Nanometer-scale active thermal devices for thermal microscopy probe calibration

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Heat transfer in micro and nanoscale materials or devices gains more and more attention due to increasing thermomechanical issues and the dependence of many phenomena involving an Arrhenius-type law on local temperature [1]. Scanning Thermal Microscopy (SThM) is a technique derived from Atomic Force Microscopy (AFM) where a thermal sensor is located on the probe [2,3]. This technique allows the thermal characterization in nanoscale a reality. However, many challenges still remain as among which the sensitivity of the SThM probe and its quantitative calibration [4,5].

In this work, dedicated micrometer devices are designed in order to provide ultimately flat surfaces and thermally active samples which are suitable for the characterization and calibration of SThM probes. The design includes as well various characterization platforms, such as Van der Pauw measurement, 4-point electrical resistance measurement and 3-omega measurement in order to better control various sample properties. Finite Element Modeling (FEM) was used to simulate the device, so as to understand the impact of critical factors to our samples and determinate the final fabrication dimensions at different parts.

The first device was completed by using ion implantation in the top layer of a silicon-on-insulator (SOI) substrate to create conductive channels that will be used as resistive elements for heat generation. The narrow conductive channels are down to 20 or 40 nm wide, fabricated via electron-beam lithography. Some preliminary characterizations, such as IR camera and Raman thermometry, will be tried to test its functionalities.

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