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Franche-Comté Electronique Mécanique Thermique et Optique - Sciences et Technologies

PhD Available Position

Title:

Contribution to thermal microscopy by means of thermoelectric probe for nanostructures thermophysical characteristics quantification

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LABORATORY

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DESCRIPTION OF WORK

Context -

Near-field thermal measurement tools represent a highly strategic field which exceeds by far the only problem of the imaging techniques. The measurement techniques of the temperatures and the thermal flows at short scales of space and of time are closely related to expected improvements in the field of the nanotechnologies. Indeed, beyond the check of the behavioral models, new means of characterization and detection of defects are to be developed for:

- the understanding of the heat transfers in the interfaces and in materials at these micro and nano-scales,
- microelectronics and nanotechnology which rely on,
- materials sciences,
- biology and medical sciences…

For two decades, the progress in this domain was regular but slow, mainly for technological reasons and inherent to the physics of the thermal transfers.

As an example, to date, the measurement uncertainties of the best surface temperature microprobes usually vary from 40 to 95 %, whereas the apparent resolution is lower than 100 nanometers.
The complexity of the heat transfer modes between a probe and a surface leads to widen the reflection both on the design of the probe and on its way of functioning and the associated calibration techniques.

The FEMTO-ST institute is committed in this thorough work, both on the elaboration of new techniques and on their processes of calibration. Among the different near-field thermal microscopes using local probes (SThM), our choice concerns thermoelectric probes which exhibit several advantages compared with the most used resistive probes:

_ localization of the measurement at the junction,
_ direct conversion of the Seebeck voltage to the junction temperature,
_ a higher contrast in active mode using 2ω method regarding to 3ω resistive techniques.

The principle of a microscope using a wire thermocouple in platinum and 10% rhodium-platinum of different diameters is now operating. It is used in passive mode for hot surface thermography or in active mode for local thermal characterization (thermal conductivity measurements). This sensor is embedded on a quartz resonator to control the tip-to-surface contact (force spectroscopy mode). First results have led to develop an additional system that will work under vacuum. These developments are performed in the frame of a European project (Quantiheat - http://www.quantiheat.eu/).

Références

- A. Bontempi, L. Thiery, D. Teyssieux, D. Briand, and P. Vairac, *Quantitative thermal microscopy using thermoelectric probe in passive mode*, Rev. Sci. Instrum. 84, 103703 (2013).
- A. Bontempi, L. Thiery, D. Teyssieux, D. Briand and P. Vairac, *DC and AC scanning thermal microscopy using micro-thermoelectric probe*, Quantitative Micro and Nano Thermal Imaging and Analysis, July 10-12, 2013 Reims, France, accepted for publication in High Temperatures-High Pressures.
- L. Thiery, D. Teyssieux, A. Bontempi, D. Briand and P. Vairac, *Passive Thermal Contact Calibration of Thermoelectric Micro-sensors*, Phonons and Fluctuations 3 Workshop, 21-24 May 2012, San Feliu de Guixols, Girona (Spain).
- M. Chirtoc, L. Thiery, J.F. Henry, J. S. Antoniow, B. Cretin and J. Bodzenta, *Comparison of Microthermocouple, Resistive Wire and Nanofabricated Thermal Probes for Scanning Thermal Microscopy in Active Mode*, Eurotherm Seminar 91, Microscale Heat Transfer III, Poitiers, France, Aug. 29-31, 2011.
- L. Thiery, E. Gavignet and B. Cretin, *Two omega method for active thermocouple microscopy*, Rev. Sci. Instrum. 80, 034901 (2009).
- L. Thiery, S. Toullier, D. Teyssieux, D. Briand, *Thermal contact calibration between a thermocouple probe and a micro-hotplate*, J. Heat Transfer **130**, 091601 (2008).

Schedule

Starting from the present available systems which have been developed in the frame of a previous PhD work (A. Bontempi) that will be presented in December 2014, the applicant will:

- operate and optimize the use of the systems,
- participate to the definition and implementing of calibration protocols of passive and active measurements proposed in the Quantiheat project,
- exploit calibration devices developed by the project collaborators,
- participate to studying and modeling of local heat transfers and to understanding of these phenomena in the conditions established in the project,
- contribute to future evolution of the system, notably in the improvement of the probe.

Financial ressources and collaborations

Outside the european project, collaborations have already been engaged with some companies (E2V, Sensirion…) or with academics (EPFL, Samlab Neuchatel).

The financing is totally insured by the European project as long on the grant (ministerial basis) that on tangible investments or functioning. The financing of the project spreads out from December 2013 till December 2017.

PhD beginning: October 2014 (ending October 2017).

PhD MANAGERS

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