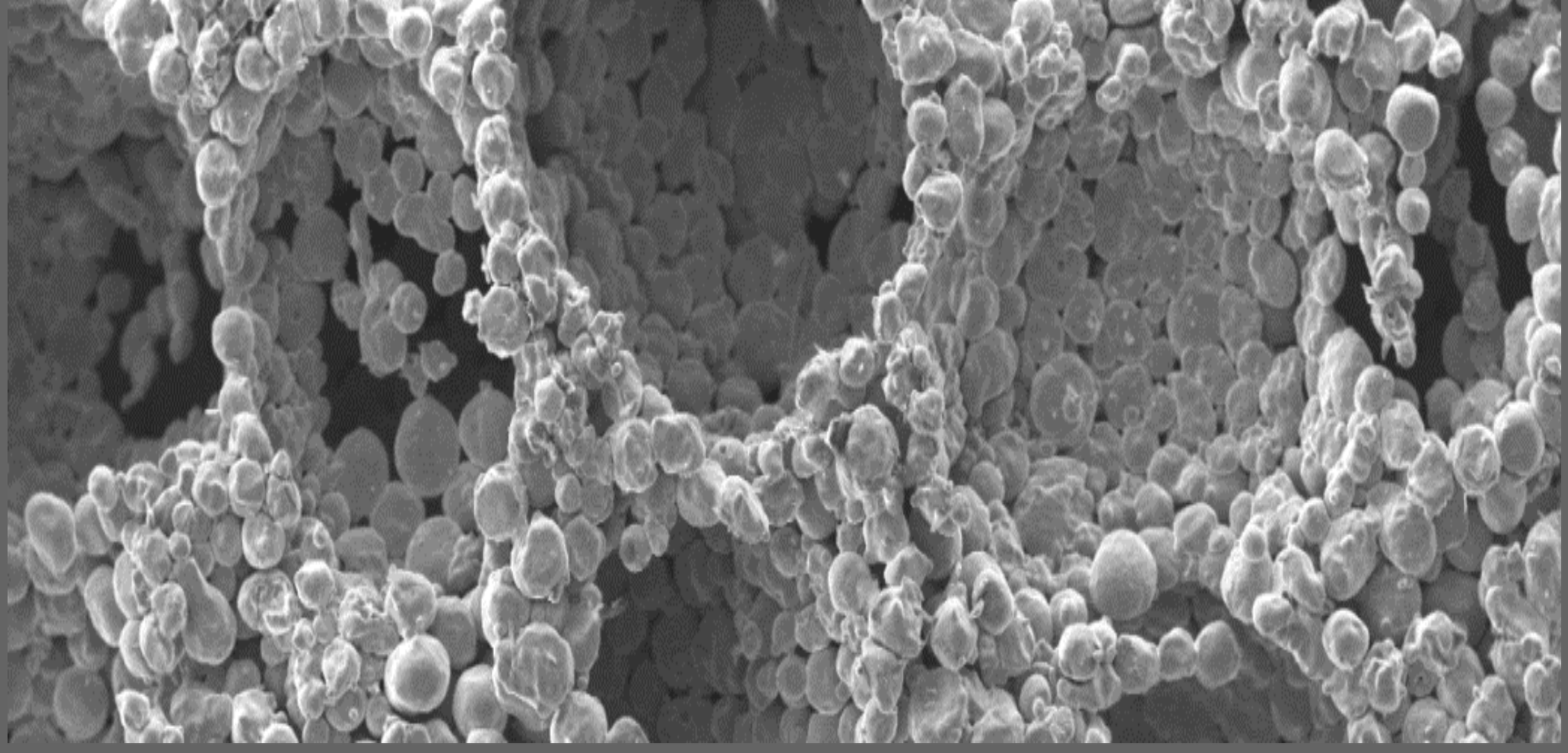


Thermal conductivity of copper foam

G. Tomás, D. Martins, A. Cooper and G. Bonfait

FACULDADE DE CIÊNCIAS E TECNOLOGIA UNIVERSIDADE NOVA DE LISBOA

LIBPhys-UNL

Versarien PLC

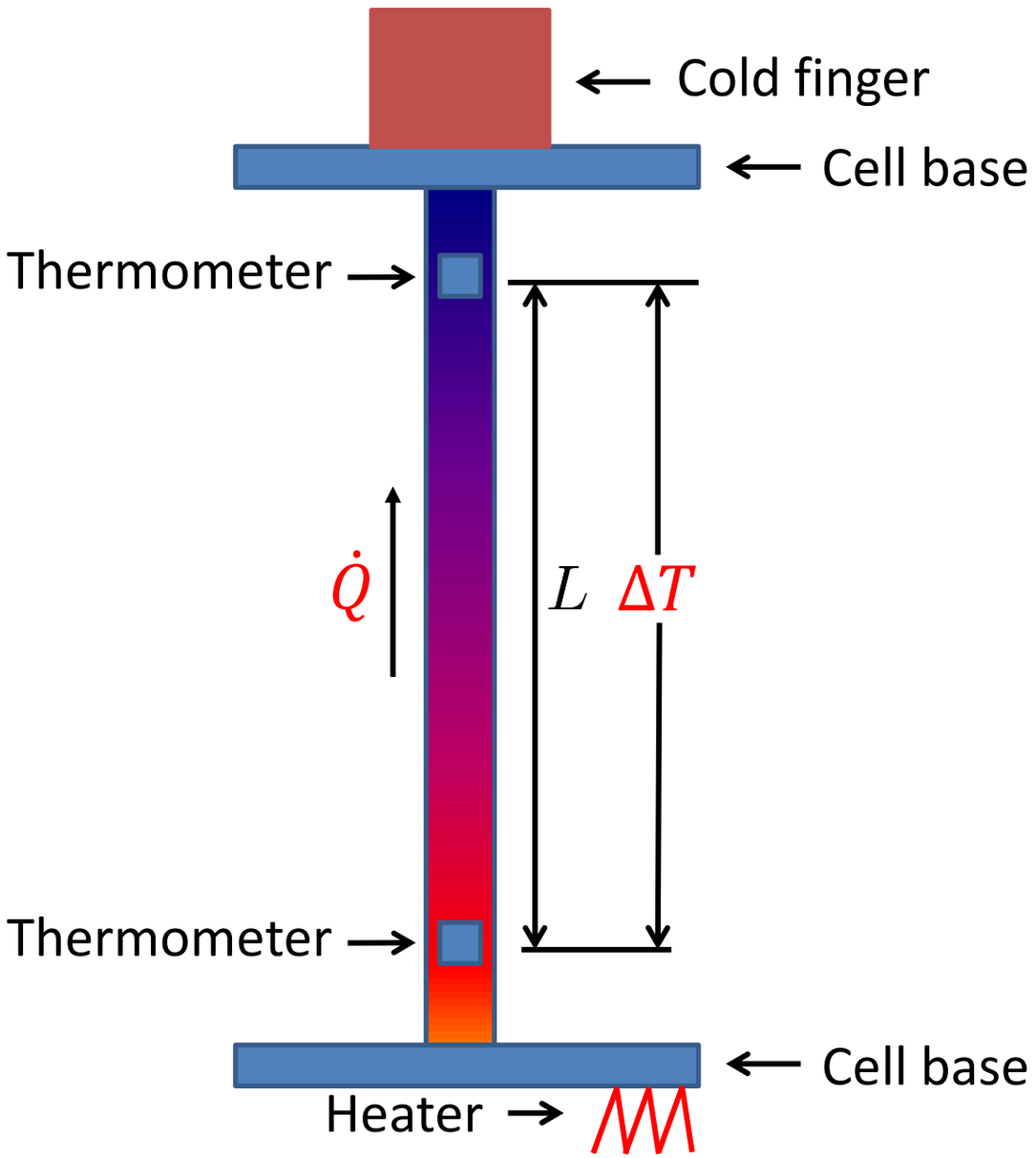
June 29th 2015 Tucson, Arizona, Cryogenic Engineering Conference

Motivation

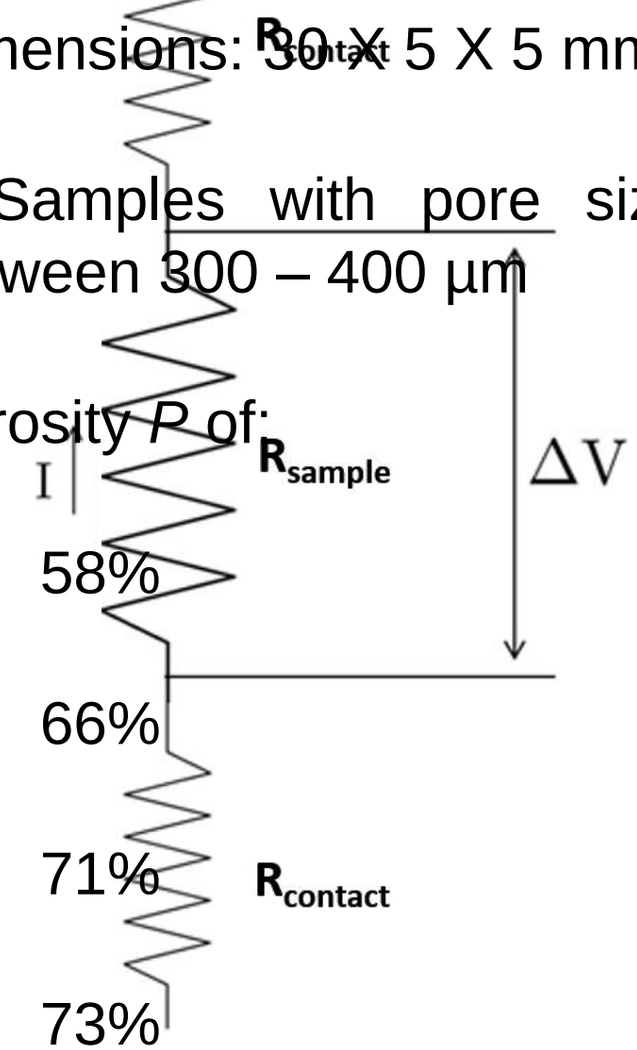
- Highly porous and good thermal conductor materials have interesting applications in the cryogenics field.
- Particularly in microgravity systems, for liquid confinement by capillarity like energy storage units (see Thursday C4OrD-05 10:00 “15 K H2 ESU”).
- Absence of such materials with pore size below 500 µm.
- Characterization of copper foam thermal conductivity with pore size between 300-400 µm and porosity between 58-73% (from Versarien, UK).

Measuring directly in the sample

$$\dot{Q} = k\frac{S}{L}\Delta T$$



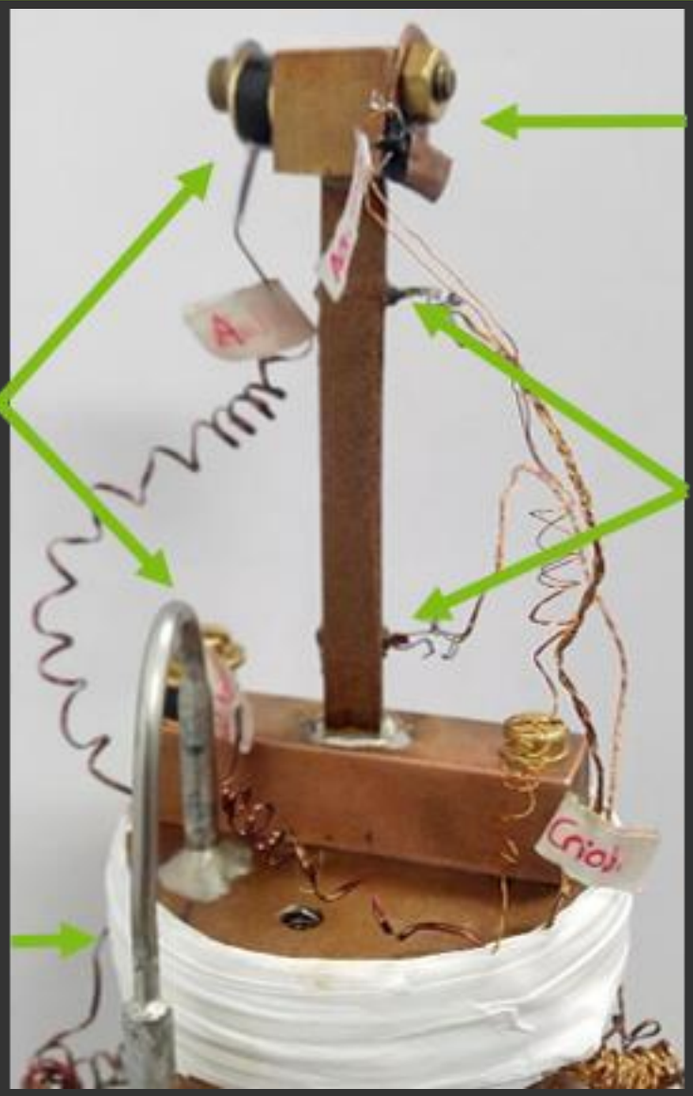
- Cryocooler: 2 W @ 20 K
- $\frac{\Delta T}{T} = 10\%$
- Dimensions: 30 X 5 X 5 mm
- 4 Samples with pore size between 300 – 400 µm
- Porosity P of:
  - 58%
  - 66%
  - 71%
  - 73%

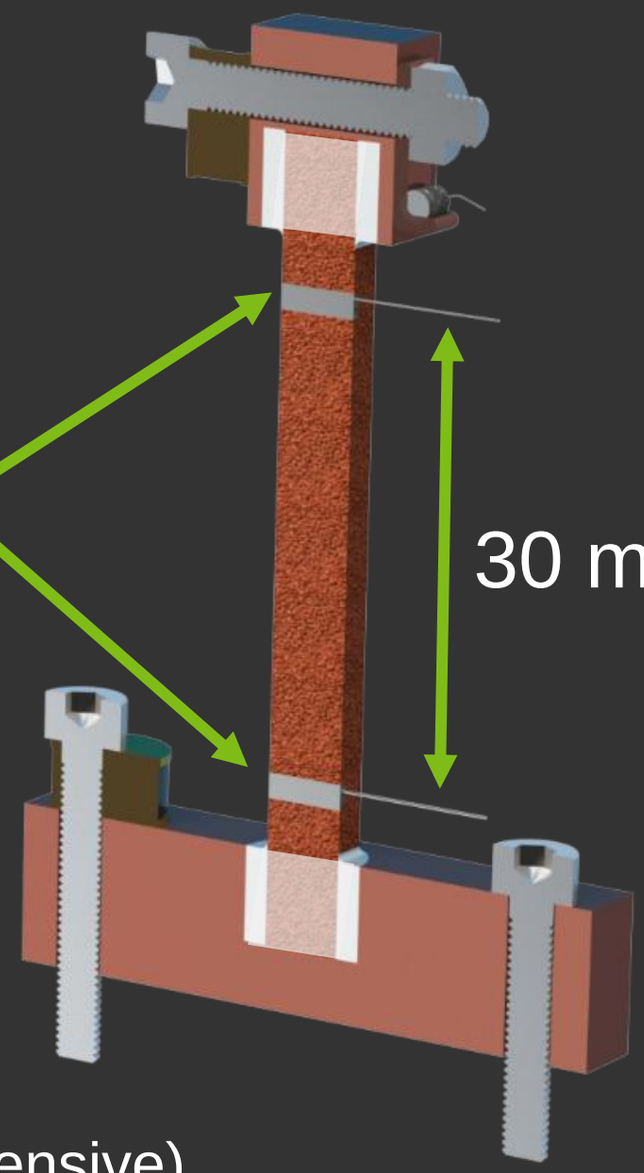


Experimental set up

Diode

Cold finger

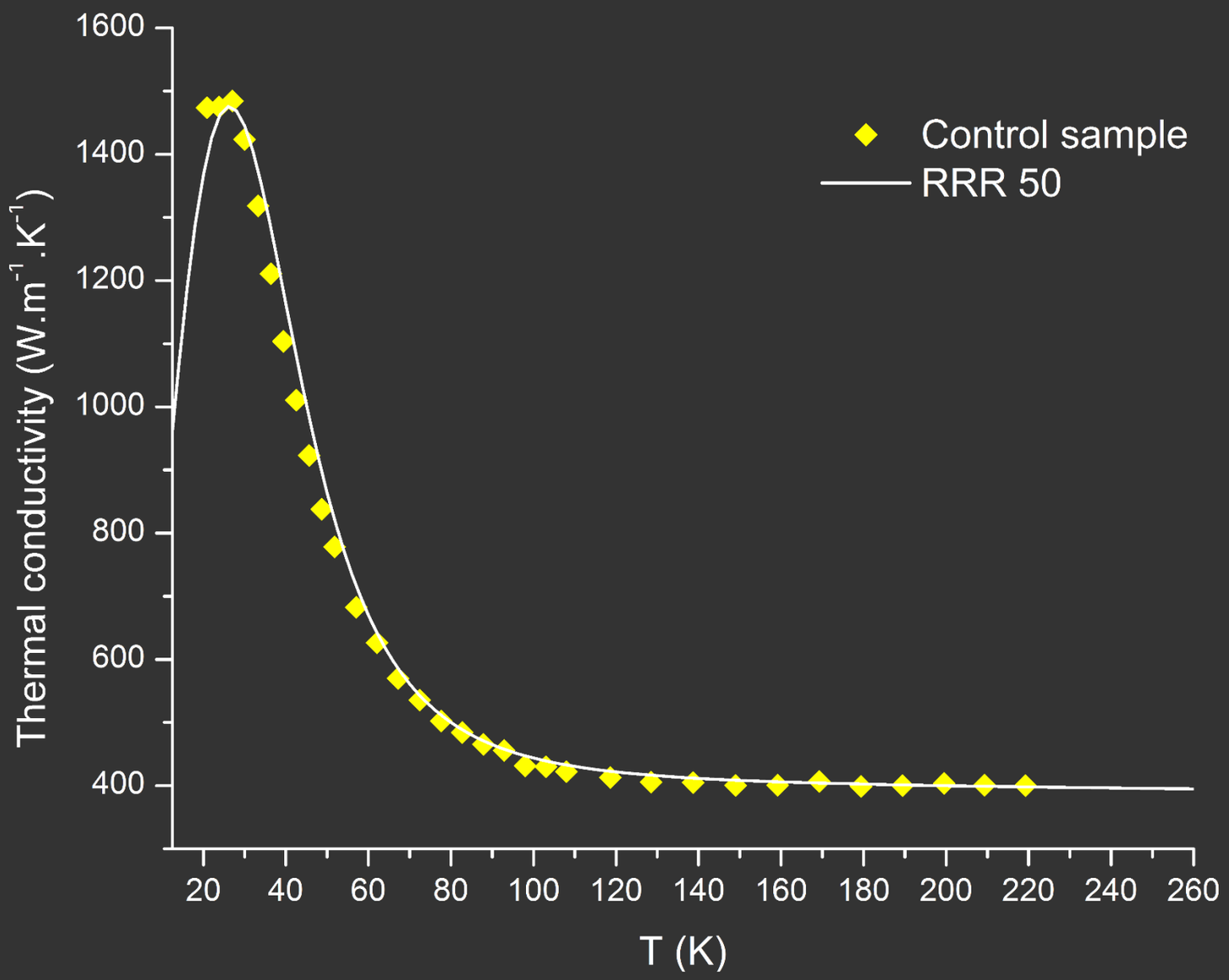




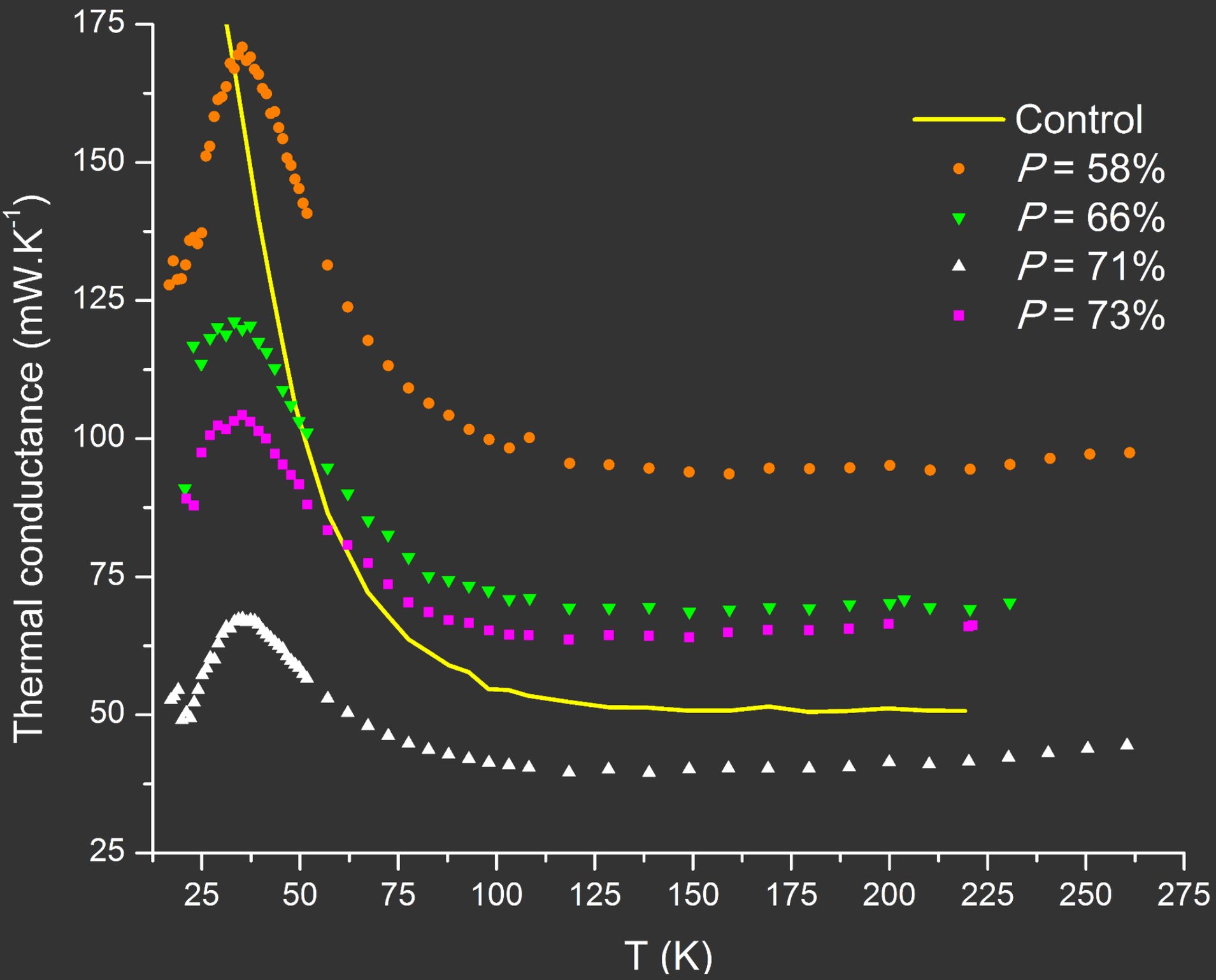
- 1.6 mm x 5 mm $Pt_{100\,\Omega}$, stycast encapsulation (inexpensive).
- Homemade calibration down to 20 K.
- Upgrade: GaAs diodes for measurements down to 10 K.

Control Sample

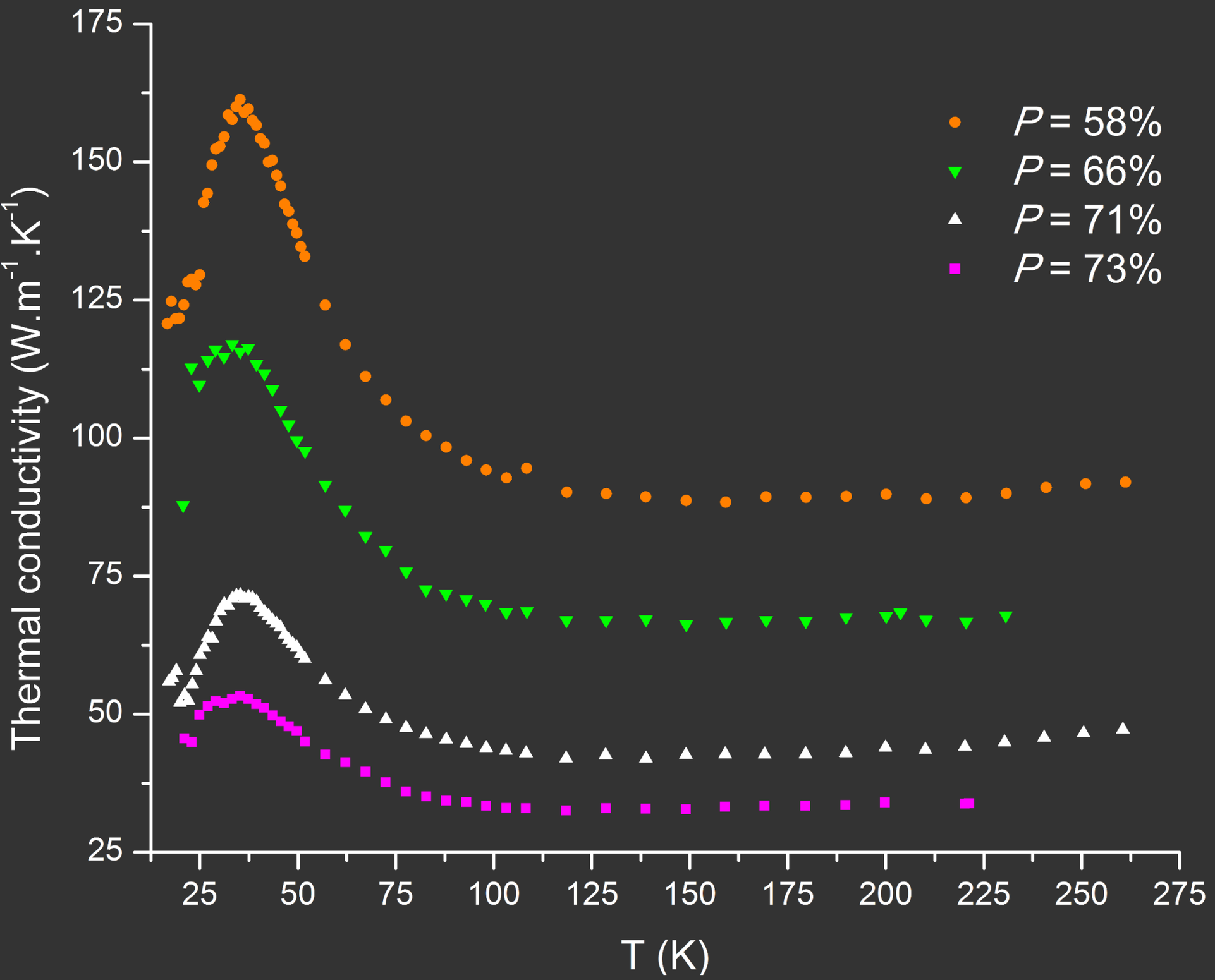
- Bulk of ETP copper
- Dimensioned to have a thermal conductance similar to the samples



Results


Thermal conductance (mW.K-1)
T (K)
175
150
125
100
75
50
25
25
50
75
100
125
150
175
200
225
250
275
Control
P = 58%
P = 66%
P = 71%
P = 73%

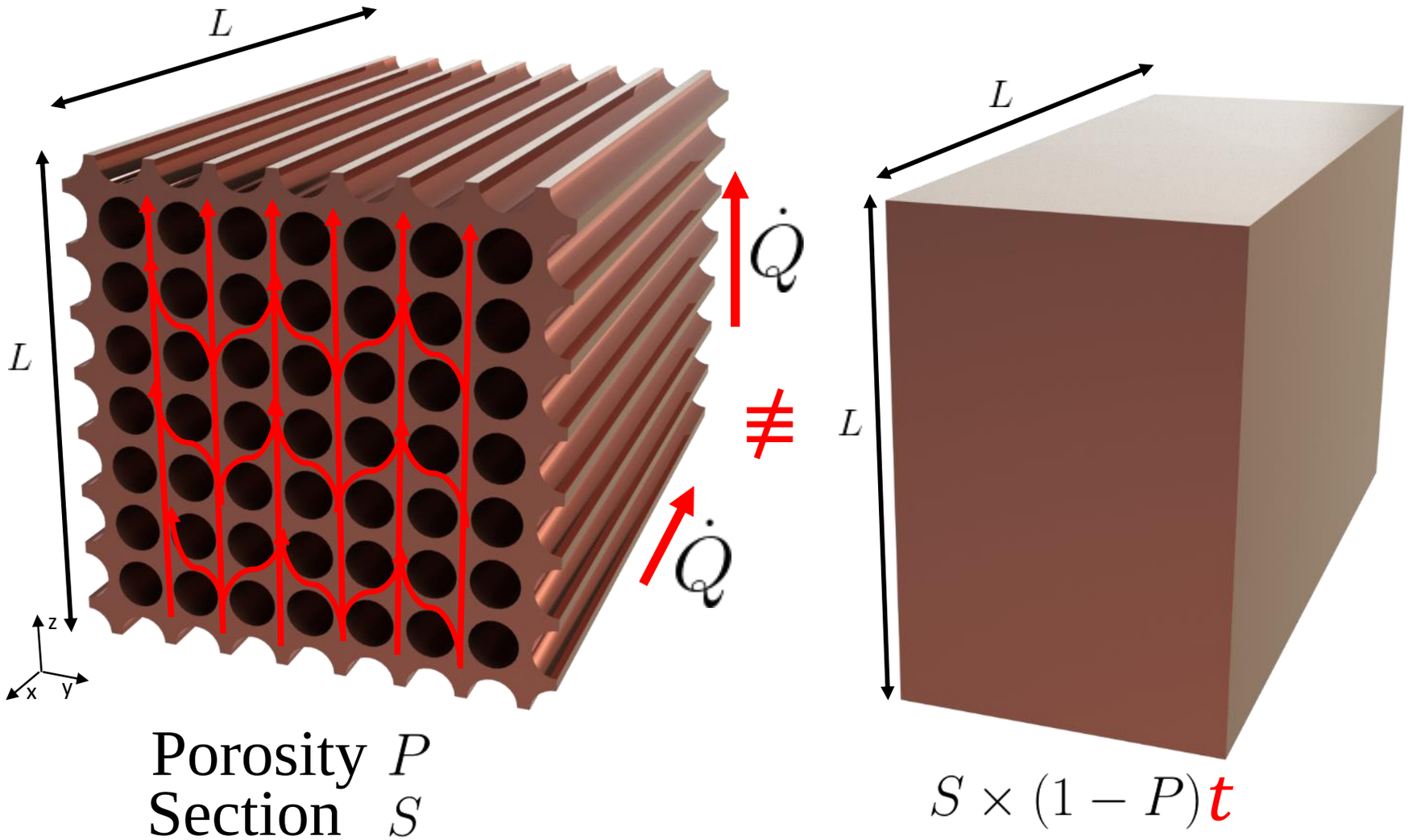
Thermal conductivity of the samples



Porous material model

$$K_{foam} = K_{bulk}(1 - P)\, t$$

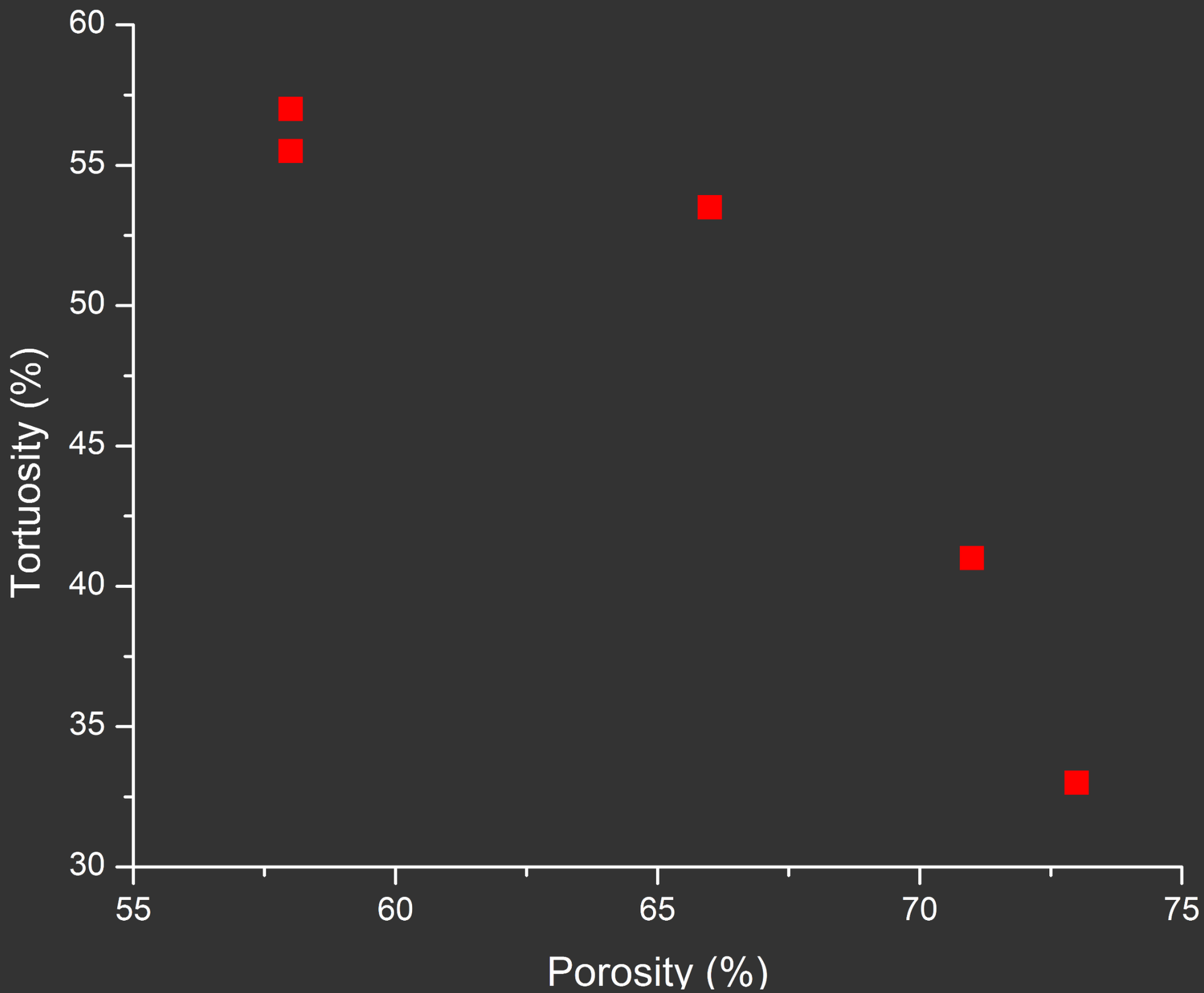
Tortuosity t



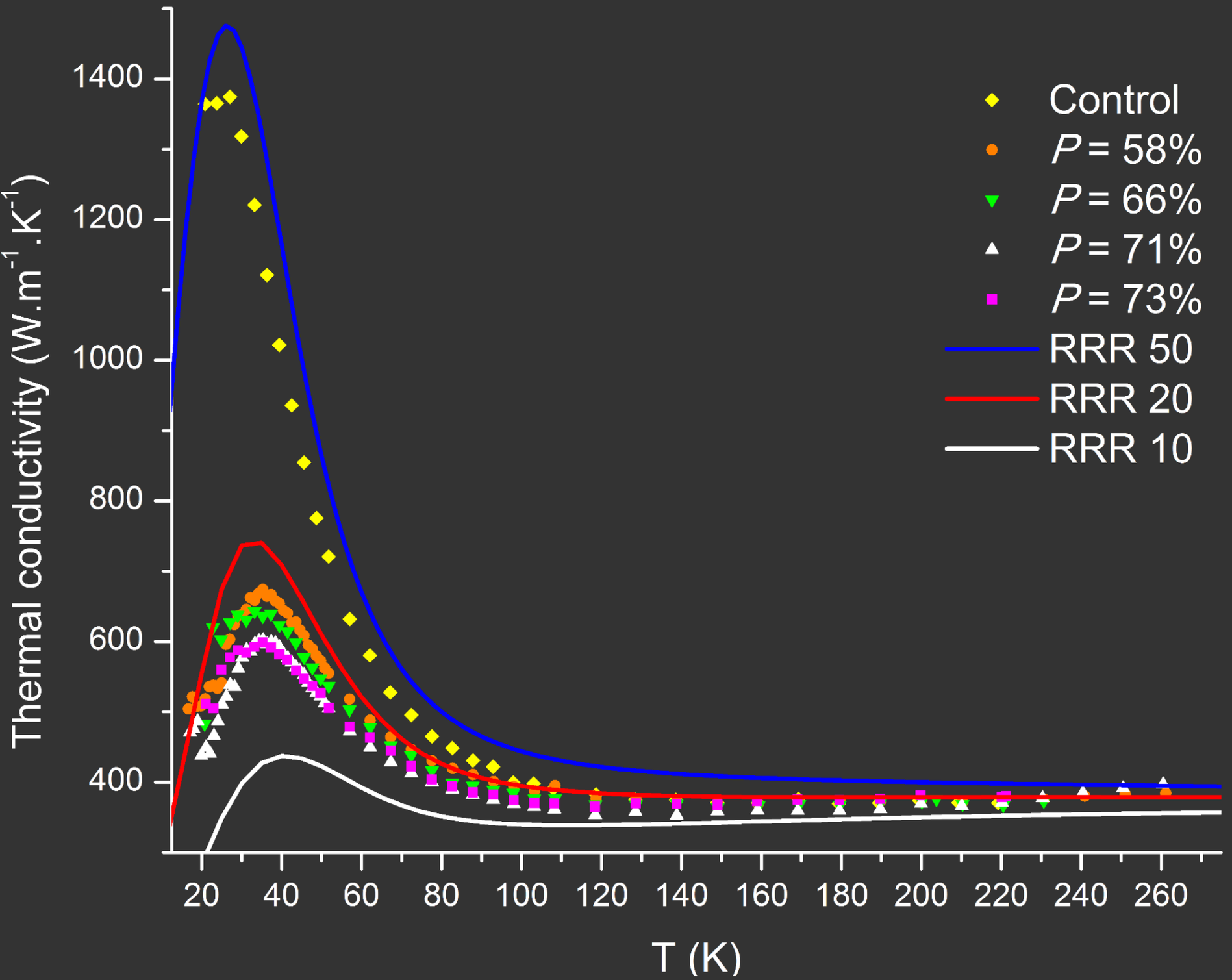
$\not\equiv$

Porosity P
Section S

Tortuosity dependence



Normalization of the samples

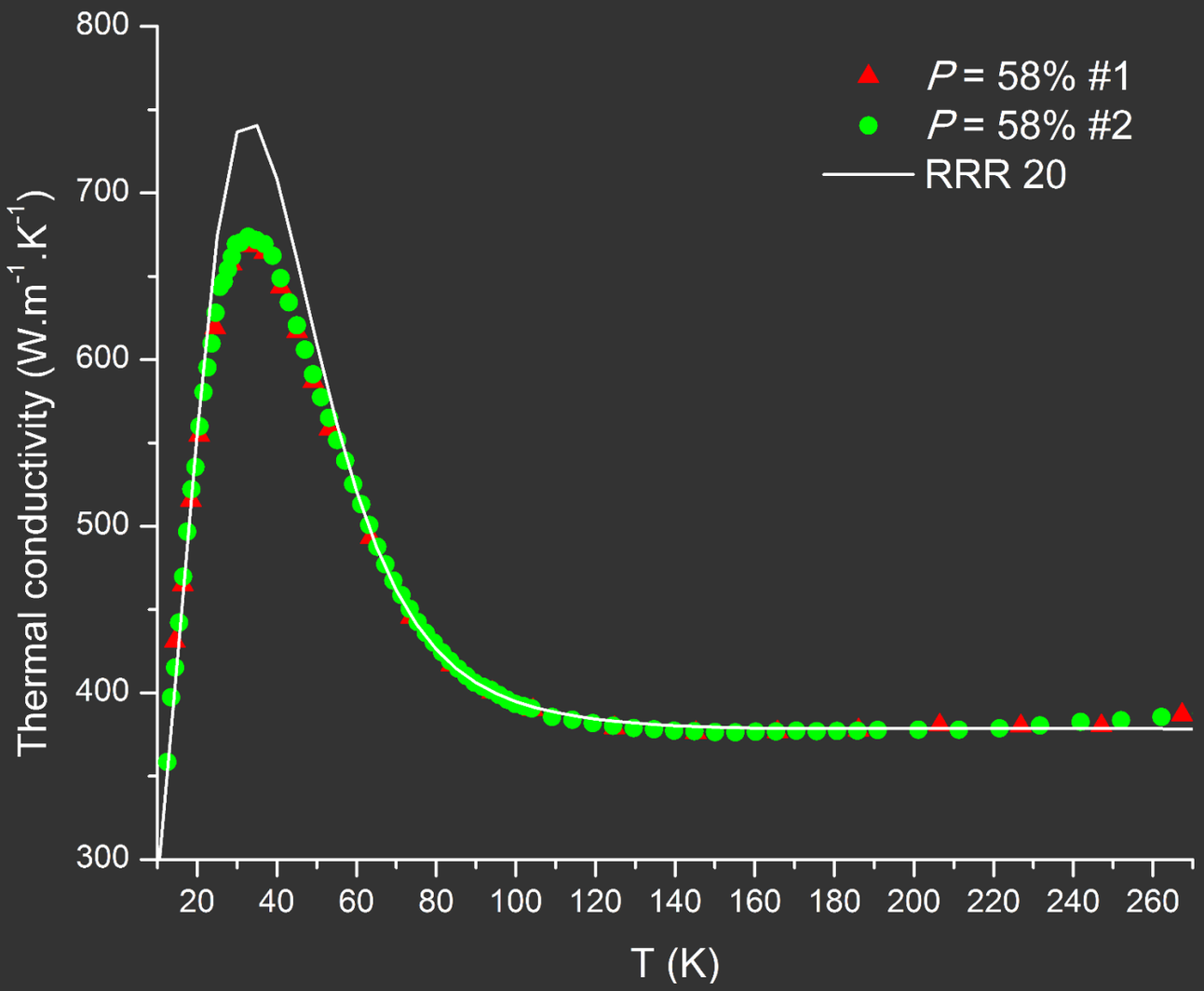


Conclusions

- We built and validated a system to measure the thermal conductivity of highly conductive materials.
- The system allowed the measurement of the thermal conductivity of the control sample and the four copper foams.
- The behavior of the thermal conductivity of the copper foam is similar to that of bulk copper.
- The purity level of the copper within the foam decreases only slightly with porosity and is between RRR 20 – RRR 10.

Conclusions

- The tortuosity was calculated for all samples and was shown that it decreases with porosity.
- The system has now been upgraded allowing for more precise measurements down to 10 K.



CRYOGENICS LABORATORY @ FCT

- This work was partially supported by the European Space Agency.

- Contacts:
  - G. Tomás: g.tomas@campus.fct.unl.pt
  - G. Bonfait: gb@fct.unl.pt
  - Cryogenics laboratory: http://www.libphys.fct.unl.pt/services-facilities/cryogenics-laboratory

Thank you!