RESISTIVE SWITCHING AND DIOD EFFECT IN CONDUCTIVITY OF $TiTe_2$ POINT CONTACTS

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Abstract

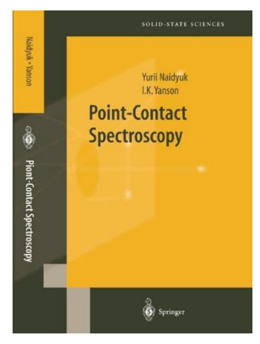
We have measured the *I(V)* and *dV/dI(V)* characteristics of $TiTe_2$-based point contacts (PCs) from room to helium temperatures. The features indicating the emergence of charge density wave (CDW) were detected. They are represented by the symmetrical with respect to V=0 humps in *dV/dI(V)* around +/-150 mV at liquid helium temperatures, which disappear above 150 K, similar to the case of the sister CDW compound $TiSe_2$. Applying higher voltages above 200 mV, we observed a resistive switching in $TiTe_2$ PCs from a metallic-like low-resistance state to non-metallic type high-resistance state with a change of resistance by an order of magnitude. A unique diode-like effect was registered in "soft" $TiTe_2$ PCs with hysteretic *I(V)* at the negative voltage on $TiTe_2$. The discovery of the resistive switching and diode effect adds $TiTe_2$ to transition-metal dichalcogenides, which could be useful in the development of non-volatile ReRAM memory and other upcoming nanotechnologies.

Methods

Classical PCs were established at T^{He} by touching of thin Cu/Ag wire to a cleaved surface of $TiTe_2$ (heterocontacts).

"Soft" PCs were made by dripping a small drop of silver paint onto the sample surface/edge.

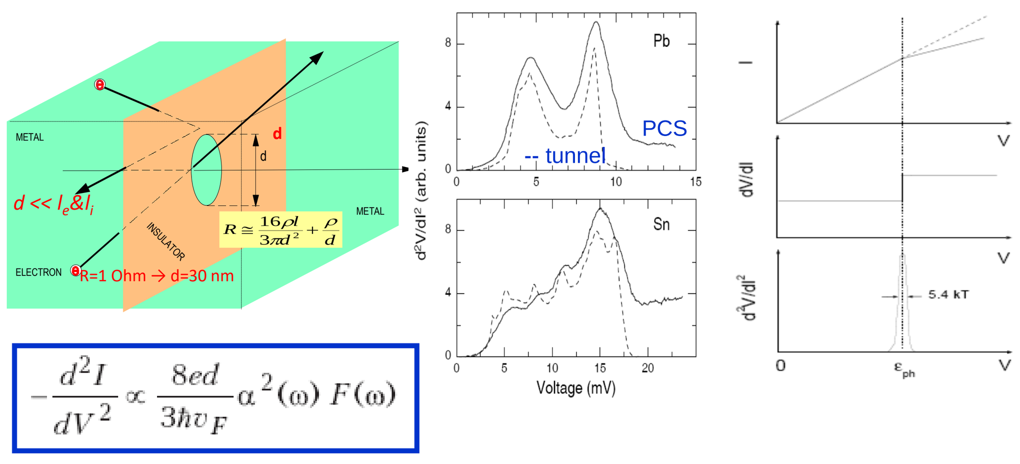
The IVC and their derivatives of PCs were measured at 1.5-300K using **point-contact spectroscopy method.**



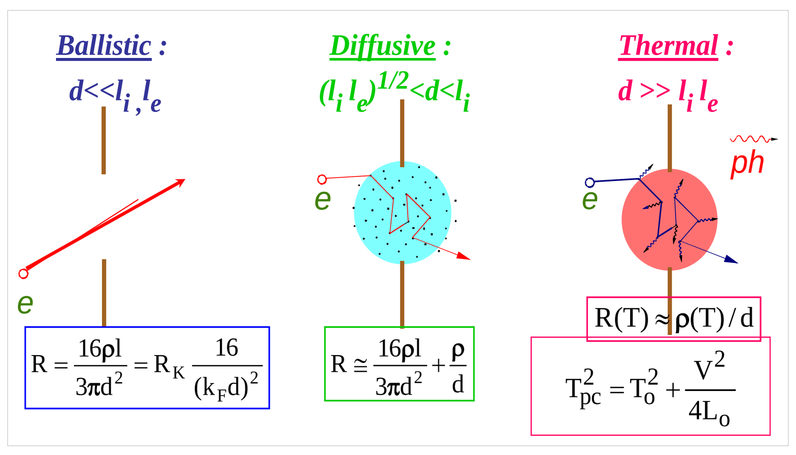
[Yu.G.Naidyuk, I.K.Yanson, *Springer, 2005*]

Introduction

Yanson PC spectroscopy

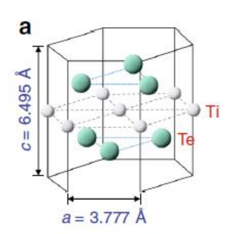


$$-\frac{d^2I}{dV^2} \propto \frac{8ed}{3\hbar v_F}\alpha^2(\omega)F(\omega)$$

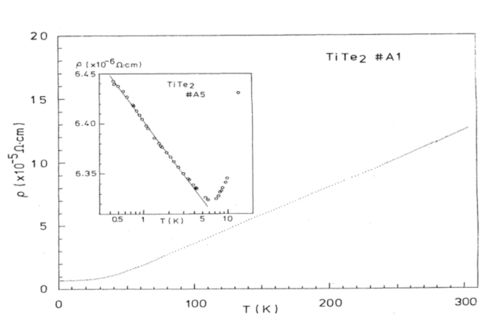


$$T = 3.2\,\tfrac{K}{mV}\,V \qquad I(V) = Vd\int_0^1 \frac{dx}{\rho(T\sqrt{1-x^2})}$$

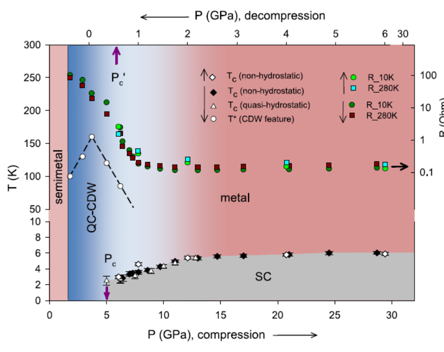
Properties of $TiTe_2$



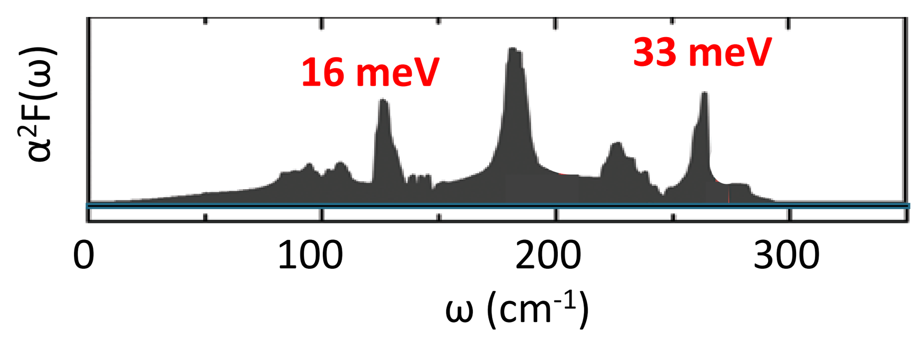
- semimetalic transition metal dichalcogenide
- metallic resistivity *ρ(T)* with log- increase below 10 K
- small nonhydrostatic compression leads to an abrupt change in low-temperature resistance, a signature of possible CDW and SC ordering



Electrical resistivity of $TiTe_2$ single crystals. Y. Koike *et al., JPSJ* **52**, 597 (1983)



The phase diagram for 1*T*-$TiTe_2$ under nonhy-drostatic compression and decompression. Dutta, *et al., PRB* ***97***, 060503(R) (2018)].



EPI Eliashberg function $\alpha^2F(\omega)$ of $TiTe_2$.
R.C. Xiao *et al., J. Mater. Chem. C,* **5**, 4167 (2017)

Experimental

Emerging of CDW ordering?

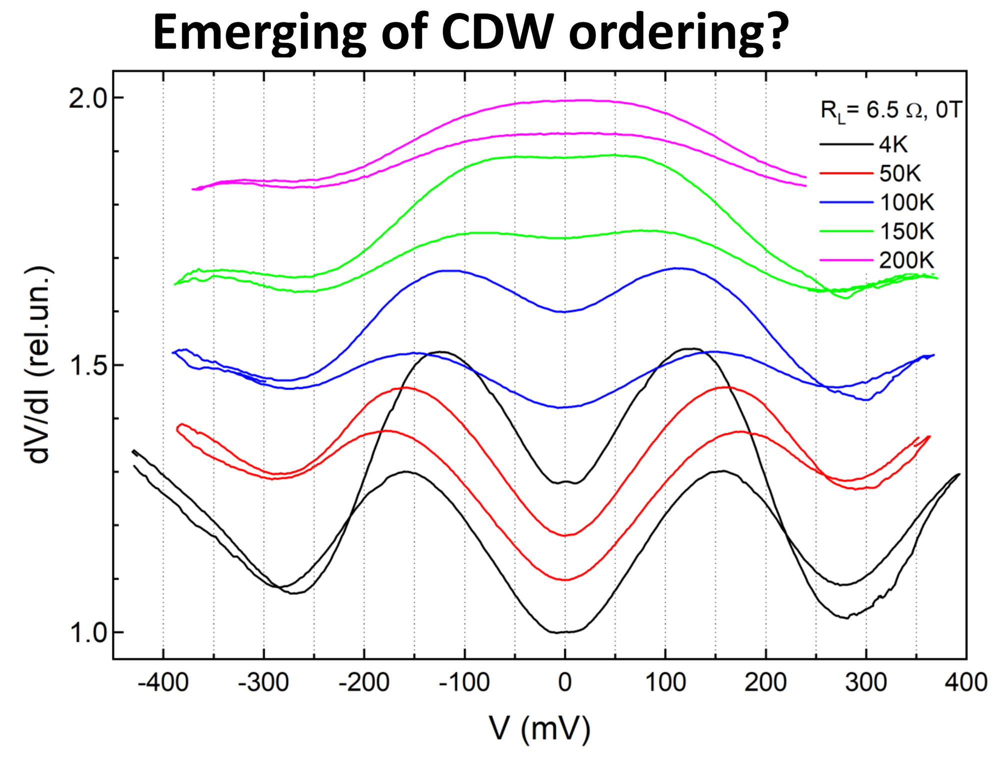


Fig.1. *dV/dI(V)* with symmetrical humps of $TiTe_2$ PC at different T like in the case like in the case of sister compound with CDW ordering $TiSe_2$ [D.L. Bashlakov, O.E. Kvitnitskaya *et al.*, LowTempPhys **49**, 916 (2024)]

Schottky diod-like effect

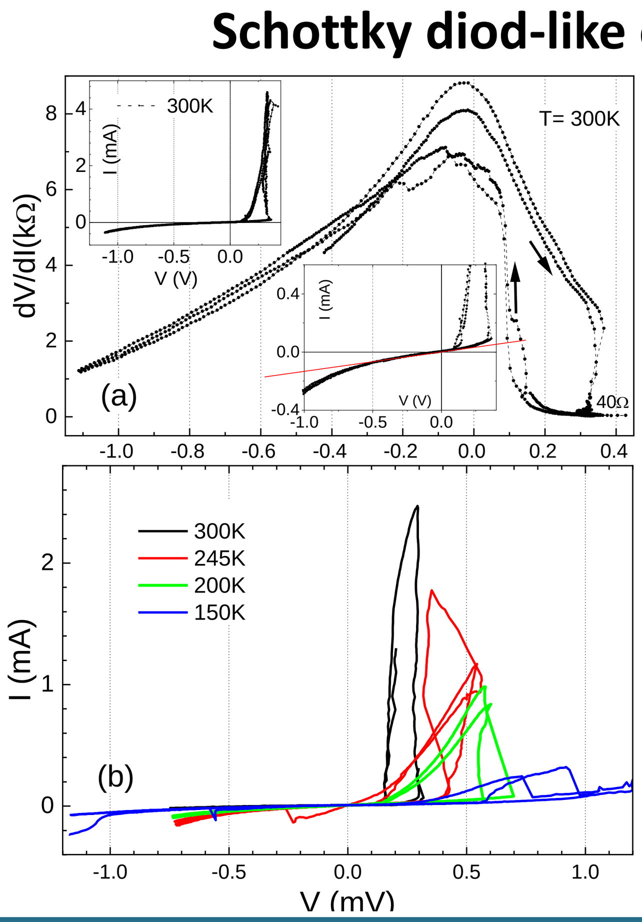


Fig.2. a) *dV/dI(V)* and *I(V)* curves (insets) at 300K with "diod"-like effect for $TiTe_2$ "soft" PC.
(b) *I(V)* curves for another soft PC at T= 300 →150K.

Experimental

Switching effect

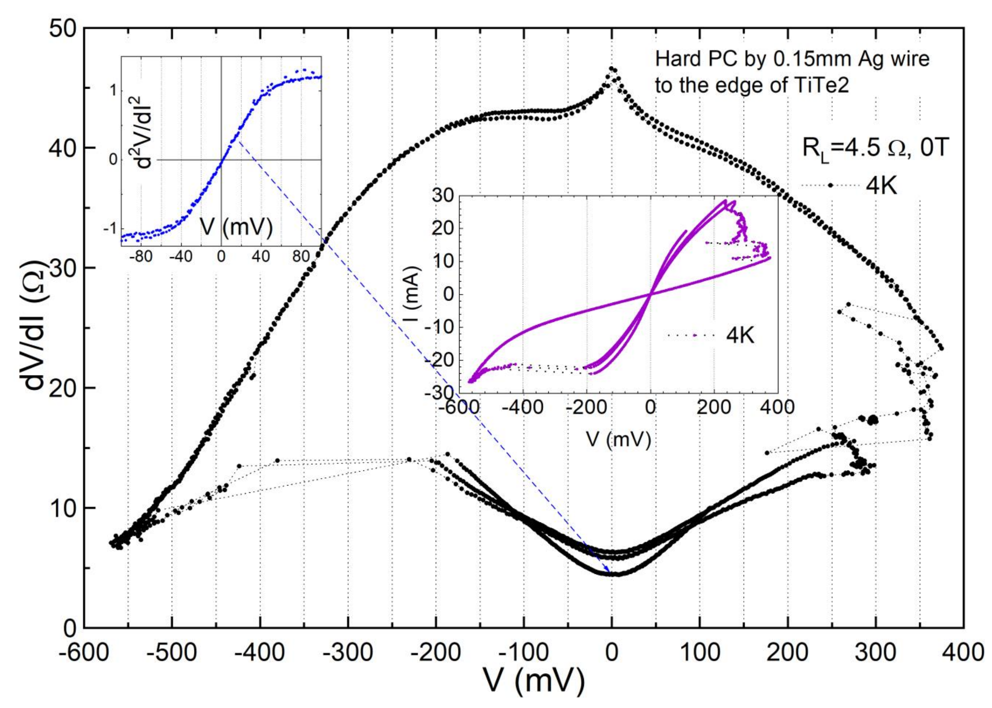


Fig.3. Resistive switching in *dV/dI(V)* for $TiTe_2$ PC by „clock wise" V-sweeping. Central inset: *I-V –C* of the same PC. Left inset: calculated d^2V/dI^2 of low-resistance state for the same PC.

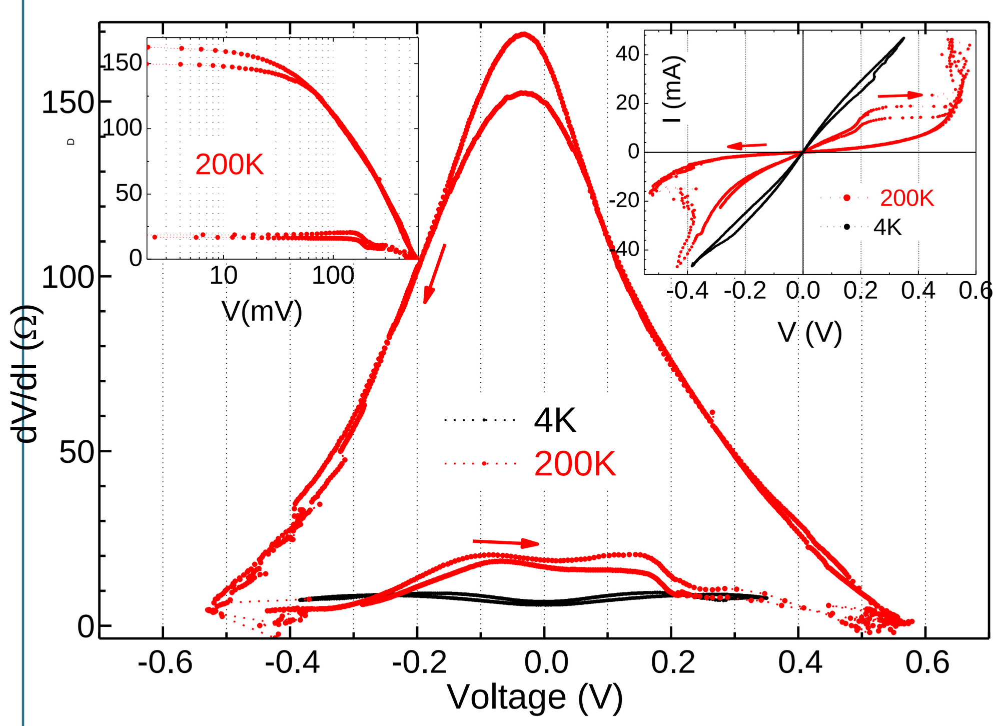


Fig.4. . Resistive switching in *dV/dI(V)* for $TiTe_2$–Ag "hard" PC at two temperatures. Inset (right): *I(V)* curves for this PC . Inset (left): *dV/dI(V)* in log-scale

Summary

- **We observed an emerging of CDW ordering in $TiTe_2$ due to the pressure in "hard" PC, which appears on PC spectra in the form of symmetrical humps like in the case CDW compound $TiSe_2$.**
- **Resistive switching in $TiTe_2$ PCs, between metallic LRS and semiconducting-like HRS with changing resistance up to 2 orders of magnitude is detected. The switching effect can be due to the electric field induced change of stoichiometry in PC core owing to the drift of Te vacancies.**
- **Unexpected diode-like effect was observed in "soft" $TiTe_2$ PCs with hysteretic *I(V)* at negative voltage on $TiTe_2$.**
- **Discovering of the resistive switching and diode effect adds $TiTe_2$ to the list of compounds promi-sing for non-volatile ReRAM engineering and other up-and-coming nanotechnologies. On the other hand, we demonstrate the great potential of the Yanson PC spectroscopy for the search for promising materials and it will help reveal the internal nature of these intriguing phenomena.**