# Detailed description of the research work proposed at CETHIL

## Title: Modeling for Scanning Thermal Microscopy applied to polymeric materials


### Supervisors

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Dr. **M. Boutaous** (PhD Strasbourg, 1998), head of Thermal Sciences in Polymers group at CETHIL. His skills concern the theoretical and experimental analysis of the interaction between processes and polymer material thermomechanical behavior.


### Localisation

Centre d'Energétique et de Thermique de Lyon (CETHIL, CNRS UMR 5008), Campus La Doua-LyonTech, Villeurbanne (Lyon), France


### Key words

Scanning Thermal microscopy, nanoscale thermophysical measurements, polymeric materials, microstructure, nanotechnology, nanometrology


### Context

This research project is in the framework of the development of Scanning Thermal Microscopy (SThM) techniques at CETHIL for the thermophysical characterization of new materials at micro and nanoscales. Focus will be on polymeric materials.
The development of nanotechnologies and new nanomaterials is highly dependent on significant advances in the field of metrology at the submicron scales. Different metrologies with high- spatial and/or temporal resolutions are currently in development for thermal measurements. Among these methods, Scanning Thermal Microscopy (SThM) is a technique that combines the ultra localized analysis of surfaces allowed by Atomic Force Microscopy and the measurement of temperature and thermophysical properties by contact [1]. Breakthroughs are expected through this type of metrology, particularly because the description of heat transfer is very different at the nanoscale: thermal diffusion Fourier's law is rarely applicable, thermal radiation is different and convection is poorly understood when the sizes involved are comparable to the one of the boundary layer. The understanding of the thermal interaction between the probe and the surface of the object to analyze is the main issue to characterize and interpret rigorously the SThM measurement. As demonstrated by previous works, several heat transfer vectors determine this interaction: mechanical micro- and nano- contact between the tip and sample, meniscus of water adsorbed between the surface of the tip and sample, the surrounding gas and radiation. The dependence of these mechanisms of heat transfer on the geometry and the size of the tip, the surface chemistry and other factors such as the roughness of the surfaces is very poorly known. Therefore, the complexity of contact heat transfer between the probe and the sample makes difficult the assessment of the performance of SThM techniques, towards its thermal environment and the nature of samples, topography etc...

## Goals

The project concerns the analysis of the link between microstructure and thermophysical properties of polymeric materials. The application of SThM to polymers involves non-normal conditions of use of the method and requires developments in terms of multi-scale and physical modeling of the probe-sample interaction. Thermomechanical modeling works will be crucial for a proper interpretation of the measurement.

Various modeling have been already proposed in the scientific literature. This work aims:

- to establish a detailed analysis of these modeling,
- to identify the modeling the more adapted to the SThM silicon probe available (Thermal lever from Anasys Instruments) in the laboratory,
- to improve the modeling of heat transfer at the tip-polymeric sample contact.

*Reference:*

[1] S. Gomès, A. Assy, and P.-O. Chapuis, Scanning thermal microscopy: A review, Phys. Status Solidi A, 1–18 (2015) / DOI 10.1002/pssa.201400360.

## Education / Competencies / Strengths

- The candidate (s) will have a degree in physics or engineering science. He (she) will be interested by, not only experimental manipulations, but also the development of models in support of experiments for their understanding.
- Mastering English.
- Mastering French would be a plus.