NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2019-2020

Phonon thermal transport in nanostructured GeTe based materials

General Scope:

This internships deals with the study of novel materials for solving the thermal management issue in microelectronic and energy harvesting applications. One of the main challenges for our modern society consists in reducing the heat losses associated with energy consumption, amounting to about two thirds of the whole energy produced. In this context, nanostructuration has arisen as a promising approach, as the presence of interfaces and the intertwining of different materials at the nanoscale has shown to effectively act on the quasi-particle responsible for heat transport: phonons .

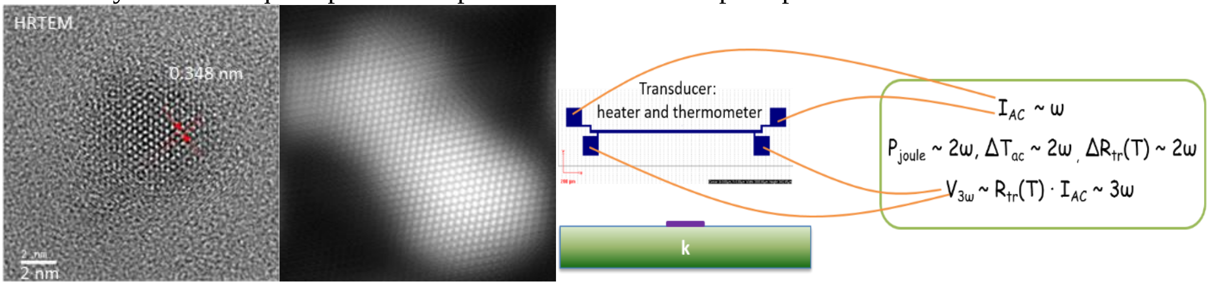

Figure 1 Left and center: Transmission microscope image of GeTe materials showing the nanocrystal in the amorphous matrix. Right: thermometer for the 3 omega measurement.

Research topic and facilities available:

We focus here on GeTe-based nanocomposites, made of nanometric crystalline grains of GeTe embedded in an amorphous matrix (see Figure). GeTe is largely investigated for the novel technology of the phase change memories: memories where the information is coded through the amorphous to crystalline phase change. The electric contrast between the two phases allows to identify the phase and then the 1 or 0 bit. The extremely rapid phase change is assured through Joule heating of the material, which however requires high programming currents, leading to a very large local heating, which hinders any further miniaturization. Recently, nanostructuration has been found to greatly reduce the programming currents, indicating a drastic thermal conductivity reduction of the material. Such reduction is expected to significantly enhance as well the ability of GeTe to convert heat into electric current (thermoelectric conversion), giving the perspective to use it to recycle the heat waste in the microelectronic devices.

We plan to understand how the nanostructuration affects the thermal properties in GeTe nanocomposites, depending on a variety of parameters, such as the GeTe grain size, the film thickness, the amorphous phase properties. In this internship we propose a fundamental investigation aimed at getting the microscopic understanding needed for the technological progress. To this purpose, in collaboration with the CEA-LETI and the ILM in Lyon, thermal conductivity and thermoelectric properties of the GeTe nanocomposites will be measured with laboratory equipments, and compared to microscopic measurements of phonon dynamics at synchrotron radiation sources.

The trainee will performed thermal conductivity measurements on thin film of GeTe based materials. The technique used to measure the thermal transport properties is the 3-omega method with which thermal conductivity and specific heat can be obtained. This technique, based on resistive thermometry, is particularly adapted for low thermal conductivity materials like GeTe nanocomposites. The thermometers are prepared using state-of-the-art clean room processes and the measurement involves low noise electronic in order to get the best sensitivity.

Possible collaboration and networking:

This project (Nanocharme) is financed by a regional grant in collaboration with ILM in Lyon, LETI in CEA and STMicroelectronic.

Possible extension as a PhD: The internship could be followed by a PhD

Required skills: A Master level in physics or applied physics is required.

Starting date: winter to spring 2020

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