An atomically flat, single-crystal, gold film thermometer on mica to study energy (heat) exchange at the nano-scale

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There is a great interest in the scientific community to apply calorimetry to samples with mass in the nanogram range. A detailed knowledge of the energy exchange in the fast growing family of micro and nano-systems could allow to obtain valuable information about the chemistry and physics at the nano-scale. The possibility to have an atomically flat thermal probe represents an added value, allowing the unique opportunity to perform Scanning Tunneling Microscopy (STM) experiments together with calorimetry. Here we report on the development of an original experimental setup able to detect temperature variations as low as 10 mK in a sample of ~10 ng using a thermometer device having physical dimensions of 5x5mm^2. The technique has been utilized to measure the enthalpy release during the adsorption process of D_2 on a titanium decorated monolayer graphene (see Fig. 1a). The sensitivity of these thermometers is high enough to detect a hydrogen uptake of ~10^{-10} moles, corresponding to ~0.2 ng, with an enthalpy release of about 23 μJ [1]. Moreover, we present the fabrication, characterization and calibration of an atomically flat, monocrystalline gold film thermometer on mica substrate. Gold re-crystallization has been obtained inside the STM chamber, allowing the successive investigation of the thermometer surface by LEED and STM imaging (see Fig. 1b). The thermometer calibration demonstrated a thermal exchange coefficient of 2.2x 10^{-7} W/K and a sensitivity of 1.5 mK at room temperature. The experimental setup allows the simultaneous achievement of heat exchange and surface physics analysis on the same sample.

References:

[1] L. Basta, S. Veronesi, Y. Murata, Z. Dubois, N. P. Mishra, F. Fabbri, C. Coletti and S. Heun, *A sensitive calorimetric technique to study energy (heat) exchange at the nano-scale,* Nanoscale **10**, 10079 (2018).

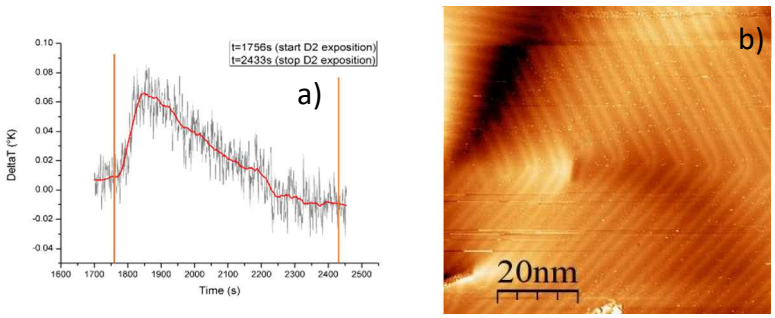

Fig. 1: a) Temperature variation during D_2 adsorption in Ti functionalized MLG; b) STM image of the Au(111) surface reconstruction.