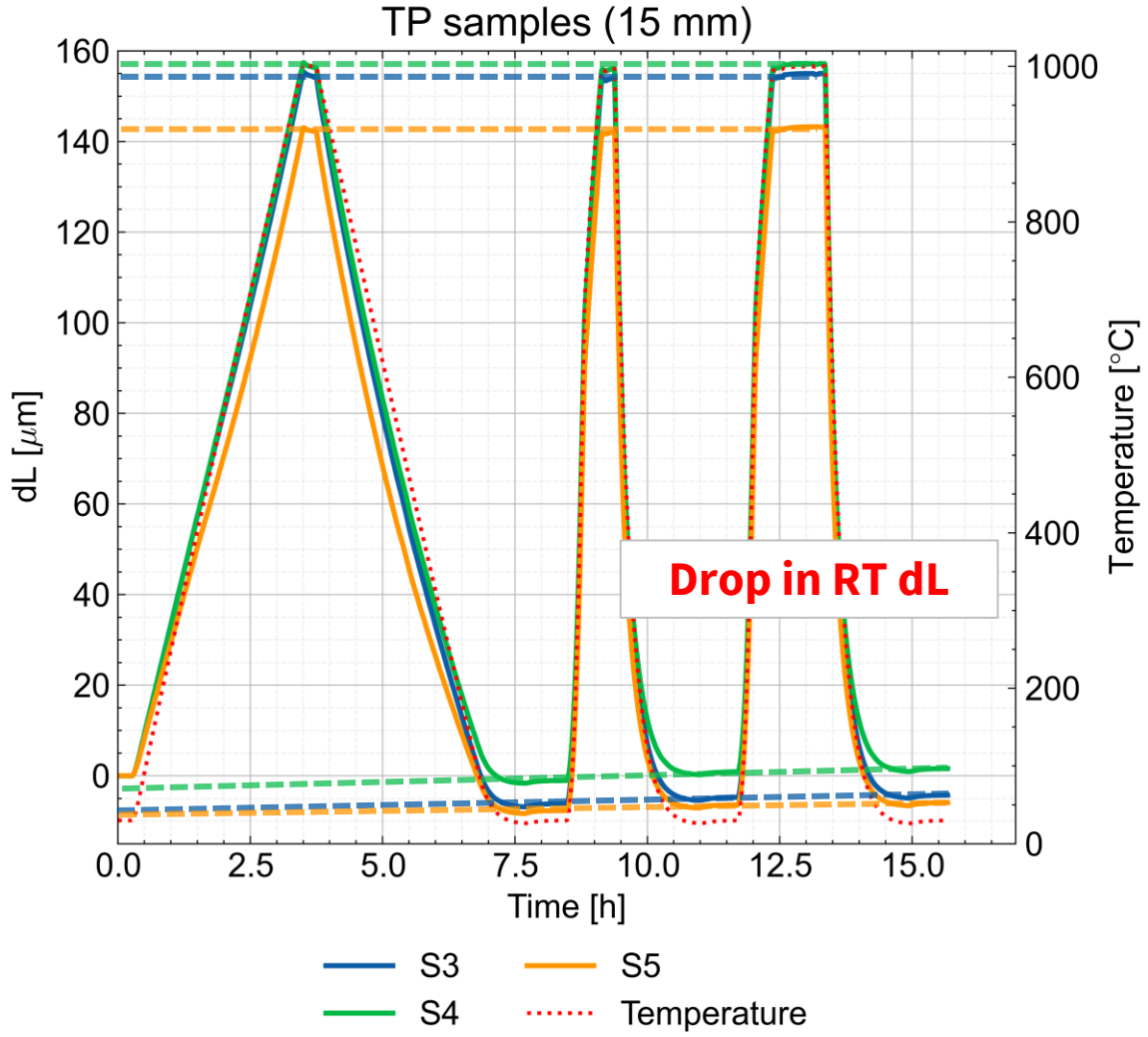


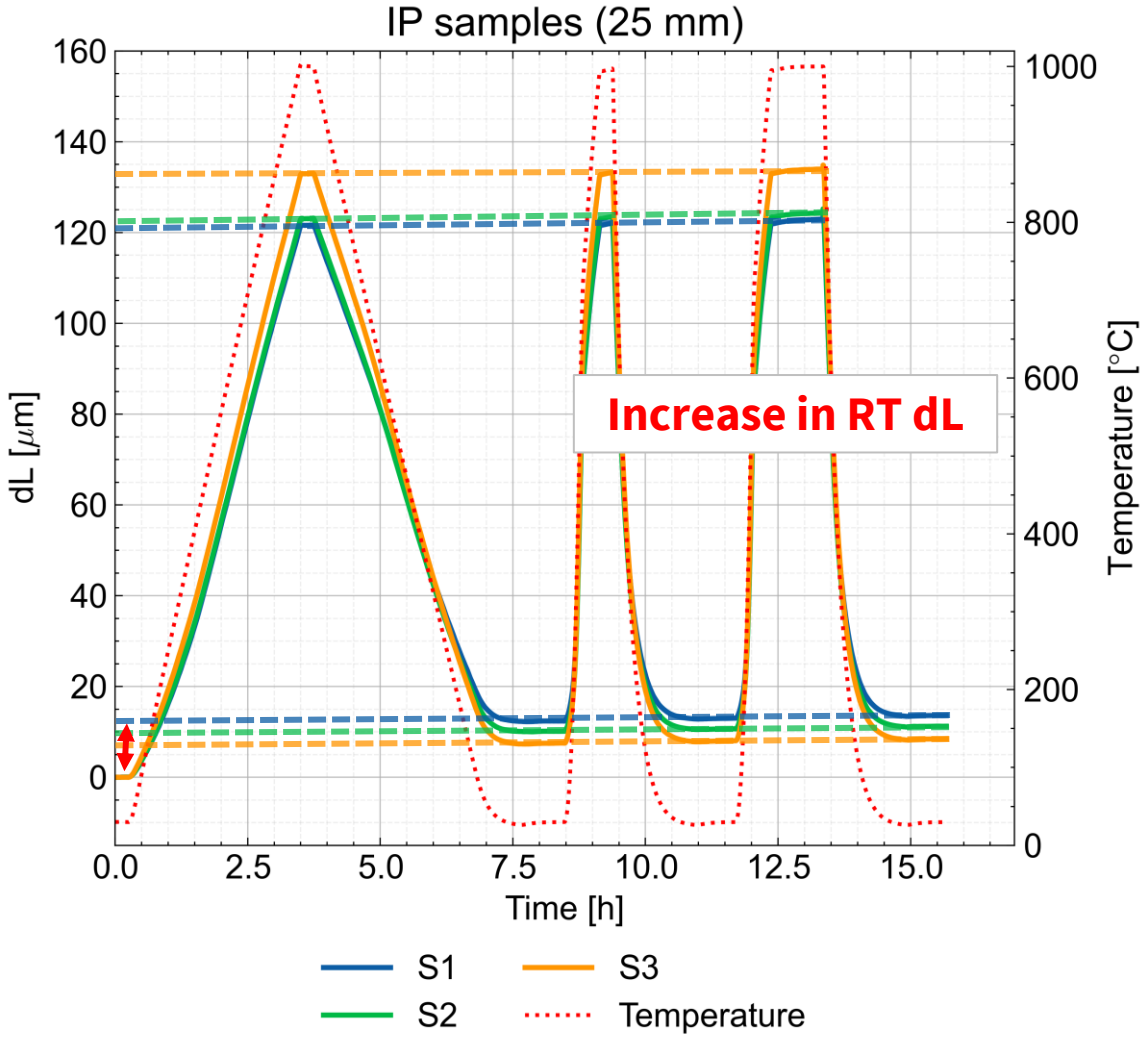
Collimator application – Cycles from RT to 1000°C



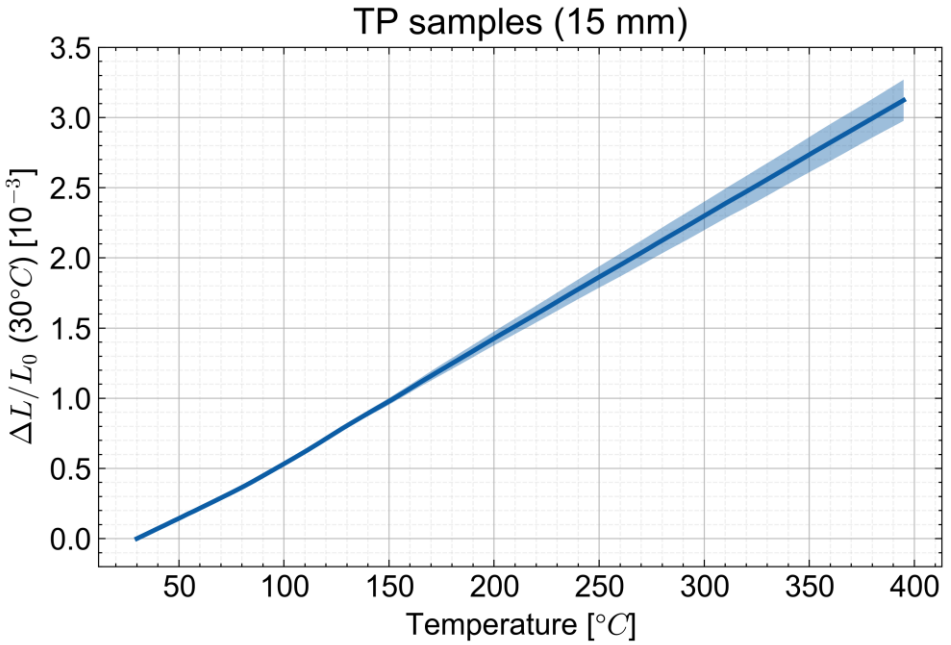


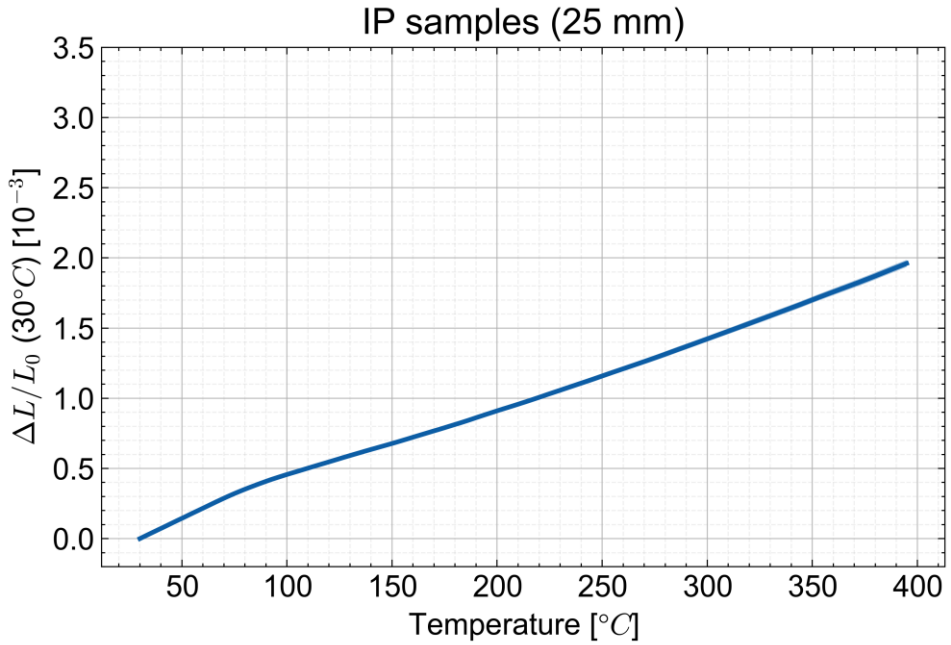
Collimator application – Cycles from RT to 1000°C

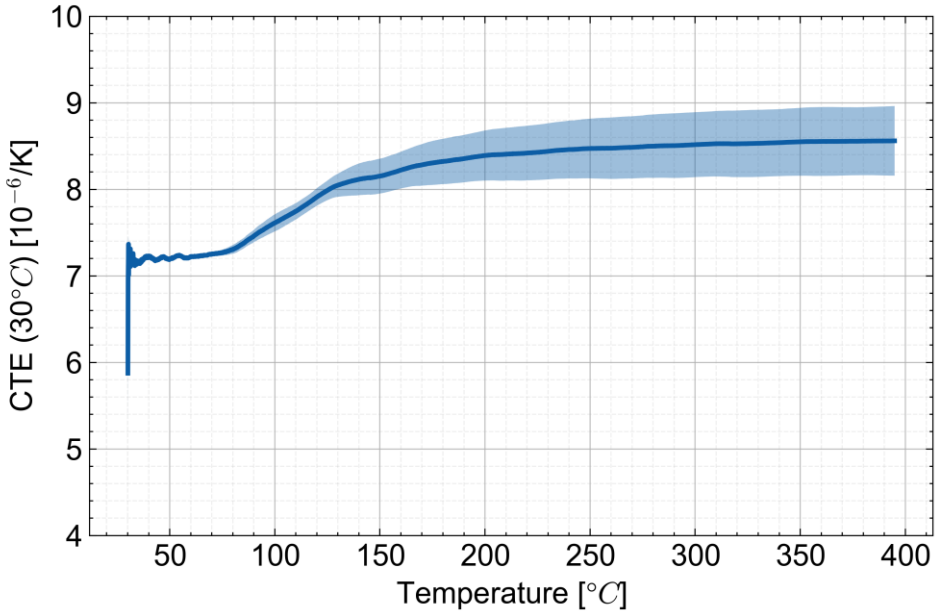


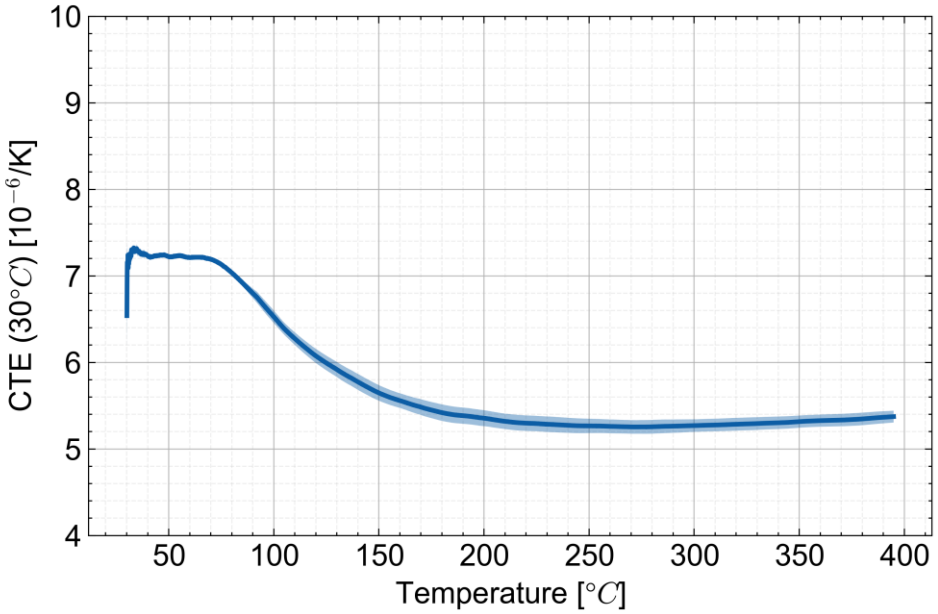


dL/L0 and CTE – 400°C









dL/L0 and CTE – 1000°C