Electrooptical studies of metastabilities during the phase transition of 1T-TaS_2

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The discovery of layered materials such as graphene or hexagonal boron nitride revealed a variety of novel phenomena. Transition metal dichalcogenides exhibit a particularly interesting behaviour, as their properties in the case of few layer thick materials, examined via photoluminescence or Raman spectroscopy, are very distinct from bulk [1].
Trigonal tantalum disulfide (1T-TaS_2) - a representative of these materials - focuses the attention of researchers due to its rich phase diagram. The material undergoes temperature-dependent metal-insulator phase transitions, accompanied by a change of its structure, which affects properties such as the Seebeck and Hall coefficients. A current-induced switching between these two phases was recently reported, which may be useful for creating new-generation memory devices [2].
We present a new method of studying phase transitions in a bulk sample of 1T-TaS_2, using a local laser induced thermoelectric effect. The so recored spatially resolved Seebeck voltage changes its magnitude and sign on different parts of the sample. Figures 1(a) and 1(c) depict voltage maps for low and high temperature phases, where the voltage peaks are inverted due to the change of sign of the majority carriers. A specific temperature manoeuvre allows us to "freeze" a state in beetwen two different phases as shown in Fig. 1(b). Consecutive measurements prove that we established a metastable state with a long lifetime.

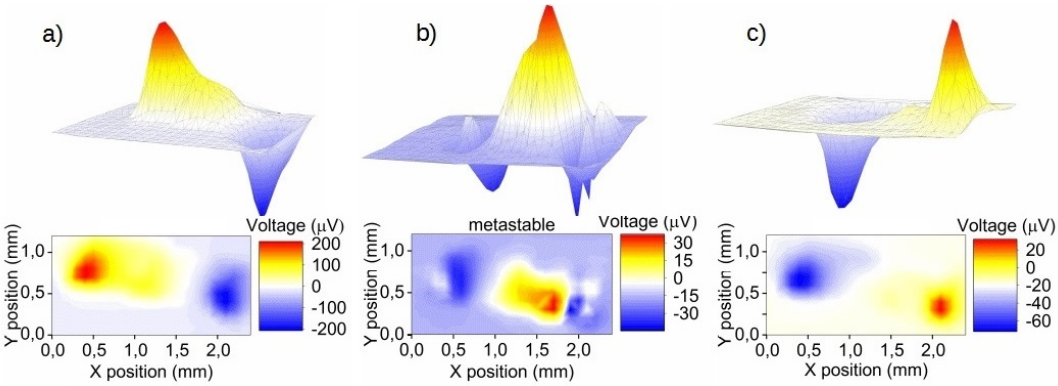

Figure 1: Laser-induced thermoelectric voltage maps obtained for (a) low-temperature state, (b) metastable state during the phase transition (c) high-temperature state.

Our results show that we can capture and freeze an early state of phase nucleation in the first order phase transition of 1T-TaS_2, hence two distinct phases are present at the same time on the same sample.

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[1] H. Terrones et al. Scientific Reports 4, 4215 (2014).
[2] M. Yoshida et al. Science Advances 1(9), 2015.