MS33. Mechanical effects and properties of ordered matter

Chairs: Pančе Naumov, Helena Shepherd

MS33-P1 Thermosalient effect of an organic aminonitrile and its derivatives

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The thermosalient effect is an extremely rare propensity of certain crystalline solids for self-actuation by elastic deformation or a ballistic event. Thermosalient compounds, colloquially known as “jumping crystals” are promising materials for fabrication of actuators that are also being considered as materials for clean energy conversion because of their capabilities to convert thermal energy into mechanical motion directly. Herein, an organic aminonitrile and its derivatives have been probed by a combination of structural, microscopic and thermoanalytical techniques. Crystals of these compounds were analysed by means of single crystal XRD and hotstage microscopy in the temperature range of 100 to 298 K and found to exhibit the thermosalient effect. We also carried out differential scanning calorimetric analysis at the temperature corresponding to that at which the crystal jumps as observed under a hotstage microscope.

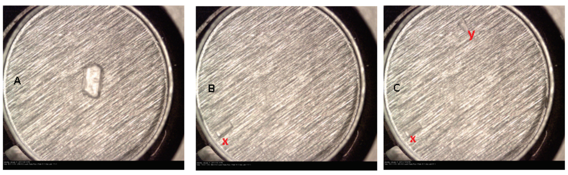

Figure 1. Hotstage micrographs showing the thermosalient effect from 100 to 298 K

Keywords: actuation, jumping crystals, hotstage microscope, temperature, thermosalient effect

MS33-P2 Thermosalient shuttle: *N*'-2-propylidene-4-hydroxybenzohydrazide

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Systems providing mechanical response to external stimuli (heat or light) are rapidly becoming one of the focuses of material science investigations, since these materials are very promising in the sense of conversion of thermal (or light) energy into mechanical work on the nanoscale. One class of such materials are thermosalient materials, or colloquially commonly called “jumping crystals”. These materials, when heated or cooled, undergo a sudden and sharp topotactic phase transition. During the transition, the crystals experience a change in their shape, as well as in the size of the unit-cell, that is so energetic that crystals literally jump off the stage to distances several times bigger than their dimensions [1].

It was reported [2] that N'-2-propylidene-4-hydroxybenzohydrazide behaved similarly as the jumping crystals. This system exhibited three polymorphic modifications (I, II and III), all having the same polar space group $Pna2_1$, with the phase transitions I to II and III to II reported as topotactic. It was also reported that during the irreversible phase transition from I to II single crystals of the phase I were violently disintegrated into single crystal fragments of the phase II (without jumping), while in the reversible phase transition III to II the periodicity along the polar axis expanded (approximately 14%) and the integrity of the single crystals was preserved, i.e. no movement of crystals was observed.

Our measurements showed a somewhat different behaviour. During the irreversible phase transition from I to II some of the crystals did indeed disintegrate into smaller fragments, but a large number remained intact and showed a typical jumping crystal behaviour – jumping all around over large distances (several cm). Also, during the reversible phase transition II to III, and III to II, crystals exhibited the jumping behaviour, perhaps somewhat weaker than during the phase transition I to II. This is in contrast to the statements reported previously. We performed detailed structural and mechanical measurements, with special emphasis on the strain evolution in the crystal lattice during heating/cooling and on basis of that propose a new mechanism for jumping crystals phenomenon in this system.

References:

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Keywords: thermosalient effect, polymorphism, topotactic