Thermal Imaging of Thermoelectric 1D nanowires of Bi2Te3 using Scanning Thermal Microscopy
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Introduction: Energy harvesting is certainly one of the most exciting challenges in modern physics. Theoretical calculations, material engineering and novel experimental characterization techniques have risen to fully explore the nanoscale limit and new materials with tailored properties. The purpose of this work is to present the current state-of-progress of the thermal metrology platform developed at LEMTA and more specifically the scanning thermal microscope (SThM). We applied this SThM technique to the study of thermoelectric-based Bi₂Te₃ nanowires.

Scanning Thermal Microscopy principle

Principle

The nano-probe can be seen as an electrical resistance inside a Wheatstone bridge. When a current I is send, Joule effect takes place and heats up the nano-probe. The knowledge in the variations of current send in the probe are related to its temperature changes and thus to the heat transferred to the nano-objects.

Temperature imaging mode

Probe is kept at a constant temperature by keeping V_{bias} = constant inside a feedback loop. The changes in the current are monitored to create an image.

DC Conductivity imaging mode and 3D SThM

DC probe current is kept constant and the changes across the bridge are monitored to create an image. 3D-STM relies on the same principle except that the probe current is a AC-current. The third harmonic of the voltage, filtered by a lock-in amplifier, is proportional to the probe temperature: V(3ω) ~ T(2ω).

Imaging and thermal microscopy of nanowires

Electrochemically grown Bi₂Te₃ nanowires

Modelling heat transfer between nanoprobe and environment

Out-of-contact Probe Temperature

Contact Probe Temperature

Modelling the contact with NWs

Future improvements

3D-STM

More sensitive than dc-method to energy transfer between tip and nano-objects. Better suited for thermal property metrology.

Controlled Environment

Install the SThM system in a vacuum chamber

Suppress artefacts like water meniscus with temperature and external environment.

Conclusion: We have demonstrated the ability of SThM to perform images of individual Bi₂Te₃ nanowires. Future improvements will allow to extract the thermal conductivity of individual NW.

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