Relationship between thermal conductivity and free electrons in metal

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Abstract

An experiment has been done to verify if the electrons dominate the thermal conductivity in solid metals. The result shows that the electrons does dominate the thermal conductivity in bulk metal.

Introduction

Conductor:
- There are three kinds of Conductors: electricity, thermal and sound.

Thermal conductivity:
Two contribution for thermal conductivity
- Lattice vibration which in terms of phonon
- Motion of electrons

Theory :
- $K=QL/A\Delta T$ (Fourier's law)
  - K: thermal conductivity
  - L: length of the sample
  - Q: the amount of heat through the sample
  - A: the cross section area of sample
  - ΔT: Temperature difference

- The thermal conductivity K changes when changing the direction of the current run through the sample
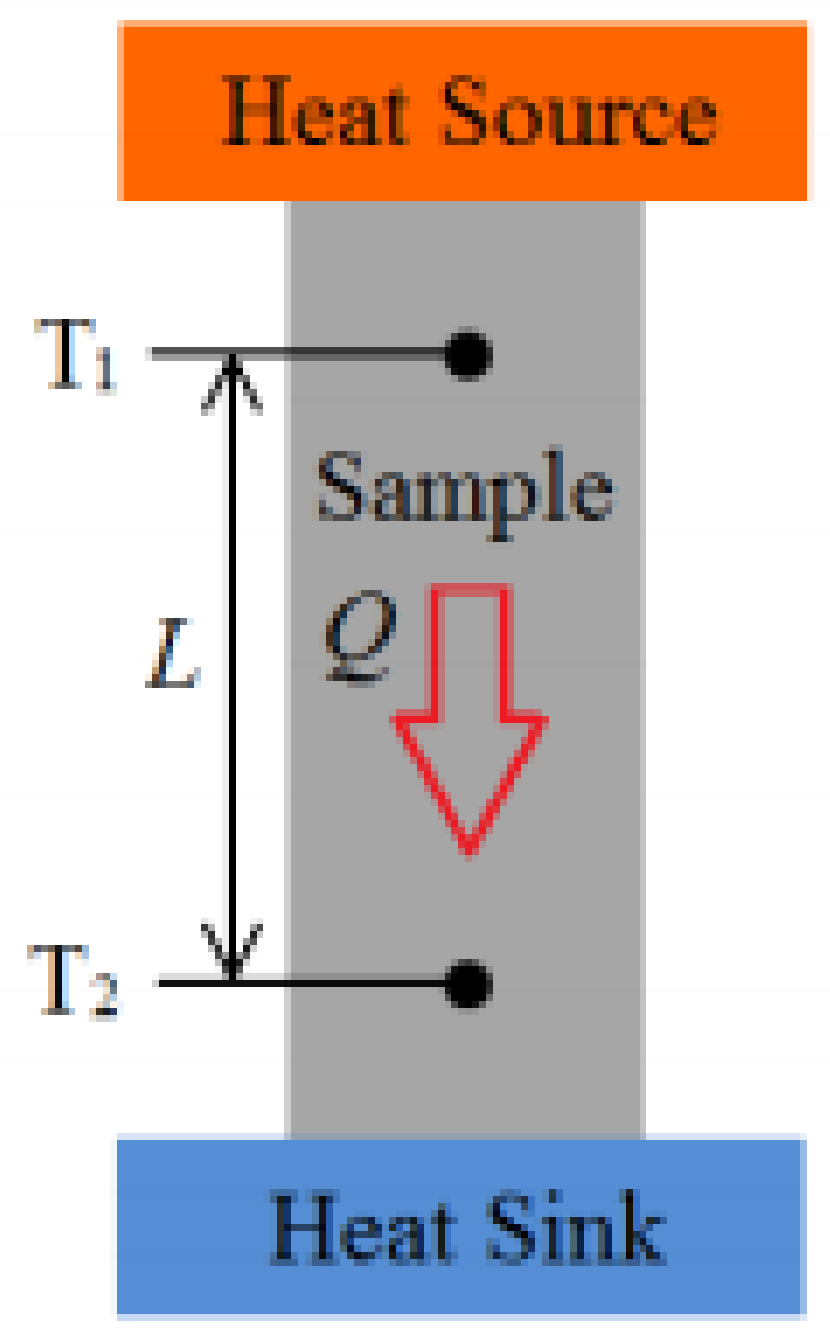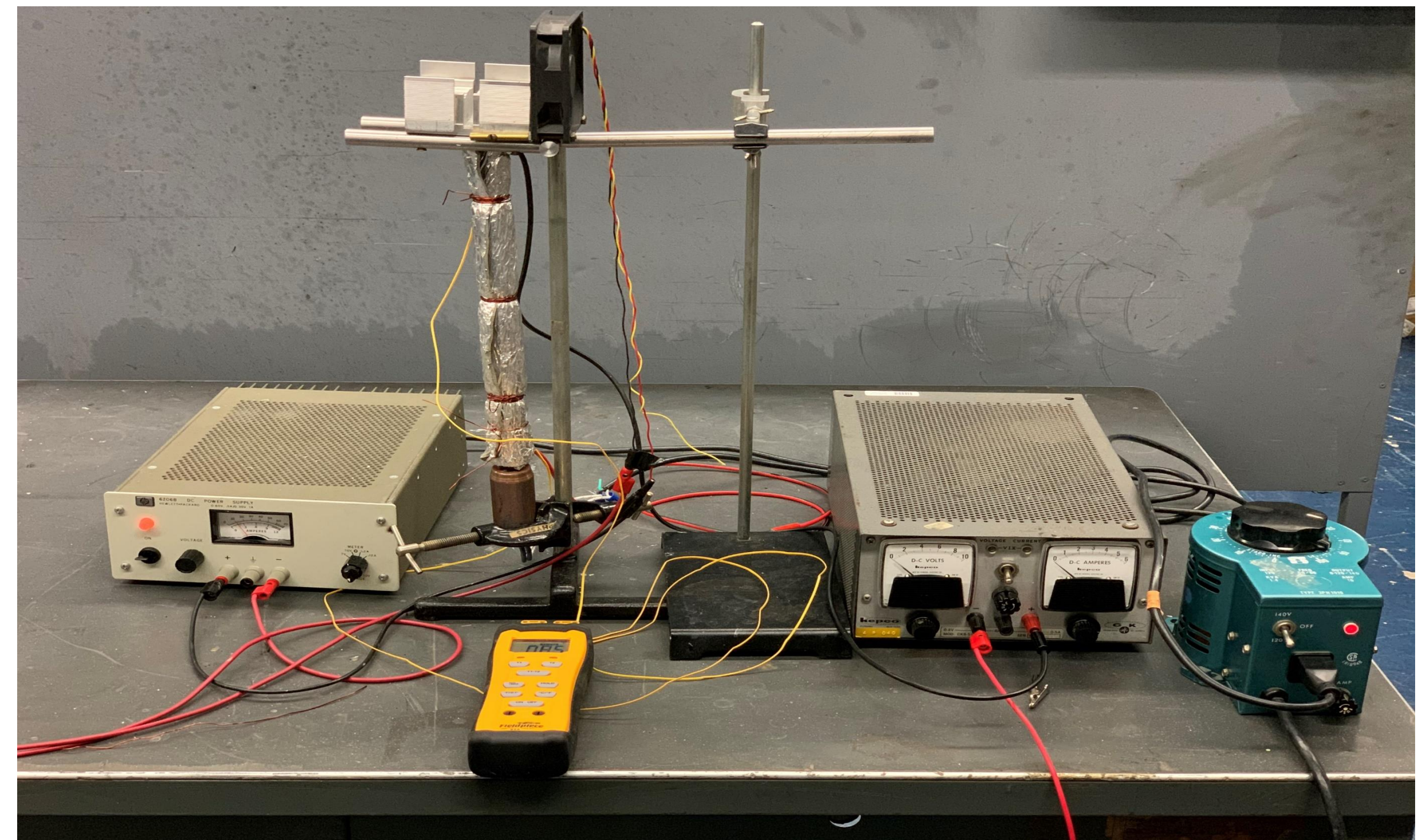

Setup & Procedure

Main Body setup:

Heater (50W 110 V)   Heat sink (12w 6v Fan+ Heat sink)

Main experimental apparatus

Procedure:
- Sample preparation
- Build up apparatus
- Procedure
  - Put a heat source on one end of the metal rod and a heat sink on another end. Turn on the heat source and waiting until temperature reach steady state (T1, T2 does not change with time).
  - Thermal conductivity calculation using Fourier's law
  - Run electric current through the sample along the direction of heat flow
  - Repeat the same experiment but the electric current is in opposite direction

Results & Discussion

Electrons Follow The Heat Flow (Cu, 5A)

(After Turning Off) Time vs temperature difference
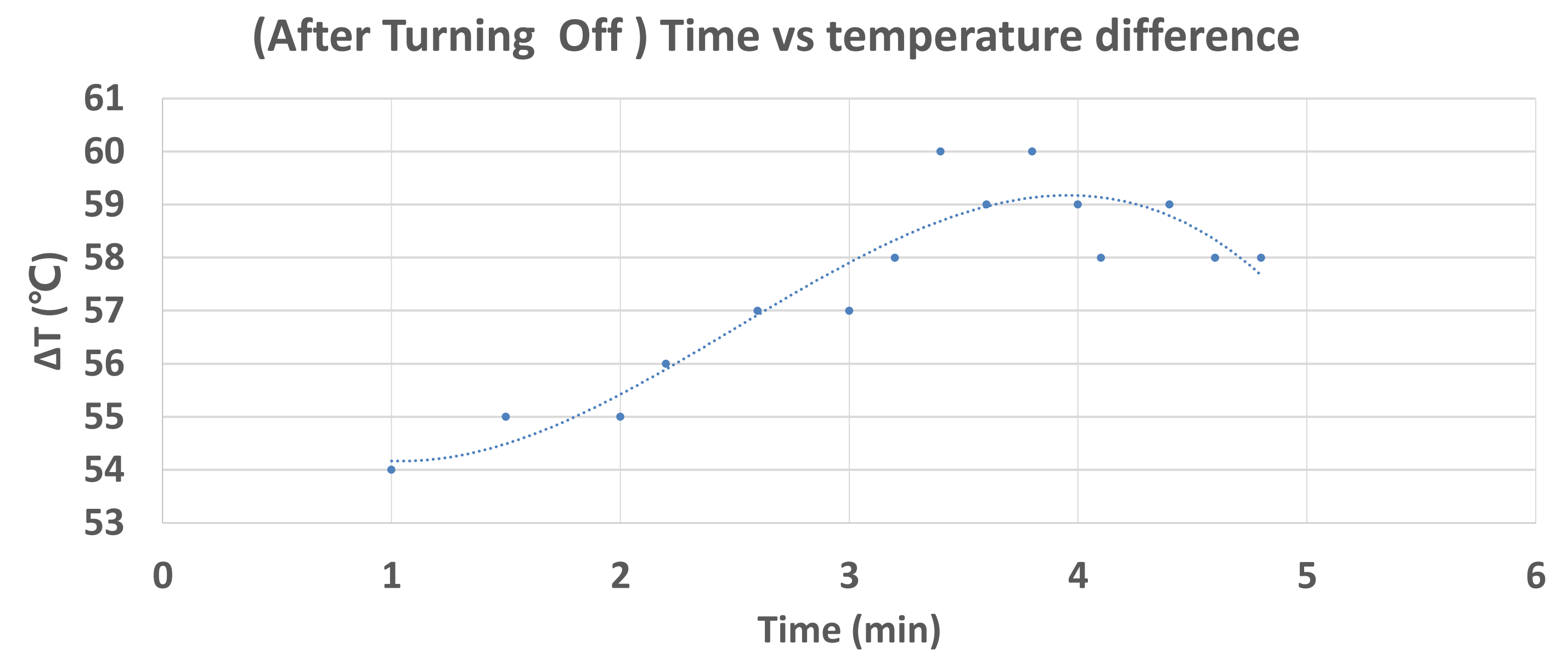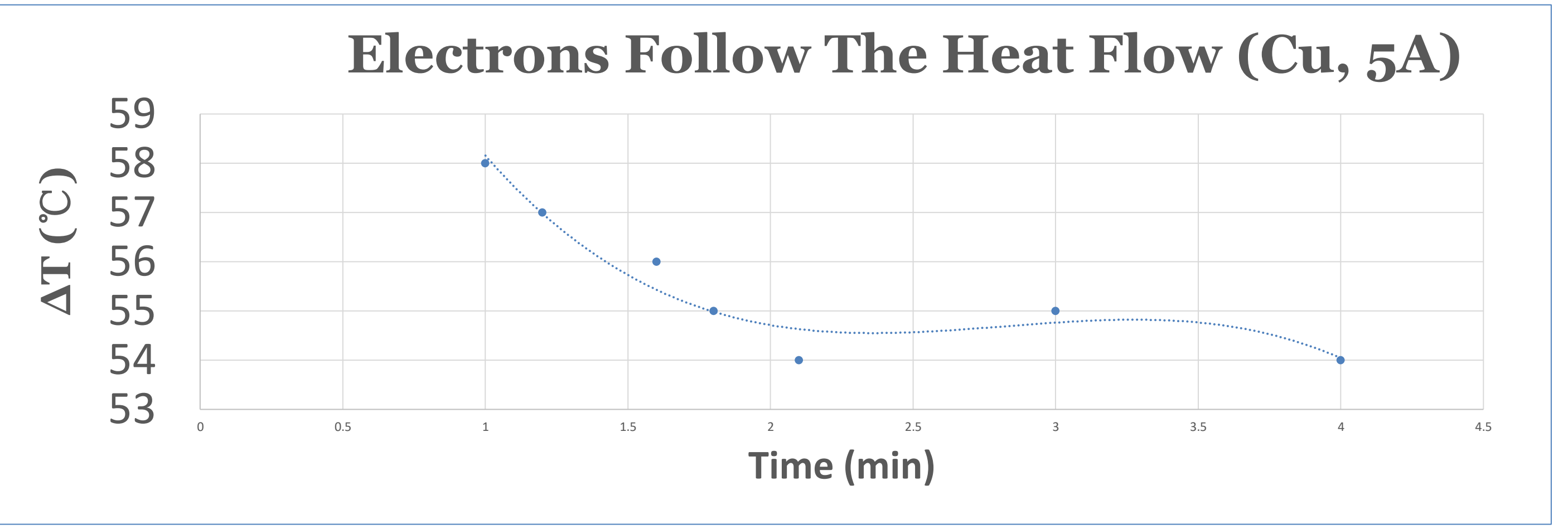
Conclusions: The electrons dominate the thermal conductivity, when the electrons act on the metal rod, the ΔT changes which means K changes

Future Works

- Increase the current to higher value (make the result more visible)
- Try more materials.
- Seeking theoretical explanation

Acknowledgements

References

Zhao etc. https://arxiv.org/ftp/arxiv/papers/1605/1605.08469.pdf