Observation of Dynamic- and Thermo- Anomalies at the Surface Electron to Surface Anions Transition over Helium Film on Structured Substrate.

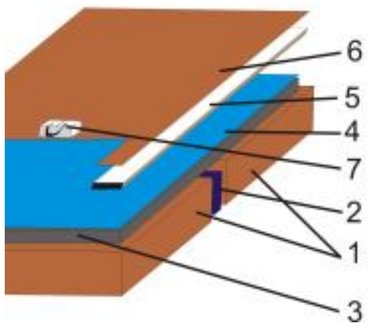
V. A. Nikolaenko, A.S. Smorodin, E.Ya. Rudavskii and S.S. Sokolov

B. Verkin Institute for Low Temperature Physics and Engineering, National Academy of Sciences of Ukraine, 47 Nauka Ave., Kharkiv, 61103, Ukraine

E-mail: nikolaenko@ilt.kharkov.ua

Introduction. The exchange interaction of electron with the neutral matter is nontrivial and the condensed matter researchers are challenge. The surface electrons over liquid helium (SEs) is used here as a research tool. At the large pressing electric field or/and at the dense surrounding gas the SE forms dimple in helium - a surface anion (SA). In this work the electro- and the thermo- dynamic anomalies of SE/SA transition over the helium film on a structured substrate were study by the transport method and by the temperature monitoring.

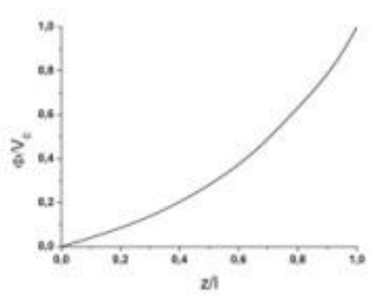
Setup



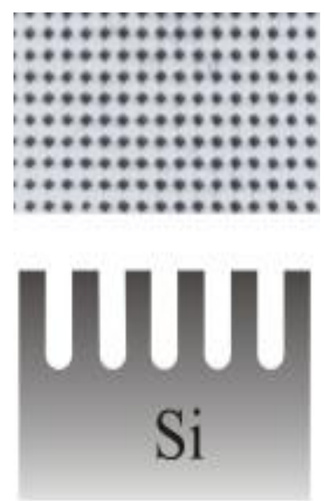
A low frequency transport method for anomalies study is used. Measurement of electron conductivity consider the capacitive coupling of charged substrate with measurement electrodes.

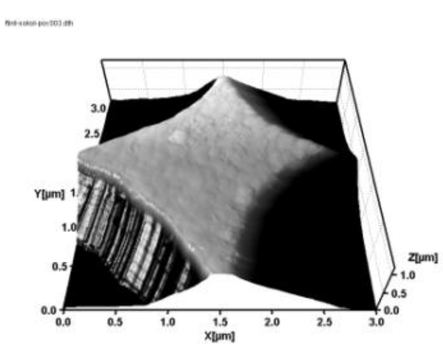
Cell. 1 - measurement electrodes; 2 - screening stripe; 3 - substrate; 4 - He film; 5 - guard ring; 6 - pressing electrode; 7 - tungsten thread. The thermometer situated under sell (not shown).

Porous substrate. A Si mono-crystalline plate 1 cm^2 in square and 0.3 mm in thickness arranged the periodical grid of pores 2 μm in diameter and 60 μm in depth shown on left picture; right fragment is a ASM scan.

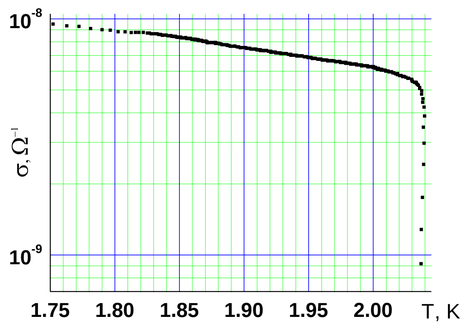


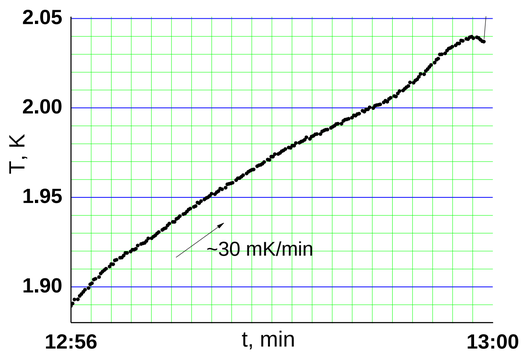
Dependence potential on immersion into deep of pore.





Results

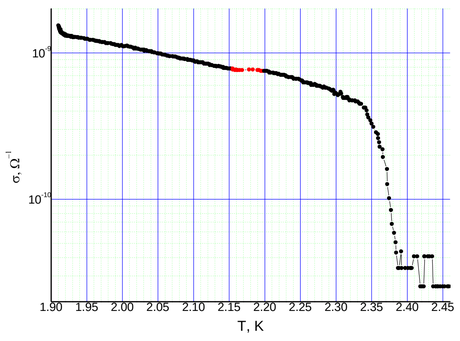


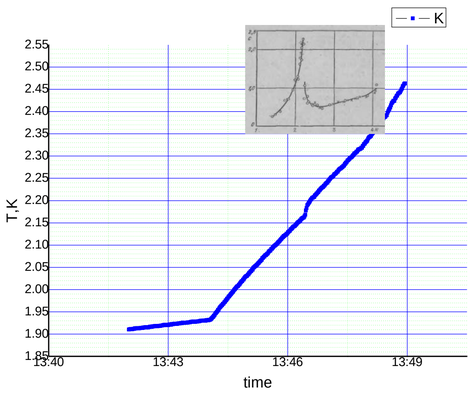


Step 1 – the helium film is 20 nm in thickness covers porous of substrate.

Dependence σ vs T (left Fig). The SE-SP transition take a place at 2.04 K (right Fig.). Time of scanning the cell temperature at rate ~ 30 mK/min. ***T*-dip** is near 5mK in magnitude has a place at SE/SA transition.

A balance the energy both the SE-SP transition (ΔV) and the helium heat capacity ($C_{He} \cdot m$): $e \cdot \Delta V \cdot N = C_{He} \cdot m \cdot \Delta T$ gives the value ΔT.





Step 2 - the massive helium is in pores of substrate.

Dependence conductivity, σ vs T. SE/SP transition take a place at 2.34 - 2.38K.

During time scanning of the cell temperature the value ***T*-dip** is absent at SE-SP transition (T = 2.32K–2.38 K).

Insert. A superfluid transition of helium has a place at T ≈ 2.15 – 2.19 K.

Conclusion

Were performed both the experimental setup and the researches electro- and thermo- dynamic anomalies at surface electron to surface anions transition over the helium film on structured substrate. According procedure:

step 1. Scan T vs t shows at SE/SA transition (T = 2.04 K) the thermo-dip ~5 mK takes a place during ~10 s in time.

step 2. At both the massive helium in chamber and higher the SE/SA transition temperature the thermo – effect is absent.

The effect can be related to row of the analogical effects like to electro-caloric or magneto-caloric one.

References for information

1. *Yu. P. Monarkha, Phys. Nizk. Temp., v.1, 1975, pp. 526–534.*
2. *T. I. Zueva and S. S. Sokolov, Low Temp. Phys. /Fiz. Nizk. Temp., 2022, Vol. 48, No. 9, pp. 764–773*
3. *Yu. Z. Kovdrya, F. F. Mende, and V. A. Nikolaenko, Phys. Nizk. Temp., v.10 (11), 1984, pp. 1129–114.*