Nanocalorimetry: a new way to study explosives.

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The present work investigates the thermal signatures of explosives studied by a novel calorimetric technique: the Nanocalorimetry.

Usually, the Differential Scanning Calorimetry (DSC) is used in materials science to address the thermal properties such as heat capacity or latent heat of phase transitions. Most of the physical or chemical modifications of materials are associated with thermal effects: heat is absorbed in the case of endothermic phenomena (as melting) or released for exothermic phenomena (as crystallization and thermal decomposition). Analyses of energetic materials by DSC are performed on several mg of sample and usually in closed crucibles because of a possible increase of pressure in the crucible during the thermal decomposition. The main advantage of Nanocalorimetry for explosives analysis is the extremely high heating rates (up to 1 million °C/s) [1,2,3,4] and the possibility to characterize one single micro-crystal of the explosive. The Nanocalorimeter (figure 1a) developed in our lab can also perform experiments at the same heating rates than in the classical DSC (1 °C/min to 50 °C/min). In the nanocalorimetric experiment, the sample is placed in the centre of the measurement area (figure 1c) of the nanocalorimetric sensor (figure 1b) using a micromanipulator. In our experiments, the sample is an isolated single micro-crystal of a few nanograms of explosives (figure 2).
This technique allows determining the thermal signature of single crystal of explosive or blends (e.g. nanoRDX/TNT blends).
A wide range of detection devices based on different physical properties exist already. Here, we are also going to evaluate the capacities of the nanocalorimetry with regard to differentiating the energetic materials, as well as with regard to the detection limits and compare it to the existing methods (dogs[5], amplifying fluorescent polymers[6], microcantilever sensors[7]).

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Figures

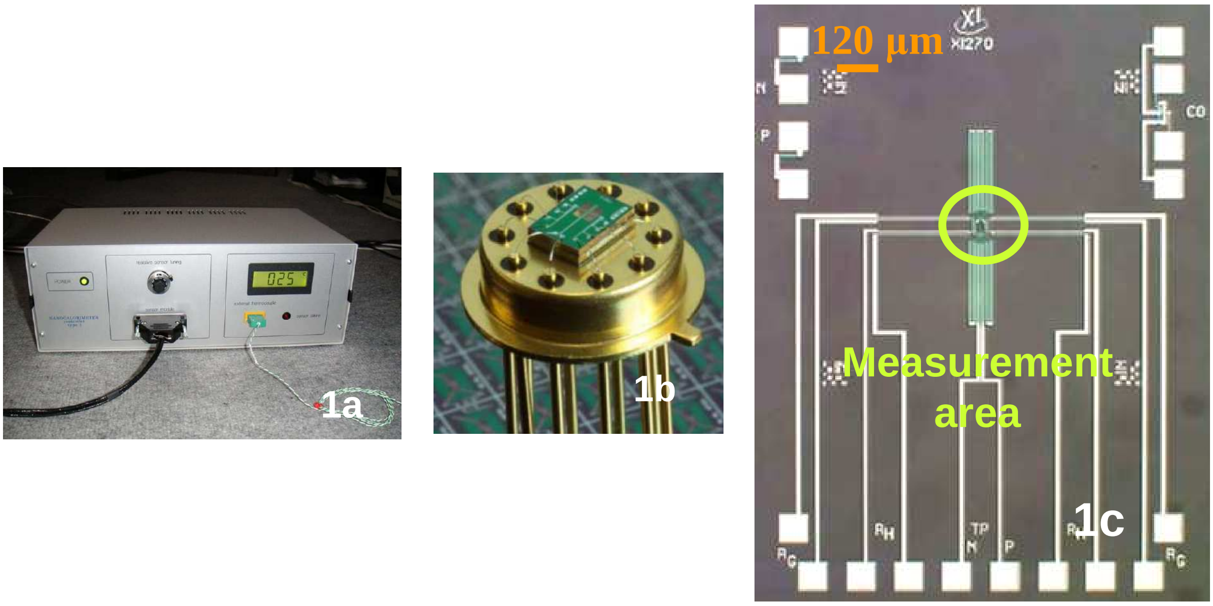

Figure 1. Nanocalorimeter (1a), calorimetric chip sensor from Xensor company (1b) and zoom on the suspended membrane in the center of the chip (1c).

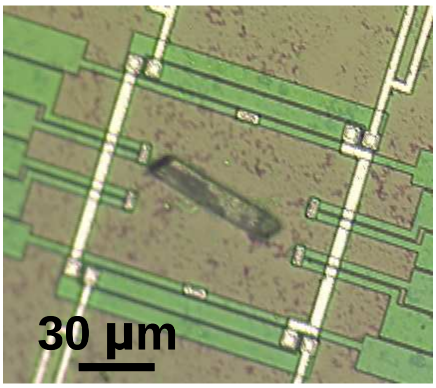

Figure 2. Single micro-crystal of energetic material placed on the nanocalorimetric sensor.