Update on Temperature Sensors

Miriam Kümmel
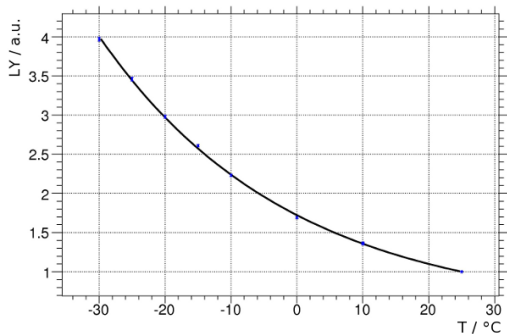
Ruhr-Universität Bochum

$\overline{\text{P}}$ANDA Meeting
June 2019

EMC: Thermal Requirements

PWO-II: LY depends on T with $\frac{d(LY)}{dT} = 3\,\%/°C$ at $20\,°C$

Goals for $\overline{P}$ANDA:

- Stability $\Delta T < 0{,}1\,°C$
- Homogeneity $\Delta T/\Delta l < 0{,}1\,°C/cm$
- $\rightarrow$ Temperature resolution $\sigma_T = 0{,}02\,°C$

Amounts of ultrathin sensors

	X/S	Required	Ready	Pending
Forward End Cap	8	482	98+12	372
Barrel	10	1152	83	1069
Backward End Cap	4	160	0	160

Ultrathin Temperature Sensors: Design and Production

- Maximum width $\lesssim 150\,\mu m$
- 4-wire measurement of a Pt wire with $d = 25\,\mu m$ and $l = 0{,}5\,m$
- In 18 windings of 27 mm each
- Semi-automization with 3D printer
- Ultrathin cables based on copper coated polyimide foil with gold-plated contacts
- Contacting Pt wire and cables via conductive adhesive
- Small PCB with a used as a mechanically stable plug

adhesive polyimide foil

copper coating

silver adhesive

gold-plated contact pads

platinum wire
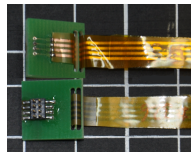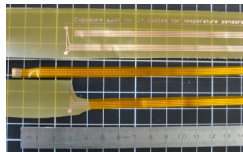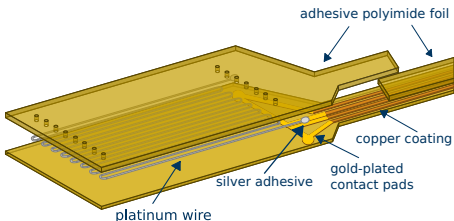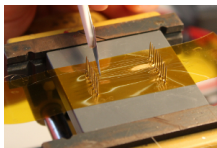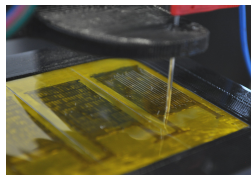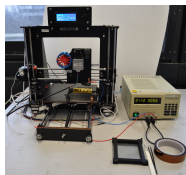
Ultrathin Temperature Sensors: Printer Improvements
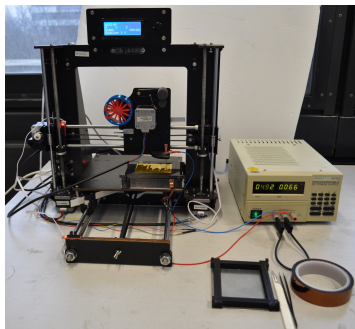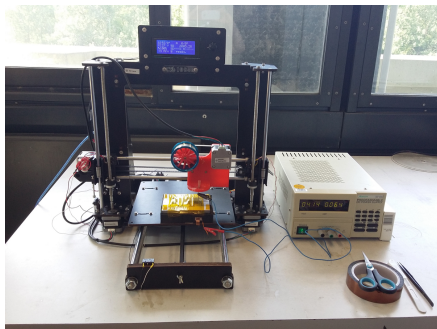
In the scope of the Bachelor's thesis of Jürgen Klooß:

- New firmware and own GUI: e.g. Stop works now immediately
- Mechanics to adjust orientation the printing bed
- 2 more reels (tape and felt covered) pulling the wire

Suggested and designed by student assistant Vincent Freudenreich:

- Frame for putting the tape on to easily remove it after printing
- Frame holder to prepare the tape easily before placing it in the printer

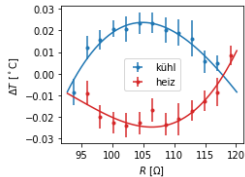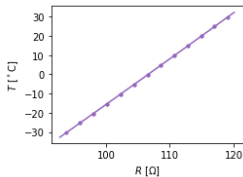# Ultrathin Temperature Sensors: Calibration Evaluation

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- Polynomial $f(R)$ of 3rd suited best to describe data
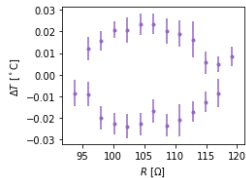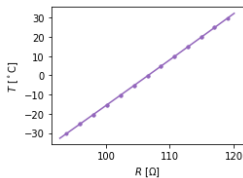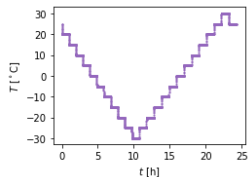
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- Quality criterion for calibration
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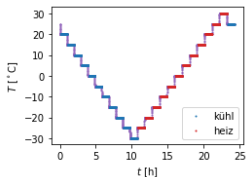
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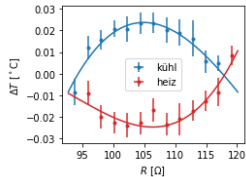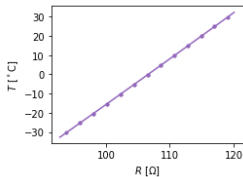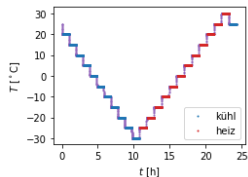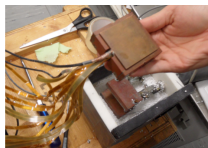- Polynomial $f(R)$ of 3rd suited best to describe data
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- Modified calibration setup to calibrate 30 instead of 12 sensors simultaneously and more efficiently
- Tested alternative methods for sensor production

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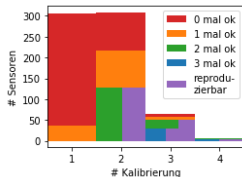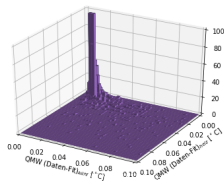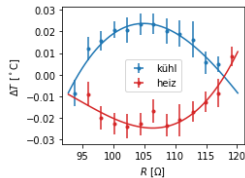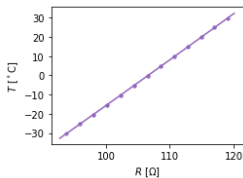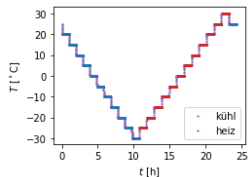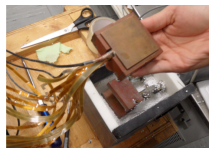$$\sqrt{\frac{1}{N} \sum (T_i - f(R_i))^2} < 0{,}02\,°C$$
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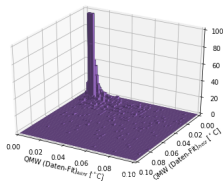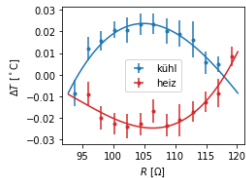- Modified calibration setup to calibrate 30 instead of 12 sensors simultaneously and more efficiently
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Ultrathin Temperature Sensors: Production Methods

- Winding the Pt wire manually (0, 1) or with 3D printer (2-19)
- Preparation besides cleaning contacts with isopropyl alcohole
  - Surface roughening with He plasma (3, 4)
  - Cleaning both wire and contacts with acetone (5-6, 8, 11-12, 14, 17-19)
  - Combustion chemical vapor deposition of silicate (7-8, 10-11, 13-14)
  - Prohibiting Pt wire from touching sticky side of tape (16)
- Contacting the Pt wire with the contact pads of the cable
  - Bonding (externally: Fraunhofer IZM SIIT)
  - Conducting adhesives
    - Epotek H37MP (0-8)
    - Elecolit 414 (9-11)
    - Elecolit 3661 (12-14)
    - Polytec EC 242 (15-17)
  - Soldering (18-19)

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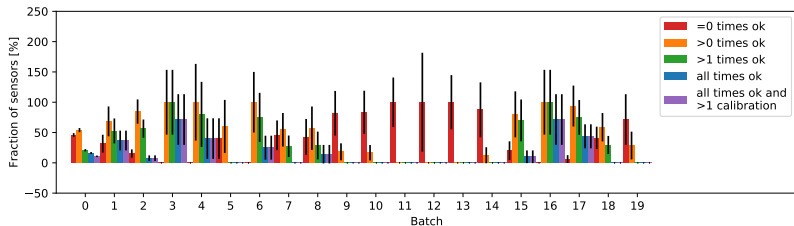   - Polytec EC 242 (15-17)
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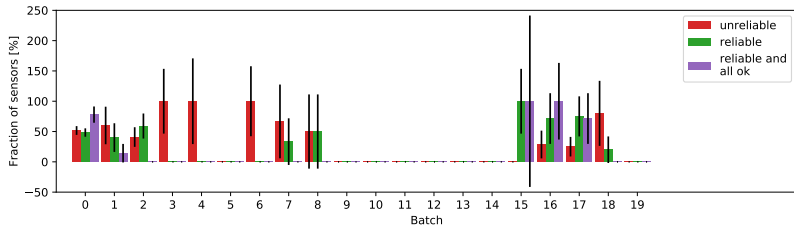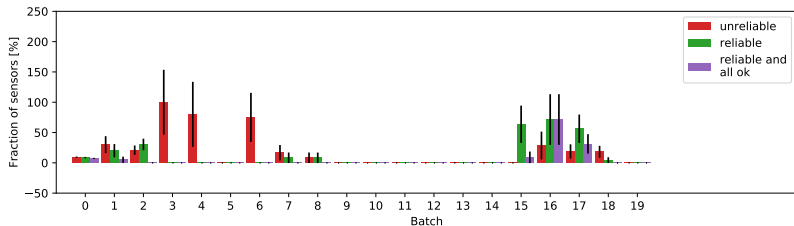   - Polytec EC 242 (15-17)
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Achievements, Issues and Approaches

! Urgent need for sensors to bulid FWEC APD submmodules
✓ Improved calibration setup to simultaneous calibration of 28 instead of 12 sensors in 24h
✓ Improved production procedure to a rate of 75%
✓ Several improvements of 3D printer setup
✓ Required amount of Polytec EC 242 ordered
→ Mass production with shift plan of 72 per week:
  Print 6 times 3 windings on 4 days, 1 or 2 days for gluing
  due to 48h pot life at room temperature

! Test run with remaining glue from tests revealed several issues:
  ! 3d printed frames do not fit precisely and frame holder broke
  → Ordered precisly milled more stable version at the workshop
  ! Torn Pt wire caused by broken ball bearing
  → New ball bearings arrived, currently adjusted in workshop
  ! How to deal with failed prints?
  → Flexible shift plan takes them into account
    and visualizes if more shifts are need
  ! How to store printed wires savely?
  → Attach to sensor area immediately except for contacts
  ! How to gather all informations?
  → Detailed printed instructions and control slip
! Often sensors need to be replugged before
→ Reconsider 2×4 pin header plug?