Nanoindentation testing conditions

controlling temperature and humidity

Wolfgang Stein, Dennis Bedorf, Martin Knieps, and Daniel Habor

SURFACE, Rheinstr. 7, 41836 Hückelhoven, Germany

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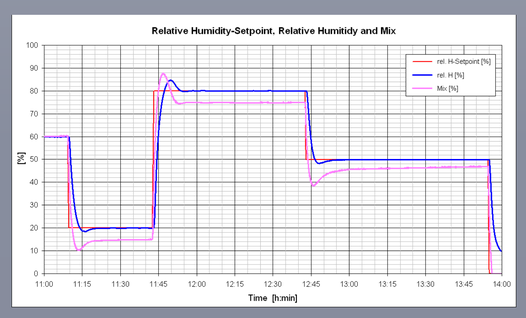
Temperature and humidity dependent properties:
- Soft materials
- Polymers
- Biomaterials

Humidity control is difficult without temperature stability → temperature control is crucial.

Humidity controller with **digital sensor**:

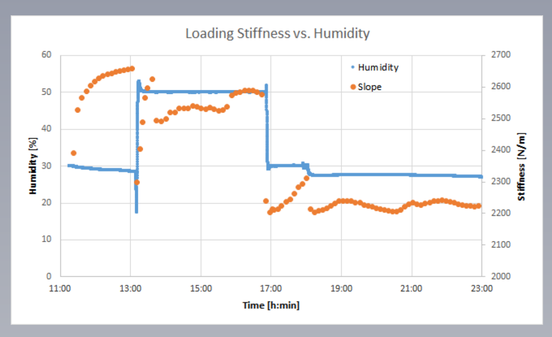
- Resolution increased to 0.03 % r.H.
- Full sensor range: 0… 100 % r.H.
- Sensor temperature range: – 40 …+125 °C
- Accuracy: ± 1.8 % r.H. and ± 0.2 °C
- Compensated for temperature effects and non-linearity

Humidity controller with gas flow meter and humidifying bottle

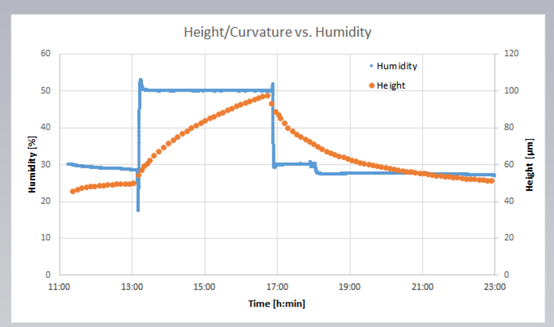


Humidity control with PID feedback

Testing pasta:
Cantilever from dry noodle sheet



Bending stiffness becomes unstable



Cantilever is bending due to humidity changes

Heating cooling humidity stage:

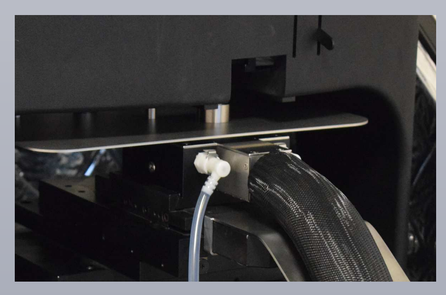
Starting point: Heating cooling stage

- Cooling liquid circulator to control temperature of sample holder / copper block
- PT 100 within sample mount to control liquid temperature
- Temperature range: -40 … +180 °C
- Temperature stability ± 0.05 °C

Heating cooling stage with sample mount (copper)

Add-on: SURFACE Humidity controller

- Dry air / pure nitrogen is humidified passing through water bottle
- Humid gas and dry gas are mixed to chosen humidity level
- Metrology grade humidity sensor senses actual humidity next to the sample
- Sensor signal used for PID feedback to control humidity level
- Humidity range: 0 … 90 % r.H., at RT
- Humidity stability: ± 0.1 % r.H. or better

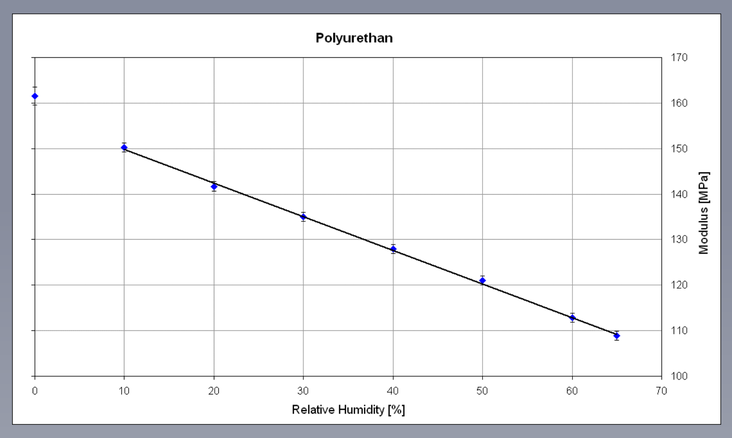


Stage within G200 nanoindenter. There is an enclosed environment between stage and shield to be purged.

User interface to control temperature and humidity

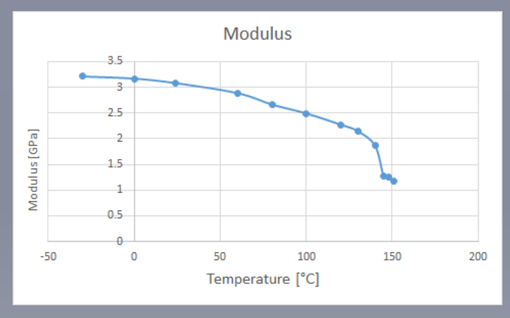
Left: Circulating chiller to stabilize nanoindenter temperature
Center: Humidity controller with heating cooling humidity stage
Right: Circulating chiller for large sample temperature range

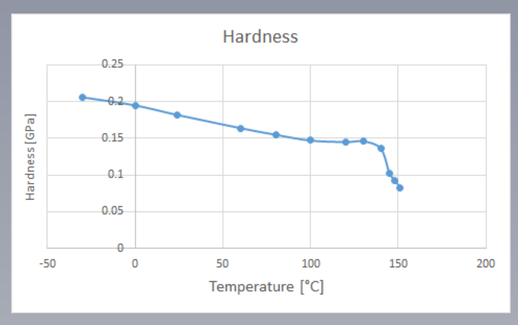
Modulus of polyurethane sample vs. humidity



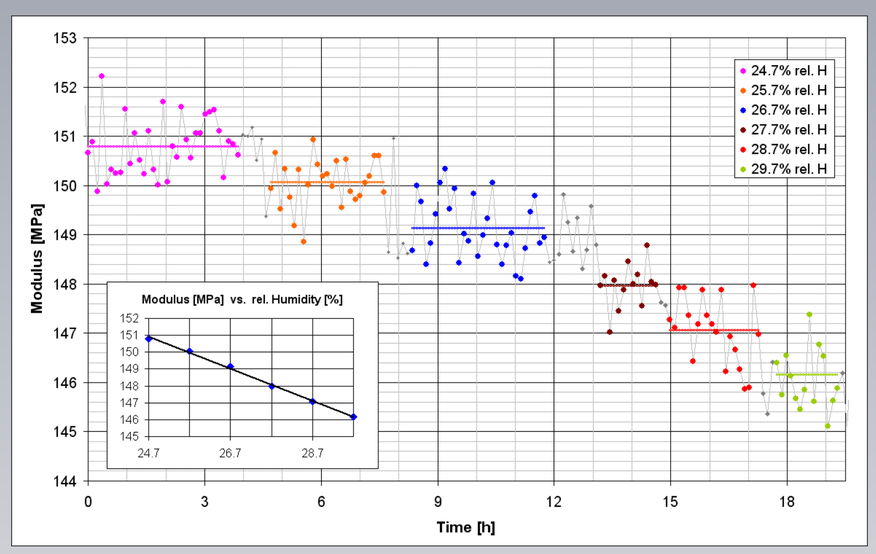
Modulus of polyurethane sample at 33°C over a large humidity range.
Data at zero humidity shows modulus above linear tendency.

Polycarbonate studied with heating cooling stage

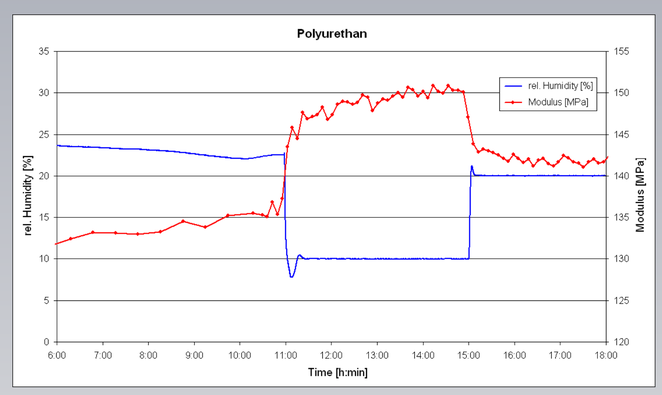




Softening of PC at ~140°C



Sequence of multiple CSM indents for 1 % humidity steps
Inset: Mean value of modulus shows linear decrease vs. humidity



Time dependency between humidity changes and modulus changes. Humidity control started at 11:00

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nanometrology tools - always one step ahead